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Energy saving of Railroad analysis based on cobweb area grey target decision-making model

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Abstract.As an important infrastructural facility, the energy consumption of the railroad during the built is the main part among the overall process. There have not the criteria to evaluate the contractors on saving energy during building the railroad. A system of saving energy， concluding four main indicators and eleven derivatives, is built for the building of the railroad due to the domestic and international research. Ensuring the weight of every indicator by the method of AHP and computing the areas which are surrounded by the connections between each index value of the index set and the bull's-eye. the paper evaluates the pros and cons of the LAN XIN Railroad with five parts by the panel with five people, they set the index's value on five-point scale. The result of the ranking of five parts illustrate the value of the model.

Introduction

As China is commitment to the road of ongoing development, considerable theoretical efforts have been put into the energy saving of some phases of railway. Early research focused primarily on energy saving of the railway operations ,there have been few studies of energy saving in railway construction. Zhou xinjun[1] confirms that the railway vehicles cost less energy than any other transports which is conducted by the thought that railway cost electricity nor oil; Based on the characteristic of the life cycle energy consumption of and greenhouse gas commissions from the passenger transport of the high speed train have been provided by Feng xu[2]which presents an analysis frame and measuring approach to access the energy consumption and greenhouse gas due to the infrastructure construction of the high-speed rail. An evaluation system of green construction of building engineering based on variable fuzzy set theory was established by Xu wei[3], there are some similarities in the energy saving system between building and railway engineering. As different instruments and construction technologies are implemented in the two engineering, the energy saving system of railway is not the same as the building engineering' s.

According to the main sectors of energy consumption, energy consumption index given by experts in railway, associate with some relevant researches in saving energy of railway from domestic and abroad, a new analysis system of energy saving is built in the text. Four firs grade indexes, six secondary indexes and eleven three level indexes. Make assessment on the five parts of Lanzhou-Xinjiang railway through experts marking them on the principle that the total is five. The

gray-scale decision model based on the cobweb area can weaken the influence of the extreme index, and the objectivity of the expert scoring method is weakened, so that the result is almost whitened. According to the energy saving evaluation index system established in the railway construction stage, combined with the decision model based on the cobweb area, it provides a reference for the evaluation mechanism of the energy saving effect in the railway construction stage. as a new method to analysis the energy system is, therefore, important to evaluate the energy saving of railway in construction phase.

The constitution of the analysis index system and the firm of the index's weight

The constitution of the analysis index system. In the Evaluation standard for green construction of building engineering (GB/T 50640-2010),the energy saving system as Fig.1.

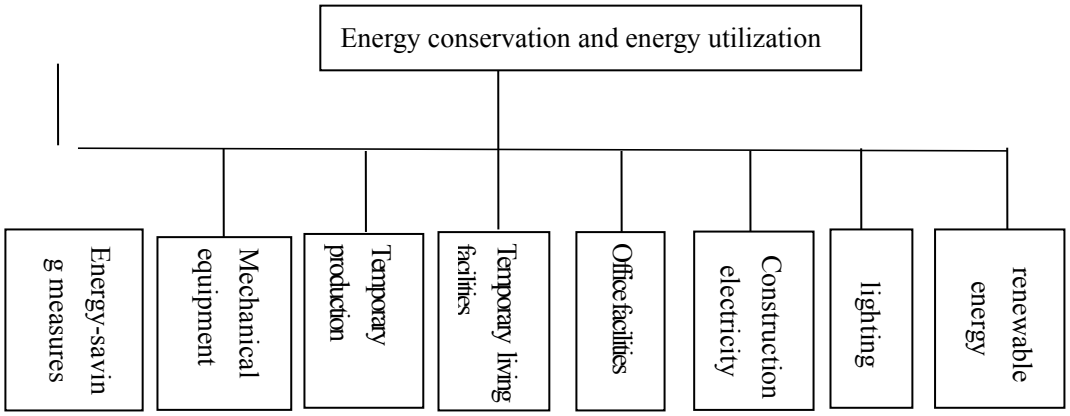

Fig1.The frame of energy saving system of housing construction

From the Fig1, the divisions of the system is separated, some can be merged, such as temporary facilities in living area and office area. According to the main energy consumption in the process of railway construction, the standard will be part of the energy-saving production area is divided into energy-saving, energy-saving office area, it will be very intuitive understanding of the production and life of the office of the two parts of the proportion of energy consumption, which can be targeted to take energy-saving measures; and because the production and life of office area lighting energy consumption and temporary electricity demand, so the temporary use of electricity and lighting this one as a separate set of new energy utilization; this is a response to the National Energy Bureau of the development of "renewable energy development" 12th Five-Year "plan" put forward "increase of renewable energy in the proportion of energy consumption. The general goal, encourage enterprises to make use of new energy unit. Specific framework is as follows:

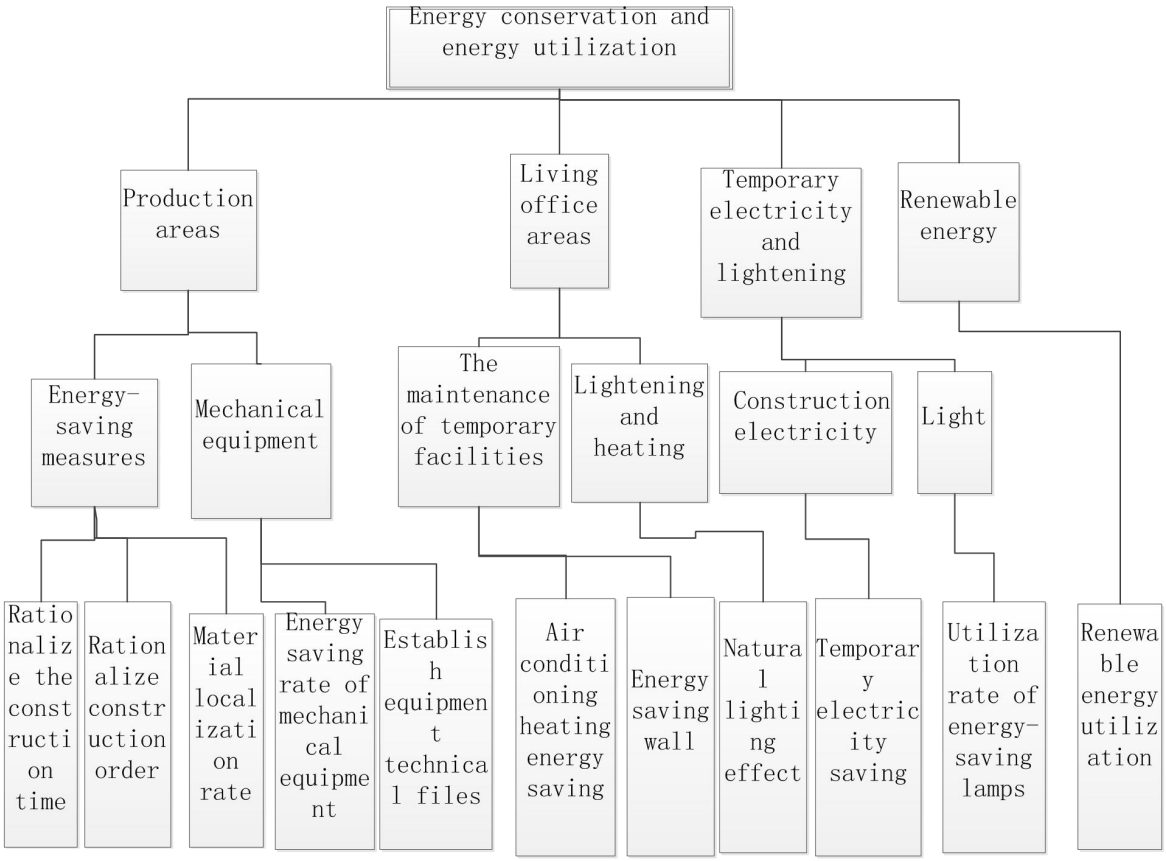

Fig.2.The frame of energy saving system of railway construction

There are two methods to determine the weights, which are the subjective weighting method and the objective weighting method. Because of the subjective weighting method to determine the existence of a certain subjective randomness by expert consultation and analysis, can not guarantee the objectivity of index weight; objective weighting method depends on the existing data, can not reflect the people of different preference index. The determination of the weight of the railway energy efficiency evaluation should consider both the weight of the existing railway energy saving index and the preference of the index weight. Finally, the analytic hierarchy process is used to determine the weight. Using nine degree method to determine the relationship between the indicators, with the MATLABA software to calculate the weight of the final table as shown in table 1.

