Research and Application of Rural Revitalization Active Power Index Construction Based on Analytic Hierarchy Process

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Abstract. Based on the relevant planning requirements of the government and power companies on rural revitalization, combined with the basic data of electric power marketing, this paper refines and forms the evaluation system of the rural revitalization vitality power index, and uses the analytic hierarchy process to quantify the evaluation indicators of the rural revitalization vitality power index, and obtains the rural revitalization dynamic power index evaluation model. Based on this model, the rural revitalization vitality power index platform is designed and developed, which can calculate the rural revitalization vitality of streets and towns in the area in real time, providing important technical support for the implementation of the rural revitalization strategy of government departments.

Keywords: Rural Revitalization; Analytic Hierarchy Process; Power Index Evaluation System; Vitality Index Platform

1 Introduction

Cities and villages are an organism, and only when they are sustainable can they support each other. Therefore, the comprehensive implementation of Rural Revitalization is a major strategy to promote urban-rural integration [1-3]. Under the new situation and new requirements of Promoting Rural Revitalization in an all-round way, it is imperative for rural development to implement the Rural Revitalization Strategy. However, there is an imbalance in the development of rural areas in China. Therefore, it is particularly important to adapt measures to local conditions and formulate different Rural Revitalization policies, of which the current situation evaluation on the indicator system is the basis [2, 4, 5]. Although some industries have studied the corresponding Rural Revitalization system based on their own reality, at present, the power industry has not carried out the corresponding evaluation system research for rural revitalization, which can not give full play to the value of power data [2-8].

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Based on the existing relevant basic data of power marketing, State Grid Zhejiang company gives full play to the advantages of real-time, accuracy and wide distribution of power data, and takes the power consumption as the starting point, analyzes the current situation and development trend of regional infrastructure construction, production investment, residents' living standards, etc. by mining the rural power consumption structure and power services, and builds a Rural Revitalization power index system, Build an electric power index platform for rural revitalization, comprehensively reflect the vitality of Rural Revitalization from the perspective of industrial prosperity, ecological livability and affluence, assist the government in formulating Rural Revitalization policies, and accurately measure the policy effects.

2 Introduction to Analytic Hierarchy Process

Analytic hierarchy process (AHP), as a comprehensive evaluation method combining qualitative and quantitative analysis methods, has been widely used in many fields [8]. Analytic hierarchy process (AHP) aims to express people's subjective decisions in a numerical and written way, so as to strengthen the theoretical persuasiveness of decision-making problems in the form of mathematical formulas. It is mainly based on the social problems that require decision-making. By analyzing the factors that have an impact on the results, the influencing factors of the decision-making problems are compared with each other through systematic and simple analysis steps. Then we can get the ranking of the degree of influence, and combine the perception standards of experts and other authorities to finally get the weight of each influence factor [8-13].

In order to quantify the relevant evaluation indicators of the Rural Revitalization vitality power index and ensure the objective and fair evaluation results, the system uses the tomography analysis method based on the weight idea to weight each evaluation factor, formulate the corresponding scoring standard and weight coefficient, obtain the scoring standard of the Rural Revitalization vitality power index, and scientifically and objectively evaluate the rural electrification level. The low-carbon level of energy consumption and the quality level of energy efficiency services. The specific ideas and steps of AHP are as follows:

2.1 Construct judgment matrix

After the hierarchy model is established, the relative importance of each factor in each hierarchy should be judged first, and the decision judgment should be quantified by introducing appropriate scales to form a judgment matrix, as shown in Table 1.

Table 1. Form of judgment matrix.

A_k	B_1	A_k	···	B_n
B_1	b_{11}	b_{12}	···	b_{1n}
A_k	b_{21}	b_{22}	···	b_{2n}
···	···	···		···
B_n	b_{n1}	b_{n2}	···	b_{nn}

The judgment matrix describes the comparison of the importance of the factors at the current level affecting a factor at the previous level to the factors at the previous level. As shown in Table 1, the relationship between the factors B1, B2, ……, Bn at the current level B and the factors Ak at the previous level a is reflected, Generally, the scale method of 1-9 and its reciprocal shown in Table 2 is used to compare two by two to obtain the values of matrix elements that can reflect the relative importance of each factor.

Table 2. Meaning of the scale method of 1-9.

