New Low Carbon Power Marketing Scheme for Island Based on User Ranking

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Abstract. With the social progress, the market competition in the power industry is becoming more and more fierce. In order to improve their economic benefits and competitiveness, power enterprises implement power precision marketing from the aspects of power marketing management. In the context of the island power market, from the perspective of the power supply company, this paper uses the improved least square method and entropy weight method to get the weight for the power users of the island, combined with the user ranking, and carries out the user ranking, so as to implement accurate marketing for different users.

Keywords: Power marketing · User ranking · Least square method of weight · Entropy weight method · Index evaluation

1 Introduction

With the massive access of distributed energy, the island's new energy has been developed and utilized, and its tidal energy, wave energy, photovoltaic power generation, wind power generation and other new energy has been widely developed and applied, promoting the construction and development of green islands [1]. For island power marketing, it is necessary to combine the island's special geographical environment with the island's power users to implement accurate and low-carbon power marketing.

Nowadays, when conducting power marketing and management, electric power enterprises mostly meet people's power consumption needs from the perspective of users, which leads to the generation of user ranking and is accepted and applied by more and more enterprises [2]· User ranking can help enterprises to classify users in marketing, implement differential marketing strategies, and improve user satisfaction and user stickiness [3, 4]. In the power market, most users are classified by their electricity consumption behaviour [5, 6]. Literature [7] evaluates and classifies users according to

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their reliability and sensitivity to power supply, and literature [8] proposes a two-stage classification algorithm for power users based on their electricity consumption behavior.

This paper conducts electric power marketing on the island. Aiming at the island's special geographical environment, different power users and various distributed new energy situations, on the basis of user classification and user ranking, it implements electric power precision marketing. At the same time, in view of the unstable and objective problems caused by the traditional analytic hierarchy process (AHP) in weighting, this paper uses the least square method of weights and entropy weight method to empower indicators, and constructs a scientific and comprehensive evaluation index system to improve the accuracy of user ranking.

2 User ranking index evaluation system

In electric power marketing, it is of great significance for power supply companies to conduct personalized analysis of users and analyze their electricity consumption behavior. In this paper, the power users are ranked by the user ranking. The user ranking is reflected by the user value. The higher the user value is, the more significant it is to the power supply company. The user value is evaluated and quantified by the user's consumption level, load level, credit level, and customer stickiness level.

The power supply company determines the user value of the user on the premise of determining the target user. High user value means that the potential value and current value of the user are high for the power supply company. The power supply company will implement precise marketing according to the user's electricity use behavior to enhance the stickiness of the customer, so as to achieve a win–win situation between the user and the company.

This paper establishes a user value evaluation indicator system as shown in Fig. 1. The first level indicators include consumption level, load level, credit rating, and customer

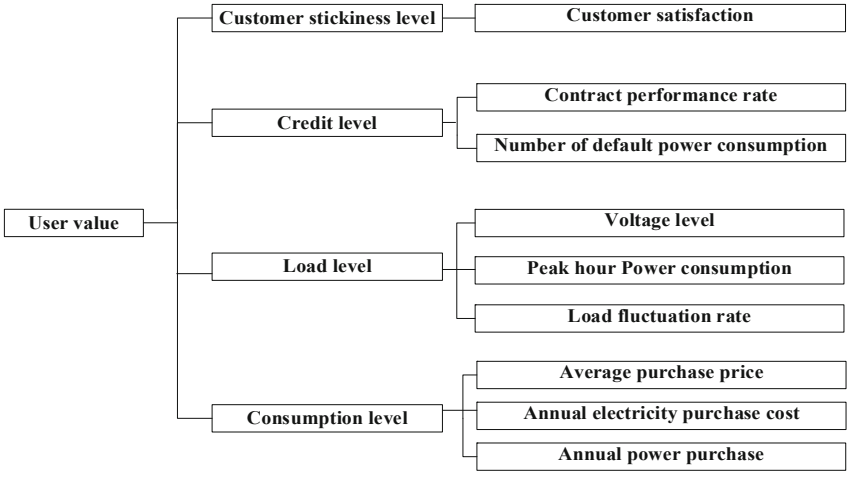

Fig. 1 User value evaluation system

stickiness. The second level indicators are further refined on the basis of the first level indicators. The specific formula is as follows.

(1) consumption level: Considering the annual power purchase, annual power purchase cost and average power purchase price of users, it means the contribution of users to the GDP of power companies.

$$C_l = a_1 \cdot b_l + a_2 \cdot m_l + a_3 \cdot b_{l,power} \tag{1}$$

where, a_1, a_2, a_3 is the coefficient of corresponding index, determined by entropy weight method, $b_l, m_l, b_{l,power}$ means the corresponding indicator.

