Integrated Energy Service Package Design Based on User Profile and Cost-benefit Analysis

Weiting Xu1, Quan Tang1, Haiyan Wang1, Hao Xu1, Chao Cheng1, Ziyao Wang2,* and Huaqiang Li2

1State Grid Sichuan Economic Research Institute, Chengdu, China
2College of Electrical Engineering Sichuan University, Chengdu, China

Abstract. At present, with the acceleration of energy transition and the continuous deepening of power market reform, energy system forms in China are showing new development trends. In order to strengthen the flexibility of the power market and solve the problem of single sales model, this paper used user portrait technology and cost-benefit analysis to analyze the IES package qualitatively and quantitatively. Qualitative analysis provides the packaged purchase mode for users; in the quantitative analysis, combined with the package-based Apriori algorithm, a model of users' willingness to buy packages and a fixed-capacity model with the objective function of maximizing service provider revenue were established. Finally, based on five types of integrated energy services: power substitution service, PV service, CCHP service, energy saving renovation and energy efficiency improvement service, and operation and maintenance service, the reliability and scientificity of the model were verified through calculation examples. And by selling integrated energy services in the form of packages, both users and service providers can obtain certain benefits, achieve the goal of "1+1>2" and increase new sales methods in the power market.

Keywords: Integrated energy service; User profile; Cost-benefit analysis.

1. Introduction

With the acceleration of energy transformation and the deepening of electricity market reform, Integrated Energy Service (IES) that improve energy efficiency, reduce energy consumption costs and drive the development of related industries, have been developing rapidly. As an important strategic direction in the field of energy, IES includes not only the comprehensive utilization strategy research of electricity, gas and hot and cold energy, but also the research of engineering service, investment decision and operation scheme. According to this definition, three elements are related in the business process of IES: funds, resources and technology [1]. Therefore, IES are developed in parallel with economy and energy development in China[2]. Some research achievements have been made on IES related planning and dispatching methods and service operation framework. The superposition electricity price model is established by Cong Xiaohan et al, considering the electricity sensitivity to the type of day and temperature [3]. User portraits method is investigated by studying user behavior data, and personalized services method is analyzed and specified in [4]. Hou Jiaxuan et al. [5] constructed an integrated evaluation model of novel DR plans based on cost-benefit analysis, which can be used to the formulation of IES package. Jun Dong et al. [6] defined the connotations and value of IES, and built the theory frame of IES value evaluation system. The process of IES market in China still faces huge challenges of the following problems: 1)
strategy is much the same way, which would hinder the structure transformation process; 2) The purchase intention of users is restricted by seriously homogenized IES, for lack of targeted and differentiated service methods, which affects the IES market promotion.

In view of the above problems, this paper proposes to provide energy users with the method of combining sales of multiple energy services. The design of IES package can be analyzed from qualitative and quantitative aspects. In this paper, the method of "user portrait" and the cost-benefit analysis is analyzed and specified, and an optimal pricing strategy of IES package is established. In order to verify the rationality and economy of IES package, 36 users in a typical region is analyzed to prove the rationality of the method for formulating IES package in this paper.

2. IES Qualitative Analysis

By using user portrait technology, the targeted and unique labels of user energy feature information are extracted to help determine the qualitative content of IES package, so as to pinpoint the direction of service promotion [7]. In this paper, five kinds of IES are selected as the alternative contents representing IES package, which include: power substitution service, PV(rooftop photovoltaic) service, CCHP(Combined Cooling, Heating and Power) service, energy saving renovation and energy efficiency improvement service, and operation and maintenance service.

2.1. User Portrait Analysis

2.1.1. Multidimensional energy behavior attribute vector. The multi-dimensional attribute vector of user's energy-using behavior is the core of the intelligent analysis model. The information and interactive features of user's energy-using behavior can be realized, based on the theoretical methods including load characteristics & power consumption patterns, influencing factors of user's electricity consumption behavior, user's energy-using demand and service potential,

\[ G_j = [G_{\text{mode}}, G_{\varepsilon'}, G_{\text{PQ}}, G_{\text{SAFE}}, G_{\text{multi-energy}}, G_{\text{DLC}}, G_{\text{efficiency}}, G_{\text{industry}}] \]  

In (1), \( G_{\text{mode}}, G_{\varepsilon'}, G_{\text{PQ}}, G_{\text{SAFE}}, G_{\text{multi-energy}}, G_{\text{DLC}}, G_{\text{efficiency}}, G_{\text{industry}} \) represent the user's electricity consumption mode, electricity price sensitivity degree, electricity temperature sensitivity degree, power quality improvement demand, safe operation demand, multi-energy coupling potential, adjustable/controlled load potential, energy saving demand and industry characteristics.