Scale	Meaning and description
1	Equally important
3	Slightly important
5	Obviously important
7	Strongly important
9	Extremely important
2, 4, 6, 8	Intermediate value of adjacent judgment

2.2 Hierarchical sorting

The main task of hierarchical ranking is to rank the relative importance of all factors in this level to the previous level. It is necessary to calculate the weight according to the judgment matrix. The main methods are power method, square root method and sum product method. The square root method is mainly divided into the following steps:

- Find the product of each row element of the judgment matrix:

$$M_i = \prod_{j=1}^{n} b_{ij}, \text{i=1, 2, …, n} \tag{1}$$

- Calculate the n-th root of the product of elements in each row:

$$W_i' = \sqrt[n]{M_i} \tag{2}$$

- Normalize:

$$W_i = \frac{w_i'}{\sum_{j=1}^{n} w_i'} \tag{3}$$

Then W=[w_1, w_2, …, w_n] is the obtained eigenvector, that is, the weight of each factor.

2.3 Calculate the maximum eigenvalue of the judgment matrix λ_{max} and consistency test

In the decision-making process, it is inevitable that the judgment of the actual situation deviates from the judgment of the ideal state, that is, it is impossible to ensure the complete consistency of the judgment. In order to obtain a more scientific and reasonable conclusion when using the analytic hierarchy process to study the problem, it is necessary to use the characteristic root of the judgment matrix to test the consistency of the judgment. The consistency index can be obtained from formula (4):

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{4}$$

Where: λmax represents the maximum characteristic root of the judgment matrix, which can be obtained by the following formula:

$$\lambda_{max}=\sum_{i=1}^{n}\frac{(AW)_i}{nW_i} \tag{5}$$

The consistency check of decision-making judgment shall include the random consistency ratio CR in addition to the consistency index to check whether the judgment has satisfactory consistency, which can be expressed by formula (6):

$$CR=CI/RI \tag{6}$$

Wherein, RI refers to the average random consistency index value corresponding to the judgment matrix of different orders. The RI value is shown in Table 3:

Table 3. RI values corresponding to different orders.

1	2	3	4	5	6	7	8	9
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When CR < 0.1, it indicates that the judgment matrix has satisfactory consistency; if not, it indicates that the actual judgment deviates greatly from the ideal judgment, and the judgment matrix needs to be adjusted or reformed until the decision judgment has satisfactory and acceptable consistency.

3 Research on construction of electric power index model for Rural Revitalization

In the context of China's Current Rural Revitalization Strategy, the study of Rural Revitalization evaluation indicators and models is of great significance to scientifically measure the level of Rural Revitalization and development, as well as to monitor and correct the development level of rural revitalization, and has a positive role in promoting the smooth implementation of the Rural Revitalization Strategy [3].

3.1 Construction of electric power index evaluation system for Rural Revitalization

The national strategy for Rural Revitalization puts forward the requirements of five aspects: industrial prosperity, ecological livability, civilized rural style, effective governance and rich life [4]. Rural Revitalization vitality power index is a comprehensive index reflecting Rural Revitalization. It is composed of three subindexes: Rural re electrification index, energy consumption low-carbon index and energy efficiency service quality index, which respectively represent the industrial prosperity, ecological livability and living affluence of Rural Revitalization. At the same time, in order to realize the effective evaluation of the three first-class evaluation indicators of industrial prosperity, ecological livability and living prosperity, the second-class evaluation indicators of the three first-class evaluation indicators are constructed based on the basic data of marketing power. Among them, the industrial prosperity includes two secondary evaluation indicators, namely, the average household electricity of rural residents and the average household electricity of general industrial and commercial users; Ecological livability includes four secondary evaluation indicators, namely, the level of existing photovoltaic power generation, the level of rural power generation, the level of hydropower plants and the level of hydropower generation; Living affluence includes three secondary evaluation indicators: power consumption level, residential power consumption intensity and rural resident occupancy rate, as shown in Figure 1.