(2) (2) load level: This indicator considers the user's voltage level, peak hour power consumption rate and load fluctuation rate, and describes the load level through these three indicators.

$$V_l = b_1 \cdot V_{lever} + b_2 \cdot q_{l,high} + b_3 \cdot q_{l,power} \tag{2}$$

where, b_1, b_2, b_3 is the coefficient of corresponding index, which is determined by entropy weight method, $V_{lever}, q_{l,high}, q_{l,power}$ are voltage level, peak hour power consumption rate and load fluctuation rate respectively.

The load fluctuation rate is the ratio of the standard deviation of daily load to the average daily load. The higher the load fluctuation rate, the greater the potential of users.

$$q_{l,power} = \frac{d_{load}}{d_{l,load}} \tag{3}$$

Peak hour power consumption rate is the ratio of total peak hour power consumption to total daily power consumption. High peak time power consumption rate means high potential value of users.

$$q_{l,high} = \frac{d_{high,load}}{d_l} \tag{4}$$

(3) credit rating: This indicator is reflected by the number of power use defaults and contract performance rate of users.

$$T_l = C_1 \cdot h_l + C_2 \cdot Q_l \tag{5}$$

where, C_1, C_2 is the coefficient of corresponding index, determined by entropy weight method, C_1, C_2 Represents the number of power use defaults and contract performance rate of users.

(4) customer stickiness: The customer's stickiness to the company is described by the customer's satisfaction with the power company.

$$S_l = S_{lever} \cdot 100\% \tag{6}$$

3 The least square method based on weight entropy weight m ethod to determine the user order

The first level evaluation indicators are consumption level, load level, credit level and customer stickiness level, while the second level evaluation indicators are annual power purchase, annual power purchase cost, average power purchase price, voltage level, peak hour power consumption rate, load fluctuation rate, number of power use defaults, contract performance rate and user satisfaction. The first level index weight is determined by the least square method of weight, which can be adjusted according to different island power conditions. At the same time, the consistency test process in AHP is avoided, and the problem of randomness is solved; The weight of secondary indicators is determined by entropy weight method, which makes the results more objective. The specific process of determining weights is shown in Fig. 2.

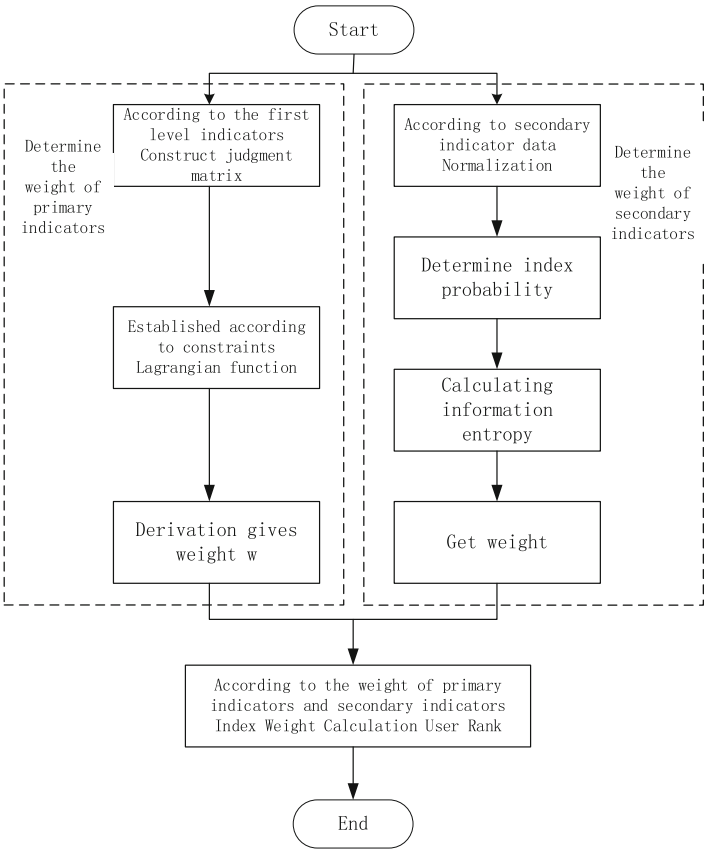

Fig. 2 Flow Chart of Weight Calculation

3.1 Least Square Method of Weights

(1) Construct judgment matrix

The 3-scale method is used to construct the judgment matrix. Compared with the traditional 9-level scale method, the 3-scale method can simplify the calculation process and reduce the calculation capacity. At the same time, it allows experts to easily obtain the judgment results when evaluating the importance of the two factors, reducing the complexity of the calculation. The judgment matrix A is obtained by comparing the indicators by experts.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}$$

where, a_{ij} represents the evaluation result of index importance,

$$\mathrm{a_{ij}} = \begin{cases} 2, iismoreimportantthanj \\ 1, iisasimportantasj \\ 0, jismoreimportantthani \end{cases}$$