The normalized representation of each attribute vector is shown as follows:

\[ \tilde{G}_x = G_x \cdot \frac{1}{\max_{j \in U}G_x - \min_{j \in U}G_x} - \frac{\min_{j \in U}G_x}{\max_{j \in U}G_x - \min_{j \in U}G_x} \]  

In (2): \( \tilde{G}_x \) is the property vector after scaling, \( G_x \) is the attribute vector before scaling; \( U \) Set for users.

2.1.2. Electricity consumption mode. The k-means algorithm [8] is used to classify typical modes of electricity consumption from the time scale of year, month and day, considering the user's personalized electricity consumption data such as electricity consumption, peak power coefficient, valley power coefficient, leveling coefficient, daily maximum load, daily average load, daily load rate, daily peak-valley difference, and daily peak-valley difference:

\[ G_{\text{mode}} = [G_{\text{stationary}}, G_{\text{monotone growth}}, G_{\text{fluctuation growth}}, G_{\text{winter peak}}, G_{\text{summer peak}}, G_{\text{double peak}}, G_{\text{fluctuation}}] \]  

In (3): \( G_{\text{stationary}}, G_{\text{monotone growth}}, G_{\text{fluctuation growth}} \) represents the user j's power mode as stationary type, monotone growth type and fluctuation growth type; \( G_{\text{winter peak}}, G_{\text{summer peak}}, G_{\text{double peak}}, G_{\text{fluctuation}} \) represents the user j's monthly power mode as stationary type, winter peak type, summer peak type, double peak type and fluctuation type; \( G_{\text{stationary}}, G_{\text{monotone growth}}, G_{\text{fluctuation growth}} \) represents the user j's daily power mode as peak approaching, peak avoiding and continuous.
2.1.3. Influencing factors of electricity consumption. Elastic matrix is used to quantify the influence of temperature and price on electric quantity. After transforming the elastic matrix into single element format, a large semi-trapezoidal membership function is introduced to construct the property vector of electricity price/temperature sensitivity of electric quantity.

The property vector of sensitivity degree of electricity price is defined as follow:

\[
G_e = \begin{cases} 
0 & \text{mean}(\epsilon) < a_e \\
\frac{\text{mean}(\epsilon) - a_e}{b_e - a_e} & a_e \leq \text{mean}(\epsilon) \leq b_e \\
1 & \text{mean}(\epsilon) > b_e 
\end{cases} 
\] (4)

In(4): mean(\epsilon) is the average value of each elements in the electricity price elasticity matrix \( \epsilon \).

2.1.4. Energy demand & energy potential index. Detailed analysis of user requirements and potential is necessary, so that when making the content of the package it could be more targeted and instructor.

- Power quality improvement demand: The economic loss caused by power quality problems is clarified to measure user demand for power quality.
- Safe operation demand: the ratio of user's power failure loss caused by security problem to the maximum power failure loss is taken as the demand for each user’s safe operation.
- Multiple energy coupling potentials: The user's multiple energy coupling potentials is expressed as the various energy types and its proportion of various energy in user’s present energy consumption mode.
- Adjustable load potential: analysis and evaluation is conducted from the peak load shaving completion rate of user’s past energy data and the degree of user’s participation willingness.
- Energy saving needs: Energy consumption ratio is used to analyze and evaluate the energy saving needs of users.

2.2. Qualitative Optimization Model of IES Package

According to the difference of user portrait, the content of IES package is qualitatively analyzed in this section. In qualitative analysis, the user’s IES priority is combined with the adaptation degree matrix and the multidimensional attribute. The user’s IES priority and the method based on Apriori algorithm can help to determine the content of IES package.

Apriori algorithm\(^9\) is a representative algorithm for the association rule. It is used to analyze the data or relationship of user’s transactions and find the frequent patterns, associations or correlations that exist in the transactions. It has two laws as follow:

Law 1: If a set is a frequent itemset, then all subsets of it are frequent item sets.

Law 2: If a set is not a frequent itemset, then all its supersets are not frequent item sets.

The above two laws of the algorithm are used to help determine the optimal service package combination, so as to ensure that the package can meet the needs of customers as far as possible. The results are as follows:

\[
J=\{J_1, J_2, \ldots, J_n\} \quad (1 \leq n \leq 5, n \in \mathbb{Z}) 
\] (5)

In(5): \( J \) represents the total content of IES package; \( J_1 \) represents service 1 in IES package, \( J_2 \) represents service 2 in IES package, and so on.