Table.1 The weight of every energy index of railway

index	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11
weight	0.13	0.14	0.08	0.05	0.08	0.10	0.13	0.05	0.09	0.09	0.08

cobweb area model

The theory of grey target decision-making

Grey target decision is a region with satisfactory effect in the relative optimization. Gray target decision can gradually shrink, and finally become a bit, that is, the optimal results, the corresponding decision for the optimal decision.

The index of energy saving system

（1）Set up n evaluation of the construction of multi index comprehensive evaluation of the formation of the program set $S=(S_1,S_2,\cdots,S_n)$; index set $H=(H_1,H_2,\cdots,H_m)$, the I_j score of the S_i is the interval grey number $\otimes(t_{ij})\in[\underline{x_{ij}},\overline{x_{ij}}]$, $i=1,2,\cdots,n;\ j=1,2,\cdots,m$, corresponding to $\otimes(t_{ij})$ the whitened weight function is $f^{(ij)}(x)$, Then the decision matrix X and S of the whitening weight function matrix Y

$$X=\begin{bmatrix} [\underline{x_{11}},\overline{x_{11}}] & [\underline{x_{12}},\overline{x_{12}}] & \cdots & [\underline{x_{1m}},\overline{x_{1m}}] \\ [\underline{x_{21}},\overline{x_{21}}] & [\underline{x_{22}},\overline{x_{22}}] & \cdots & [\underline{x_{2m}},\overline{x_{2m}}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{x_{n1}},\overline{x_{n1}}] & [\underline{x_{n2}},\overline{x_{n2}}] & \cdots & [\underline{x_{nm}},\overline{x_{nm}}] \end{bmatrix}$$

$$Y=\begin{bmatrix} f^{(11)}(x) & f^{(12)}(x) & \cdots & f^{(1m)}(x) \\ f^{(21)}(x) & f^{(22)}(x) & \cdots & f^{(2m)}(x) \\ \vdots & \vdots & \ddots & \vdots \\ f^{(n1)}(x) & f^{(n2)}(x) & \cdots & f^{(nm)}(x) \end{bmatrix}$$

According to the calculation method of interval grey number nuclear Whitenazition function under known conditions, and the decision matrix of the X samples and the whitenization weight function matrix Y, can calculate the scheme set S on the index set of H decision sample kernel matrix Z， Z＝f(X,Y)。

$$Z=\begin{bmatrix} \tilde{\otimes}(t_{11}) & \tilde{\otimes}(t_{12}) & \cdots & \tilde{\otimes}(t_{1m}) \\ \tilde{\otimes}(t_{21`}) & \tilde{\otimes}(t_{22}) & \cdots & \tilde{\otimes}(t_{2m}) \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\otimes}(t_{n1}) & \tilde{\otimes}(t_{n2}) & \cdots & \tilde{\otimes}(t_{nm}) \end{bmatrix}$$

（1）Uniform effect measure matrix

The value of the kernel matrix is limited in the range of [0,1], which can be used to directly compare the merits of different evaluation schemes. The index set H is divided into three types: benefit type, cost type, fixed type.

$$r_{ij} = \frac{\tilde{\otimes}(t_{ij})}{\max_i \max_j \{\tilde{\otimes}(t_{ij})\}} . \quad \text{benefit type} \quad . \qquad (1)$$

$$r_{ij} = \frac{\min_i \min_j \{\tilde{\otimes}(t_{ij})\}}{\tilde{\otimes}(t_{ij})} . \quad \text{cost type} \qquad (2)$$

$$r_{ij} = \frac{P}{P + \left|\tilde{\otimes}(t_{ij}) - P\right|} \quad . \quad \text{fixed type} \qquad (3)$$

notes：P is a moderate value.