(2) Constructing Lagrangian Functions

Construct judgment matrix:

$$D = \left\{ \mathrm{W} = (w_1, w_2, \ldots, w_n)\mathrm{T} | w_i > 0, i = 1, 2, \ldots, n; \sum_{i=1}^{n} w_i = 1 \right\} \tag{8}$$

The objective function L is constructed, which means that the sum of squares of the sorting vector is the minimum.

$$minL = \sum_{i=1}^{n} \sum_{j=1}^{n} \left(w_i - a_{ij} w_j \right)^2 \tag{9}$$

The sum of all weights is 1, and the Lagrangian function is made according to the constraint conditions.

$$L(\mathrm{w}; \lambda) = \sum_{i=1}^{n} \sum_{j=1}^{n} \left(w_i - a_{ij} w_j \right)^2 + 2\lambda \left(\sum_{i=1}^{n} w_i = 1 \right) \tag{10}$$

(3) Solve weight w

The partial derivative of Lagrangian function is calculated, so that $\frac{\partial L}{\partial w} = 0$, and it is expressed in matrix form after sorting out:

$$CW + \lambda e = 0 \tag{11}$$

where:

$$c = \begin{bmatrix} \sum_{i=1}^{n} a_{i1}^2 + n - 2 & -(a_{12} + a_{21}) & \dots & -(a_{1n} + a_{n1}) \\ -(a_{21} + a_{12}) & \sum_{i=1}^{n} a_{i2}^2 + n - 2 & \dots & -(a_{2n} + a_{n2}) \\ \vdots & \vdots & & \vdots \\ -(a_{n1} + a_{1n}) & -(a_{n2} + a_{2n}) & \dots & \sum_{i=1}^{n} a_{in}^2 + n - 2 \end{bmatrix} \tag{12}$$

$$e = (1, 1, \dots, 1)^T \tag{13}$$

The solution is: $w = C^{-1}e/e^T C^{-1}e$

The weight of the first level indicators is determined through the above steps, and the entropy weight method is used to determine the weight of the second level indicators.

3.2 Entropy Weight Method

(1) Data normalization

$$Y_i = \frac{x_i - \min(x_i)}{\max(x_i) - \min(x_i)} \tag{14}$$

First, determine the positive indicators and negative indicators in the secondary indicators. The annual power purchase, annual power purchase cost, average power purchase, voltage grade, peak hour power consumption rate, user satisfaction, and contract performance rate are positive indicators, and the number of default power consumption is negative indicators.

Normalization formula of positive indicators:

$$Y_i = \frac{x_i - \min(x_i)}{\max(x_i) - \min(x_i)} \tag{14}$$

Normalization formula for negative indicators:

$$Y_i = \frac{\max(x_i) - x_i}{\max(x_i) - \min(x_i)} \tag{15}$$

(2) Determine index probability

$$P_i = \frac{Y_i}{\sum Y_i} \tag{16}$$

(3) Calculating information entropy

$$E_i = -P_i \lg(P_i) \tag{17}$$

(4) Get weight

$$w_i = \frac{1 - E_i}{n - \sum E_i} \tag{18}$$

N is the number of evaluation indicators.

The weights of primary and secondary indicators are obtained by combining the least square method of weights with the entropy weight method. The user order formula is as follows:

$$P = \alpha_1 \cdot \left(a_1 \cdot b_l + a_2 \cdot m_l + a_3 \cdot b_{l,power}\right) + \alpha_2 \cdot \left(b_1 \cdot V_{lever} + b_2 \cdot q_{l,high} + b_3 \cdot q_{l,power}\right) + \alpha_3 \cdot (C_1 \cdot h_l + C_2 \cdot Q_l) + \alpha_4 \cdot S_l \tag{19}$$

4 Marketing strategy based on user order

Supported by the dual carbon goal, island power marketing has ushered in a new direction of development, moving towards low-carbon and green development, encouraging large power users and multiple small power users to establish photovoltaic power generation equipment, reducing the construction of thermal power plants on the island, while reducing the construction costs of transformers and lines for power supply companies to achieve a win–win situation for users and power supply companies. Based on the original classification of island power users, the user ranking is more refined, and the marketing strategy, profit distribution and company operation and maintenance are adjusted according to the user ranking.

Select the power data of an island for calculation, and select five typical users from the load classification in the table to calculate their user value. The results are shown in Table 1.