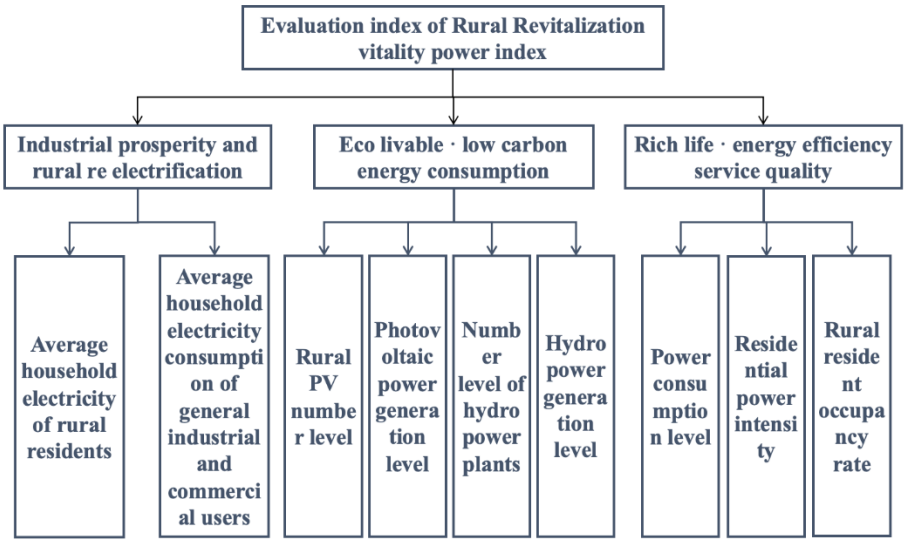

Fig. 1. Evaluation index of Rural Revitalization vitality power index.

In order to achieve operability, the calculation method of the refined secondary indicators is described in detail based on the basic marketing data, as shown in Table 4.

The calculation method of each indicator is as follows:

- Rural Revitalization vitality power index = Rural re electrification index * A + Energy consumption low carbon index * B + Energy efficiency service quality index * C;
- Rural re electrification index = Average power consumption of rural households * A1 + Low carbon index of energy consumption * A2;
- Low carbon energy consumption = Rural photovoltaic number level * B1 + Photovoltaic power generation level * B2 + Hydropower plant number level * B3 + Hydropower power generation level * B4
- Energy efficiency service quality index = Power consumption level * C1 + Residential power consumption intensity * C2 + Rural resident occupancy rate * C3

Table 4. Index system of electric power Rural Revitalization vitality.

Level I indicator	weight	Secondary indicators	Sub weight	Calculation formula and description of secondary indicators
Industrial prosperity and rural re electrification	A	Average household electricity of rural residents	A1	Electricity consumption of rural residents / number of rural residents
		Average household electricity consumption of general industrial and commercial users	A2	Electricity consumption of rural general industrial and commercial users / number of general industrial and commercial users
Eco livable · low carbon energy consumption	B	Rural PV number level	B1	Rural PV number / provincial average rural PV number
		Photovoltaic power generation level	B1	Rural photovoltaic power generation / provincial average rural photovoltaic power generation
		Number level of hydropower plants	B1	Number of rural hydropower plants / average number of rural hydropower plants in the province
		Hydropower generation level	B1	Rural hydropower generation / average hydropower generation in rural areas of the province
Rich life · energy efficiency service quality	C	Power consumption level	C1	Current electricity consumption / electricity consumption in the same period last year * 40% + current electricity charge / electricity charge in the same period last year * 40% + current number of users / number of users in the same period last year * 20%
		Residential power intensity	C2	Average household electricity consumption / average rural household electricity consumption in the province
		Rural resident occupancy rate	C3	Residential rate of rural residents = residential users in the current month / total users in the current month. Residential users are defined as users whose electricity consumption in the current month is greater than or equal to 15 degrees

3.2 Index weight analysis of evaluation system based on AHP

Based on the above, the judgment matrix formed by each level-1 evaluation index is constructed by AHP according to Table 1. The results are shown in Table 5:

Table 5. Index system and evaluation index comparison matrix of electric power Rural Revitalization vitality.

evaluating indicator	Eco livable · low carbon energy consumption	Rich life · energy efficiency service quality	weight
Industrial prosperity and rural re electrification	9	1/3	**37.42%**
Eco livable · low carbon energy consumption	1	1/3	**8.62%**
Rich life · energy efficiency service quality	3	1	**53.96%**

According to the judgment matrix constructed in Table 5, the analytic hierarchy process is applied for calculation and analysis, $\lambda max = 3.03$, and then calculate CI and RI according to formula (4) and formula (6):

$$CI=\lambda max\text{-}nn\text{-}1=3.03\text{-}33\text{-}1=0.015<0.1 \tag{7}$$

$$RI=CI/RI=0.015/0.58=0.026<0.1 \tag{8}$$

The two meet the consistency check and have satisfactory consistency. Therefore, the weights of rural re electrification, low-carbon energy consumption and energy efficiency service quality are calculated to be 37.42%, 8.62% and 53.96% respectively.