By processing the index value of matrix Z, the matrix is obtained

$$Z' = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

The weight of index is obtained by the combination weighting method, $W = (w_1, w_2, \cdots, w_m), w_j \rangle 0, j = 1,2,\cdots,m, \sum_{j=1}^{m} w_j = 1,$ The weighted index value matrix Z''is

$$Z'' = \begin{bmatrix} \omega_1 r_{11} & \omega_2 r_{12} & \cdots & \omega_m r_{1m} \\ \omega_1 r_{21} & \omega_2 r_{22} & \cdots & \omega_m r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \omega_1 r_{n1} & \omega_2 r_{n2} & \cdots & \omega_m r_{nm} \end{bmatrix}$$

Calculate the final comprehensive evaluation value of each construction section v_i ,

$$v_i = \frac{1}{2}(\sin\frac{360}{m})\sum_{m=2}^{m}(\omega_{m-1} r_{i,m-1} - \omega_{m-1} o_{m-1})(\omega_m r_{i,m} - \omega_m o_m) . \qquad (4)$$

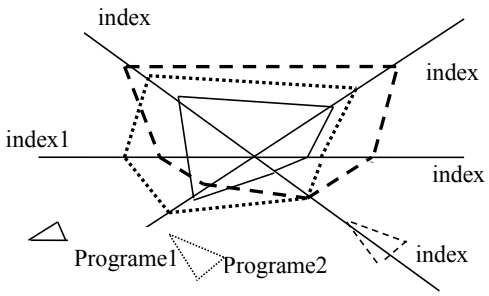

Fig.3 grey target decision-making model

Application example

Lanzhou Xinjiang Railway (also known as Lan Xin railway second double line) is divided into five construction period: Lanzhou to Xining, Xining to Zhangye, Zhangye to the Red River, red river to Hami section and the Hami section of Urumqi.

According to experts and field investigation that such part has reached the standard, but the five section energy-saving effect before and after the order did not come, to solve this problem, firstly, using comprehensive weight to empower the 11 indicators to establish the law. By interval fuzzy score for this five sections of three experts, grey target decision model based on the area enclosed by the web graphics (spider) the size of the evaluation section through the comparison and judgment, compared with the traditional grey target decision model, can reduce the individual extreme index value influence on decision-making. Invited five experts on the five tenders were scored, the score for the 5 points system, the average value of the indicators, such as table 2。

Tab.2 The interval grey number and the whitenization weight function of every part

index	Interval grey number and function	S_1	S_2	S_3	S_4	S_5
H_1	⊗	(1.3,2.1)	(3,4)	(2.2,3)	(2,4.4)	(1.9,2.7)
	$f(x)$	(1.3,1.7,2.1)	(3,3.5,4)	(2.2,2.6,3)	(2,2.8,3.6,4.4)	(1.9,2.1,2.4,2.7)
H2	⊗	(1.2, 1.7)	(1.5,2.4)	(1.3,2.7)	(1.6,3)	(1.7,2.7)
	$f(x)$	(1.2, 1.4,1.7)	(1.5,1.9,2.4)	(1.3,1.6,2.1,2.7)	(1.6,2,2.5,3)	(1.7,2.3,2.7)
H3	⊗	(1.3,2.4)	(2.8,3.4)	(2.2,2.8)	(2.7,3.5)	(1.9,2.4)
	$f(x)$	(1.3,1.8,2.4)	(2.8,1.9,3.4)	(2.2,2.5,2.8)	(2.7,3.1,3.5)	(1.9,2.1,2.3,2.4)
H4	⊗	(1.5,2.1)	(1.5,2.6)	(1.5,2.7)	(2.2,3)	(2,3.1)
	$f(x)$	(1.5,1.8,2.1)	(1.5,2,2.6)	(1.5,2.1,2.7)	(2.2,2.4,2.7,13)	(2, 2.4,2.7,3.1)
H5	⊗	(2.2,2.9)	(1.7,3)	(1.4,2.6)	(1.5,2.9)	(2,3.3)
	$f(x)$	(2.2,2.4,2.9)	(1.7,2.3,3)	(1.4,2,2.6)	(1.5,1.9,2.4,2.9)	(2,2.8,2.8,3.3)
H6	⊗	(1.3,1.9)	(2.4,3.6)	(2.4,3.1)	(1.5,2.8)	(1.5,2.7)
	$f(x)$	(1.3,1.6,1.9)	(2.4,2.7,3.3,3.6)	(2.4,2.8,3.1)	(1.5,1.8,2.3,2.8)	(1.5,2,2.7)
H7	⊗	(1.8,2.5)	(2.1,3.2)	(3.7,4.2)	(1,1.8)	(1.8,2.4)
	$f(x)$	(1.8,2.1,2.5)	(2.1,2.4,2.8,3.2)	(3.7,4,4.2)	(1,1.3,1.6,1.8)	(1.8,2,2.4)
H8	⊗	(1.9,2.5)	(2.8,4)	(2.3,3.3)	(1.6,2.5)	(1.7,2.8)
	$f(x)$	(1.9,2.1,2.5)	(2.8,3.3,3.7,4)	(2.3,2.7,3.3)	(1.6,2,2.5)	(1.7,2,2.4,2.8)
H9	⊗	(1.5,2.4)	(1.2,2)	(1.7,3)	(1.4,2.2)	(2.7,3.5)
	$f(x)$	(1.5,2.1,2.4)	(1.2,1.5,2)	(1.7,2.4,3)	(1.4,1.7,2.2)	(2.7,2.9,3.2,3.5)
H10	⊗	(1.3,2.3)	(1.4,2.4)	(2.3,3.3)	(1.7,2.5)	(1.5,2.8)
	$f(x)$	(1.3,2.1,2.3)	(1.4,1.7,2,2.4)	(2.3,2.7,3.3)	(1.7,2,2.5)	(1.5,2,2.4,2.8)
H11	⊗	(1.6,2.6)	(1.3,2.4)	(1.8,3)	(1.3,2.3)	(1.9,2.9)
	$f(x)$	(1.6,2.1,2.6)	(1.3,2.7,2.4)	(1.8,2.3,2.6,3)	(1.3,2,2.3)	(1.9,2.1,2.4,2.9)