Table 1 Specific marketing plan for island power users

	Load classification	User value ranking	Marketing program
Conventional load	Industrial electricity	1	1. Customer investment and company maintenance 2. The customer and the company jointly invest and share profits 3. The company invests, and users bear the cost of grid connection
	Commercial electricity	2	
	Residential electricity	3	
	Agricultural electricity	5	
	Fishery electricity	4	
Important load	seawater desalination system	#	Government enterprise cooperation to maintain island power operation
	lighthouse	#	
	base station	#	

The power supply company adopts different marketing strategies for the conventional load and important load of island power.

(1) Conventional load marketing strategy

Industrial users include large industrial users and small industrial users. The number of large industrial users is small, but their power consumption is large and their user value is the highest. When providing services for large industrial users, power supply companies should pay attention to enhancing customer stickiness. For large industrial users, the self built distributed energy system cannot meet their own power demand, but also increases the construction costs and maintenance costs. Therefore, in their work power consumption, they mainly purchase power from the grid. Industrial users have the highest user value, so when selling electricity to them, power supply companies can increase user stickiness by implementing preferential conditions for users. They should not only enhance customer stickiness, but also pay attention to the consumption of low-carbon electricity. By establishing a time of use electricity price mechanism or other ways, users can adjust peak and valley periods by themselves to promote the green development of islands.

Most residential and commercial users are clustered. Driven by the dual carbon goal, the power supply company encourages multiple residential users to cooperate with commercial users to establish distributed photovoltaic power generation equipment to achieve green power consumption. Participants share the cost of building a distributed photovoltaic power station equally. The power supply company maintains its equipment equally. The maintenance cost is shared equally by users. When there is a lot of electricity generated, users can choose to sell it to the grid for income.

According to the special geographical location of the island, it has tidal energy, wave energy and other island specific new energy power generation methods. The island fishery is developed, which can make full use of tidal energy and wave energy, adopt tidal light complementary power generation, promote new energy consumption and green power generation, and power supply companies promote the construction of new energy equipment. Fishery has a higher user value than agriculture, but its potential value is low. Power supply companies should focus on ensuring power security and improving the reliability of power service. Fishermen users invest in equipment construction, and new energy equipment is used for power generation. Excess electricity can be sold to obtain excess profits. Power supply companies operate and maintain equipment, and fishermen users pay the operation and maintenance costs of power supply companies.

(2) Important load

Among the island power loads, important loads such as desalination system, lighthouse and base station are of great significance to the normal operation of the island. The power supply company should focus on ensuring the normal operation of important loads. For the operation of important loads, the power supply company should adopt the way of government enterprise cooperation. Under the supervision and guidance of the government, the power supply company should maintain and manage the power generation equipment responsible for important loads, and the government should be responsible for the cost of equipment construction and maintenance, Both sides are mutually beneficial and jointly maintain the normal operation of island power.

5 Conclusion

In this paper, the power marketing is implemented in combination with the user order. The least square method of power and entropy weight method are used to rank the user order. The marketing strategy is adjusted accordingly according to the results of the ranking. For the power supply company, the user satisfaction and user stickiness are enhanced. At the same time, the development and utilization of new energy sources on the island are promoted, and the green development of the island is promoted.

References

1. Caoyu, Research on operation strategy and comprehensive evaluation of island microgrid [D]. Shanghai Jiaotong University, 2020. DOI:https://doi.org/10.27307/d.cnki.gsjtu.2020.001254.
2. Wangyao, Basic theoretical framework of customer relationship management[J]. Cooperative Economy and Science and Technology,2020(06):140–141. DOI:https://doi.org/10.13665/j.cnki.hzjjykj.2020.06.054.
3. Qi Hua Research on CG Company's Customer Relationship Management Based on Life Cycle Theory [D]. Dalian Maritime University, 2018
4. Zhao Xuan Research on power purchase and sale strategy of power selling companies based on power user classification under big data [D]. Shanghai Jiaotong University, 2019. DOI: https://doi.org/10.27307/d.cnki.gsjtu.2019.001475
5. Li Jing Research on Power Load Characteristics and User Classification Based on Data Mining [D]. Beijing University of Posts and Telecommunications, 2016
6. Zhang Yuxuan, Su Juan, Jia Tao, Chen Jin, Xing Zhanli. Evaluation and classification method of power users' sensitivity to power supply reliability [J]. Journal of Jiangsu University (Natural Science Edition), 2021,42 (05): 575–581+608
7. Wang Lei, Liu Yang, Li Wenfeng, Zhang Jie, Xu Lixiong, Xing Zheming. A two-phase classification method for power users based on digital characterization of power consumption behavior [J]. Power Construction, 2022,43 (02): 70-80.
8. Ren Min Research on optimal configuration of grid connected island microgrid capacity [D]. Dalian University of Technology, 2021. DOI: https://doi.org/10.26991/d.cnki.gdllu.2021.000003