Similarly, the sub weights of the secondary indicators of rural re electrification, low-carbon energy consumption and energy efficiency service quality are calculated respectively. By constructing the judgment matrix of each evaluation index, calculating their respective maximum eigenvalues, and calculating their respective CI and RI, the results meet the consistency check and have satisfactory consistency. Through the above calculation and analysis, the index model of electric power Rural Revitalization vitality index is finally obtained as shown in Table 6.

After the weight of each evaluation index is calculated, the calculation formula of each index proposed above is as follows:

- Rural Revitalization vitality power index = Rural re electrification index * 37.42% + Energy consumption low-carbon index * 8.62% + Energy efficiency service quality index * 53.96%;
- Rural re electrification index = Average power consumption of rural households * 50% + Low carbon index of energy consumption * 50%;
- Low carbon energy consumption = Rural PV number level * 31.36% + PV power generation level * 31.36% + Hydropower plant number level * 18.64% + Hydropower power generation level * 18.64%

- Energy efficiency service quality index = Power consumption level * 41.26% + Resident power consumption intensity * 32.75% + Rural resident occupancy rate * 25.99%

Table 6. index system of electric power Rural Revitalization vitality.

Level I indicator	weight	Secondary indicators	Subweight	Comprehensive weight
Industrial prosperity and rural re electrification	**37.42%**	Average household electricity of rural residents	50%	**18.71%**
		Average household electricity consumption of general industrial and commercial users	50%	**18.71%**
Eco livable • low carbon energy consumption	**8.62%**	Rural PV number level	31.36%	**2.70%**
		Photovoltaic power generation level	31.36%	**2.70%**
		Number level of hydropower plants	18.64%	**1.61%**
		Hydropower generation level	18.64%	**1.61%**
Rich life • energy efficiency service quality	**53.96%**	Power consumption level	41.26%	**22.26%**
		Residential power intensity	32.75%	**17.67%**
		Rural resident occupancy rate	25.99%	**14.02%**

4 Application practice

The Rural Revitalization Strategy is of great significance to shorten the gap between cities and towns and solve the imbalance of development between different regions [5]. Based on the power and electricity data, this paper innovates and develops the Rural Revitalization vitality power index system, combines data source integration, theme components and visual design technology, builds a Rural Revitalization vitality power index platform, and takes Longquan as a pilot to promote the new urbanization of Rural Revitalization and constantly optimize the urban and rural regional development pattern.

4.1 Building a Rural Revitalization vitality index platform

As shown in Figure 2, based on the Rural Revitalization vitality index model proposed in this paper, the Rural Revitalization vitality index platform is designed and developed. Taking Longquan City, Zhejiang Province as a pilot, the platform comprehensively displays the Rural Revitalization vitality index of streets and townships in the region. At the same time, based on the proposed evaluation model. The current situation of rural revitalization construction is comprehensively displayed in the five dimensions of rural wind civilization, Lidian sunshine public welfare and life affluence and energy efficiency service quality, which provides an intuitive visual display mode for power enterprises and government departments, and provides important auxiliary support for their implementation of relevant national policies on Rural Revitalization.

Fig. 2. Rural Revitalization vitality index platform.

4.2 Application

Based on the Rural Revitalization vitality index platform, the stage differences and regional differences in the implementation process of Rural Revitalization are reflected in different indicator dimensions of time and region, as shown in Fig. 3 and Fig. 4, and the evaluation results are formed. At the same time, the evaluation results are synchronously transmitted to the relevant government departments to assist the government to formulate differentiated policies according to the current situation of regional imbalance and assist the Rural Revitalization Strategy.