According to table 1 and table 2, the decision matrix X, the whitening weight function matrix Y and the weight vector W

$$X=\begin{bmatrix}(1.3,2.1) & (3,4) & (2.2,3) & (2,4.4) & (1.9,2.7)\\ (1.2,1.7) & (1.5,2.4) & (1.3,2.7) & (1.6,3) & (1.7,2.7)\\ (1.3,2.4) & (2.8,3.4) & (2.2,2.8) & (2.7,3.5) & (1.9,2.4)\\ (1.5,2.1) & (1.5,2.6) & (1.5,2.7) & (2.2,3) & (2,3.1)\\ (2.2,2.9) & (1.7,3) & (1.4,2.6) & (1.5,2.9) & (2,3.3)\\ (1.3,1.9) & (2.4,3.6) & (2.4,3.1) & (1.5,2.8) & (1.5,2.7)\\ (1.8,2.5) & (2.1,3.2) & (3.7,4.2) & (1,1.8) & (1.8,2.4)\\ (1.9,2.5) & (2.8,4) & (2.3,3.3) & (1.6,2.5) & (1.7,2.8)\\ (1.5,2.4) & (1.2,2) & (1.7,3) & (1.4,2.2) & (2.7,3.5)\\ (1.3,2.3) & (1.4,2.4) & (2.3,3.3) & (1.7,2.5) & (1.5,2.8)\\ (1.6,2.6) & (1.3,2.4) & (1.8,3) & (1.3,2.3) & (1.9,2.9)\end{bmatrix}$$