3. Quantitative Analysis of IES

This section conducts a cost-utility analysis of the service to help quantitative analysis of packages. Secondly, the quantitative model of IES is established to determine the total amount of IES package, the service component and the price of IES package.
3.1. IES Cost-utility Analysis
The cost of IES consists of fixed and variable costs. Fixed costs \( \omega_j \) including labor cost \( L_1 \), office cost \( L_2 \), fixed asset depreciation cost \( L_3 \), and other fixed cost \( L_4 \); Variable costs \( \alpha_j \) varies proportionally with the service capacity. The cost of IES can be expressed as:

\[
C_{i,j}(Q_j) = \alpha_j + \omega_j
\]

\[
\alpha_j = \delta_j Q_j
\]

\[
\omega_j = L_1 + L_2 + L_3 + L_4
\]

In (8): \( \delta_j \) represents the variable cost per unit of IES.

When considering the utility of users and service providers from the perspective of economy, the user's revenue \( V_{i,j} \) is directly proportional to the capacity \( Q_j \) of each service within IES package, and the service provider's revenue \( a_j \) is related to the pricing \( \Omega_j \) of the service to some extent.

\[
V_{i,j} = Q_j r_j
\]

\[
a_j = \Omega_j - C_{i,j}(Q_j)
\]

In (9): \( r_j \) unit utility for each service.

3.2. Quantitative Model of IES
The content of IES package is designed in monthly time series to meet the diverse needs of users. Therefore, it is necessary to quantify the content of IES package from the total capacity of the package, the content of each service in the package and the price of the package\(^{[10][11]}\).

3.2.1. Total Capacity Analysis of IES Package. As for the total capacity of IES package, it is necessary to determine the target group of IES package first, so as to accurately determine the total capacity of the package and ensure its pertinency and accuracy.

As for the method of the IES package sale, the main designing revenue of service providers comes from the users who have demand for IES package. Therefore, IES package is designed for the people whose priority matches the package content. Calculate and rank users monthly power consumption by, matching the priorities with package contents, as follows:

\[
Q_1, Q_2, \ldots, Q_n
\]

\( Q_1 \) represents the user with the lowest average monthly electricity consumption. \( Q_2 \) represents the second smallest among the users.

The total capacity of the three packages \( Q_{a1}, Q_{a2}, Q_{a3} \) can be set through the principle of box diagram and the average monthly electricity consumption of each user.

3.2.2. IES Package Content and Pricing Analysis Model. The content of IES package is composed of different services. According to the purchase intention of different kinds of packages, it is determined which kinds of services in the package on the premise of user’s priority. Therefore, when considering IES package, it is necessary to design from the perspective of users and service providers.

Taking the total package amount \( Q_{a1} \) as an example, according to the qualitative analysis of IES package, the services contained in the package can be determined as \( J_1, J_2, \ldots, J_n \), \( 1 \leq n \leq 5, n \in Z \).

When purchasing the package, the total capacity \( Q_{a1} \) of the package is used as the price \( R_{i,Q_{a1}} \) of IES package to represent the user's cost. The total revenue of users is represented by the sum \( V_{i,Q_{a1}} \) of the revenue from each IES; Express the package cost by the sum \( C_{i,Q_{a1}} \) of service costs of each service in IES package; The total sales volume of IES package represents the total revenue \( A \) of the service.
However, as the gap between the package and the expectation of users, will affect the probability of users purchasing and the revenue of service providers. A model of user’s willingness to purchase the package is established, as shown below:

$$
P_{i,Q_{nl}} = \begin{cases} 
0, & Q_{nl} > \eta_{\text{max}} \cdot Q_i \\
\frac{e^{-(R_{i,Q_{nl}} - C_{i,Q_{nl}})}}{u_{i,Q_{nl}}} \cdot e^{-r_{i,Q_{nl}} \cdot K_{i,Q_{nl}}}, & (Q_{nl} \leq \eta_{\text{max}} \cdot Q_i) \cup (R_{i,Q_{nl}} < \lambda(\sum_{j} K_{i,Q_{nl,j}} \cdot r_{j})) \\
0, & (Q_{nl} \leq \eta_{\text{max}} \cdot Q_i) \cup (R_{i,Q_{nl}} \geq \lambda(\sum_{j} K_{i,Q_{nl,j}} \cdot r_{j})) 
\end{cases}\tag{11}$$