4.2.1. Evaluation results of Rural Revitalization vitality power index.

In March 2021, the city's Rural Revitalization power index was 70.5, a slight decrease of 0.4% year-on-year. Overall, the Rural Revitalization vitality power index shows a steady growth trend, and the results are as follows:

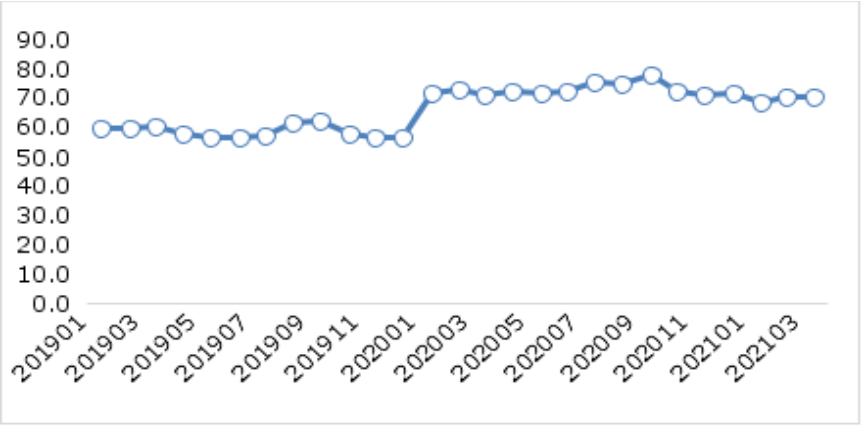

Fig. 3. Electric power index of Urban Rural Revitalization from January 2019 to March 2021.

4.2.2. Evaluation results of electric power index for revitalization of towns, streets and villages.

Based on this calculation model, calculate the Rural Revitalization vitality power index of each sub district and Township under its jurisdiction. The results are as follows:

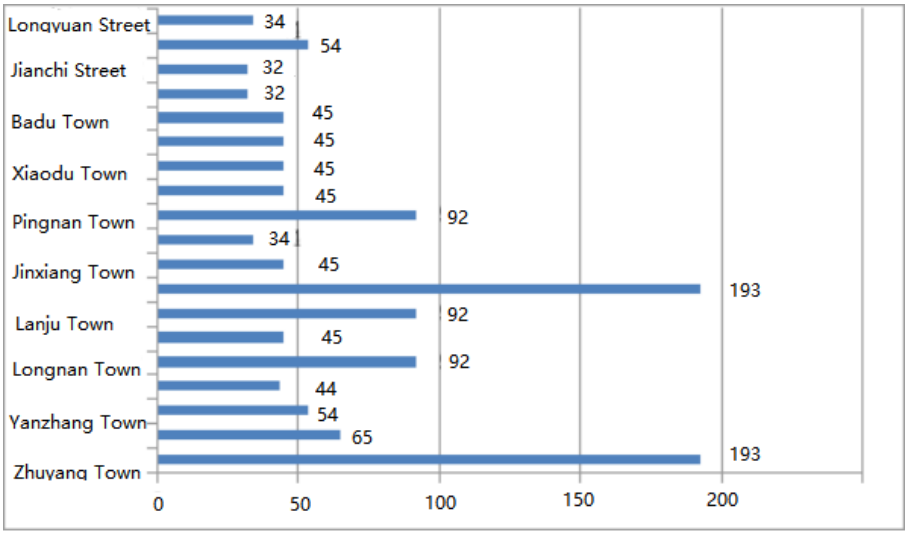

Fig. 4. Calculation results of revitalization vitality index of townships, streets and villages in the city in March 2021.

5 Conclusion

This paper focuses on the theme of rural revitalization, builds a Rural Revitalization vitality index system in combination with power big data, develops a Rural Revitalization vitality index model by using analytic hierarchy process, develops a Rural Revitalization vitality index platform, and makes a big data picture of rural areas from the perspective of power, which intuitively confirms the prosperity of rural industries, It clearly describes the low-carbon and ecological livable conditions of rural energy consumption, and shows the affluence of rural life in contemporary China in real time. At the same time, the results will be transmitted to relevant government departments to increase the government's intuitive understanding of the level and gap of rural revitalization, and provide decision support for the government to strengthen the overall planning of urban and rural development, build a beautiful village and realize the integrated development of rural industries.

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