$$Y=\begin{bmatrix}(1.3,1.7,2.1) & (3,3.5,4) & (2.2,2.6,3) & (2,2.8,3.6,4.4) & (1.9,2.1,2.4,2.7)\\ (1.2,1.4,1.7) & (2.8,1.9,3.4) & (2.2,2.5,2.8) & (2.7,3.1,3.5) & (1.9,2.1,2.3,2.4)\\ (1.3,1.8,2.4) & (2.8,1.9,3.4) & (2.2,2.5,2.8) & (2.7,3.1,3.5) & (1.9,2.1,2.3,2.4)\\ (1.5,1.8,2.1) & (1.5,2,2.6) & (1.5,2.1,2.7) & (2.2,2.4,2.7,13) & (2,2.4,2.7,3.1)\\ (2.2,2.4,2.9) & (1.7,2.3,3) & (1.4,2,2.6) & (1.5,1.9,2.4,2.9) & (2,2.8,2.8,3.3)\\ (1.3,1.6,1.9) & (2.4,2.7,3.3,3.6) & (2.4,2.8,3.1) & (1.5,1.8,2.3,2.8) & (1.5,2,2.7)\\ (1.8,2.1,2.5) & (2.1,2.4,2.8,3.2) & (3.7,4,4.2) & (1,1.3,1.6,1.8) & (1.8,2,2.4)\\ (1.9,2.1,2.5) & (2.8,3.3,3.7,4) & (2.3,2.7,3.3) & (1.6,2,2.5) & (1.7,2,2.4,2.8)\\ (1.5,2.1,2.4) & (1.2,1.5,2) & (1.7,2.4,3) & (1.4,1.7,2.2) & (2.7,2.9,3.2,3.5)\\ (1.3,2.1,2.3) & (1.4,1.7,2,2.4) & (2.3,2.7,3.3) & (1.7,2,2.5) & (1.5,2,2.4,2.8)\\ (1.6,2.1,2.6) & (1.3,2.7,2.4) & (1.8,2.3,2.6,3) & (1.3,2,2.3) & (1.9,2.1,2.4,2.9)\end{bmatrix}$$

$$W=(0.13,0.14,0.08,0.05,0.08,0.10,0.13,0.05,0.09,0.09,0.08)$$

According to the formula (8) ~ (10) to obtain the consistent effect matrix: Z'：

$$Z'=\begin{bmatrix}0.4857 & 0.6289 & 0.5914 & 0.6980 & 0.9434 & 0.5333 & 0.5378 & 0.6295 & 0.6496 & 0.6867 & 0.8678\\ 1.0000 & 0.8483 & 0.8710 & 0.7885 & 0.8805 & 1.0000 & 0.5089 & 1.0000 & 0.6627 & 0.6793 & 0.8815\\ 0.4952 & 0.8499 & 0.8065 & 0.8143 & 0.7547 & 0.9222 & 1.0000 & 0.8039 & 0.7687 & 1.0000 & 1.0000\\ 0.9143 & 1.0000 & 1.0000 & 1.0000 & 0.8222 & 0.7025 & 0.3583 & 0.5908 & 0.5738 & 0.7470 & 0.7713\\ 0.6511 & 0.9800 & 0.7005 & 0.9888 & 1.0000 & 0.6889 & 0.5210 & 0.6476 & 1.0000 & 0.7845 & 0.9663\end{bmatrix}$$

According to the vector W, we calculate the weighted consistent measure matrix:

$$Z''=\begin{bmatrix}0.0631 & 0.0883 & 0.0473 & 0.0336 & 0.0708 & 0.0533 & 0.0699 & 0.0315 & 0.0585 & 0.0618 & 0.0694\\ 0.1300 & 0.1190 & 0.0697 & 0.0380 & 0.0661 & 0.1000 & 0.0861 & 0.0500 & 0.0458 & 0.0661 & 0.0705\\ 0.0644 & 0.1193 & 0.0645 & 0.0392 & 0.0566 & 0.0922 & 0.1299 & 0.0402 & 0.0692 & 0.0900 & 0.0800\\ 0.1189 & 0.1403 & 0.0800 & 0.0482 & 0.0617 & 0.0702 & 0.0466 & 0.0295 & 0.0516 & 0.0672 & 0.0617\\ 0.0846 & 0.1375 & 0.0560 & 0.0476 & 0.0750 & 0.0689 & 0.0677 & 0.0324 & 0.0900 & 0.0706 & 0.0773\end{bmatrix}$$

The five section of the final evaluation value and ranking as follows：

Table.3 The rank of five parts's cores

Part	S_1	S_2	S_3	S_4	S_5
The comprehensive score	0.0031	0.0004	0.0006	0.0017	0.0009
Rank	1	5	4	2	3

Conclusion

(1) According to the construction stage, a set of relatively comprehensive energy-saving evaluation index system is established. There are four first-level indicators, six second-level indicators and 11 three-level indicators.

(2) The gray-scale decision model based on the cobweb area can weaken the influence of the extreme index, and the objectivity of the expert scoring method is weakened, so that the result is almost whitened.

(3) According to the energy saving evaluation index system established in the railway construction stage, combined with the decision model based on the cobweb area, it provides a reference for the evaluation mechanism of the energy saving effect in the railway construction stage.

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