In (11), $P_{i,Q_{nl}}$ represents the probability of user $i$'s purchase intention for an IES package with capacity $Q_{nl}$; $\eta_{\text{max}}$ represents the maximum load fluctuation threshold of the user; $Q_i$ represents the average monthly electricity consumption of user $i$; $K_{i,Q_{nl}}$ represents the estimated value of the demand for service $J_n$ in proportion to the demand of user $i$ when the total demand is $Q_n$; $Q_{nl}$ represents the capacity of service $J_n$ in an IES package with total capacity $Q_n$; $R_{i,Q_{nl}}$ represents the price of IES package; $V_{i,Q_{nl}}$ represents the total economic benefits that IES package can bring to user $i$; $r_{j}$ represents the unit utility of service $J_j$; $\lambda$ represents the expected price multiplier of the user.

According to the above model, only when the total package amount is within the user load threshold and the price is lower than the user's expected price, the user will have a certain probability to buy the package. At this point, what mainly affects the purchase intention of users is the capacity of each service, the package value and the ratio of utility to cost. The closer the capacity of service $J_n$ is to the user's demand, the greater the willingness to buy the package will be. On the contrary, the less willing the user wants to buy the package. Similarly, the closer the package price is to the cost, the more willing the user will be to buy the package, whereas the less willing the user will be to buy the package.

Since there are IES packages with total capacity $Q_{n1}, Q_{n2}, Q_{n3}$. As a result, the service provider's revenue model is further improved, as shown below:

$$
A = \sum_{i} \sum_{j} \left[ (R_{i,Q_{nl}} - C_{i,Q_{nl}}) \times P_{i,Q_{nl}} \right] \\tag{12}
$$

The integrated energy package pricing strategy is: under the IES’s package capacity and its value satisfying the demands of users can use as much as possible, confirm the package within each service capacity and the package price to ensure that the service provider to gain maximum profits, according to the following:

$$
\arg \max_{R_{i,Q_{nl}}, Q_{nl}} A \tag{13}
$$

4. The Example Simulation

Through the multi-dimensional analysis of users, the results of multi-dimensional attribute vector calculation of users combine with Delphi method to form the adapting degrees, which includes the five services adapting to different degrees such as monthly electricity mode, daily electricity mode, and electricity price sensitivity degree et. Fuzzy synthesis of the user's multi-dimensional attribute vector calculation results. The results are shown in Figure 1 after the priority screening.
The method based on Apriori algorithm is applied to mining association rules for user service vector priority. The support degree of each frequent item set can be obtained as shown in Table 1.

**Table 1. Support for each frequent item set.**

| Frequent itemsets | 1,2 | 1,3 | 1,4 | 1,5 | 2,3 | 2,4 | 3,4 | 4,5 | 1,2,4 | 1,3,4 | 1,4,5 |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|
| Support           | 5   | 3   | 17  | 9   | 2   | 4   | 6   | 7   | 2     | 3     | 7     |

According to Table 1, power substitution service, energy saving renovation and energy efficiency improvement service are determined as the service contents of IES package, which completes the qualitative analysis. Then, based on the analysis of the total capacity in Section 2.2, the users with service 1 and 4 among the top three service priorities among the 36 users are selected, represented as $I'$. Take their average monthly electricity consumption, round it to a whole number, and rank them from small to large, as shown in Table 2 below:

**Table 2. The average monthly electricity consumption of the package users (MW·h).**

| User | 36 | 16 | 26 | 30 | 5 | 20 | 31 | 1 | 2 |
|------|----|----|----|----|---|----|----|---|---|
| The average monthly electricity consumption | 20 | 25 | 57 | 61 | 124 | 157 | 181 | 204 | 208 |
| User | 24 | 18 | 3 | 11 | 10 | 23 | 13 | 9 |
| The average monthly electricity consumption | 256 | 469 | 949 | 956 | 1048 | 1818 | 2595 | 17955 |

According to the principle of box diagram in section 2.2, three levels of package can be set, one lower quartile, one median and one upper quartile. The total capacity of package can be set to 60,200 and 1000 (MW·h). Therefore, the total capacity of the package is 60 (MW·h) for example. By combining with formula (9), the revenue of user I can be determined as follows:

$$ V_{60} = V_{i,j_1} + V_{i,j_4} = Q_{j_1} r_1 + Q_{j_4} r_4 $$

(14)

In (14), $Q_{j_n}$ represents the service n’s capacity; $r_n$ represents the unit utility of the service n.

In combination with (6),(7),(8), package costs can be shown as follows:
\[ C_{\text{I},60} = C_{\text{I},60}(Q_{\text{I}}) + C_{\text{I},60}(Q_{\text{I}}) = \delta Q_{\text{I},60} + \delta Q_{\text{I},60} + L_1 + L_2 + L_3 + L_4 \]  

(15)

In (15), \( \delta \) represents the unit variable cost of the service \( n \).

The maximum fluctuation threshold of user load is set as 1.5. The user's expected price multiplier is set as 0.9. And calculate the demand for power substitution service through the demand scale. Combined with the formula (11), the probability model of user's purchase intention can be written as:

\[ P_{\text{I},60} = 0.60 > \eta_{\text{max}}Q_{\text{I}} \]

\[ P_{\text{I},60} = e^{\frac{1}{\nu_{\text{I},60} - C_{\text{I},60}}} \times e^{\frac{1}{\nu_{\text{I},60} - R_{\text{I},60}}} \times (60 \leq \eta_{\text{max}}Q_{\text{I}} \cup (R_{\text{I},60} < \lambda(\sum_{j} K_{\text{I},60,j} \cdot r_{j}))) \]

(16)

In the formula, \( K_{\text{I},60,j} \) can calculate the relevant data in the user service vector result, as shown below:

\[ K_{\text{I},60,j} = Q_{\text{I}} \times \frac{T_{\text{I},j}}{T_{\text{I},j} + T_{\text{I},j}} = 60 \times \frac{T_{\text{I},j}}{T_{\text{I},j} + T_{\text{I},j}} \]

(17)

In (17), \( T_{\text{I},j} \) represents the vector result of user I's service \( n \).

Therefore, after the probability of user’s purchase intention confirmed, the pricing capacity model can be sorted out and simplified with constraints, and can be expressed as:

\[ \arg \max_{R_{\text{I},60}, T_{\text{I},j}} \ A = \sum_{i \in I, I = \{1,2,3,5,9,\ldots,30,36\}} [(R_{\text{I},60} - C_{\text{I},60}) \times P_{\text{I},60}] \]

(18)

\[ \text{s.t.} \quad C_{\text{I},60} < R_{\text{I},60} < V_{\text{I},60} \quad R_{\text{I},60} \in Z \]

\[ 0 \leq Q_{\text{I}} \leq 60, \quad Q_{\text{I}} \in Z \]

\[ 0 \leq Q_{\text{I}} \leq 60, \quad Q_{\text{I}} \in Z \]

(19)

Considering that the price of the above model and the computable quantity of each capacity are not very large, there is no combinatorial explosion problem. Therefore, it can be solved by means of exhaustive method or traversal method. MATLAB is used to implement it.

In the calculation, \( \delta_1 \) is equal to 5; \( \delta_1 \) is equal to 3; \( T_1 \) is equal to 12; \( T_4 \) is taken as 8 (the above units are all thousand yuan /MW · h); \( L_1, L_2, L_3, L_4 \) is equal to 20 (thousands).

Through this calculation, the optimal price solution and the optimal service capacity composition solution of IES package with a total capacity of 60MW · h can be obtained. Similarly, the optimal price solution and the optimal service capacity component solution for the total capacity of 200MW · h and 1000MW · h can also be obtained by the same method, as shown in the following table:

**Table 3.** Each package service composition and service provider revenue.

| Total package capacity (MW·h) | Electric alternative service capacity (MW·h) | Energy saving renovation service capacity (MW·h) | Total revenue of service provider in 3 years (thousand) | Package price (thousand) |
|-----------------------------|---------------------------------------------|-----------------------------------------------|-------------------------------------------------|-------------------------|
| 60                          | 37                                          | 23                                           | 924.7                                          | 410                     |
| 200                         | 100                                         | 100                                          | 2588.3                                         | 1272                    |
| 1000                        | 474                                         | 526                                          | 6426.7                                         | 6251                    |
The user return rate is represented by the ratio of user utility and package price, and the service provider return rate is represented by the ratio of total package utility and package cost. The calculated results of each package are expressed in the form of a bar chart as follows:

![Yield comparison](image)

**Figure 2.** Yield comparison.

It can be seen from the horizontal comparison that, compared with users, package 3 can bring users the highest return rate of 158.3%. Similarly, compared with service providers, IES with a total amount of 60MW·h with package 1 can bring the service providers the highest return rate of 161.4%. In vertical comparison, the rate of return obtained by service providers from plan 1,2 is higher than that of users, while the rate of return obtained from plan 3 is slightly lower than that of users. In general, both users and service providers can get certain benefits from the package, and bundle sales of IES with the package model has good operational value and prospect. And it can be seen from the model that the sales price of IES package must be lower than the sum of the separately purchased services.

**5. Conclusion**

With the renewal of various renewable energy technologies and the emergence of various energy-saving measures, IES have been constantly promoted worldwide, which directly affects the sales form of IES. The promotion and marketing of IES have also been constantly innovated and changed. Based on user portrait technology, cost-benefit analysis and user willingness model, this paper made qualitative and quantitative analysis of packages, and the main conclusions are as follows:

1. A comprehensive description of the users in terms of their electricity usage patterns are analyzed, influencing factors and potential demand for electricity. The results show that user portrait technology can make the connection between the users and the package closer, as well as enhance the user stickiness and the market competitiveness of the package.

2. In the example of this paper, the data information of 36 users in a certain region are used to design the package, and the results verify that the IES sold in the form of package could bring certain benefits to both users and service providers.

3. Load threshold factors, price factors and package content factors all have a certain impact on user’s intention to buy packages. According to the simulation results in this paper, a reasonable evaluation of user’s intention can ensure that the results are closer to the reality.

4. For this kind of bundled sales model, user’s satisfaction with the service will be improved to some extent, while energy service providers can broaden the way to make profits of IES. It is suggested that in the improvement of the power market, the use of this effective method should be considered to strengthen the flexibility of the power market. In the further research of the power market, IES package optimization method proposed in this paper can be taken as a reference to study more practical and useful sales models.

**Acknowledgment**

The authors would like to highly appreciate the financial support provided by the science and technology project 52199619000J of State Grid Sichuan Electric Power Company.
References

[1] Feng Hongli, Gong Xundong. Experiences from the development of integrated energy service market in the park [J]. Energy, 2020(Z1): 82-85.

[2] F. Tang, H. Dai, X. Chen, Y. Zhao, Z. Sun and N. Zhang, "Economic Analysis of Emerging Integrated Energy Service Market in China: A Theoretical View," 2018 2nd IEEE Conference on Energy Internet and Energy System Integration (EI2), Beijing, 2018, pp. 1-9.

[3] Cong Xiaohan, Su Huiling, Li Haisi, Wang Beibei. Research on intelligent electricity package based on deep mining and demand response [J]. Power Demand Side Management, 2019, 21(05): 21-25.

[4] Wang Zhengyou, Zhang Haidi. Accurate video recommendation based on user portraits in the era of big data [J]. Electronic Commerce, 2019(10): 62-65.

[5] Hou Jiaxuan, Lin Zhenzhi, Yang Li, Ding Yi, Luan Kaining, Yang Bin. Design of Electricity Plans for Industrial and Commercial Customers Oriented to Active Demand Response on Power Demand Side [J]. Automation of Electric Power Systems, 2018, 42(24): 11-21.

[6] Jun Dong, Guiyuan Xue, Xu Li. Value Evaluation of Integrated Energy Services Based on Balanced Scorecard [P]. Proceedings of the 2016 International Conference on Humanities and Social Science, 2016.

[7] Liu Guangrong, Ren Jiantao. Accurate recommendation based on customer profile [J]. Science & Technology Economic Guide, 2016(35): 22+78.

[8] Li Bing, Wang Yue, Liu Yongxiang. Application of User Portrait and Intelligent Recommendation Based on Big Data Technology and K-means [J]. Modern Computer (Professional Edition), 2016(24): 11-15.

[9] Yin Rui, GUO Jiangtao, Wang Xiaolei, Wang Tianjun, Pan Jianli. Design of Association Rules Mining Algorithm for Smart Grid [J]. Application of microcomputer, 2020, 36(05): 85-88.

[10] Wu Jinghui, Zhang Jie, Pan Shuyan, etc. Standard Retail Tariff Design Based on Customer Clustering in Electricity Spot Market [J]. Price Theory and Practice, 2019, (12): 132-136. DOI: 10.19851/j.cnki.CN11-1010/F.2019.12.039.

[11] Yang Yongchun, Mu Qitian, Gao Yajing, et al. Design of Power Supply Service Plan for Electric Company Considering Harmonic Management [J]. Electric Power Construction, 2018, 39(7): 32-40. DOI: 10.3969/j.issn.1000-7229.2018.07.004.