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Evaluation Method for Heating Energy Consumption of Rural Buildings in Cold Zone

Haiyan Wan Wang[a] , Yanling Wan Wang[a] , and Fang Wang[a,*]

[a]*School of Municipal &Environmental Engineering, Harbin Institute of Technology , Harbin , China*

Abstract

Evaluation of heating energy consumption plays an important part for promoting rural building energy efficiency. Key Evaluation factors were selected and grouped from diversified factors that can affect heating energy consumption of rural buildings in cold zone by using variance analysis method according to the statistical strength of association. Two-stage evaluation index system for heating energy consumption was established , and the weight coefficients of each stage's evaluation indicators were determined by constructing an improved evaluation and comparison matrix ,which was based on comparisons of the strength value of association between indicators. The improved method is much superior to traditional analytic hierarchy process(AHP) which is subject to expert subjective judgement. The evaluation method of heating energy consumption provides comparably objective judgment and evaluation ,and may be beneficial to putting forward the corresponding energy efficiency improvements.

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Keywords: Evaluation of heating energy consumption； AHP； Strength of association Weight cofficient； Statistical analysis

1. Introduction

Heating energy consumption of rural buildings in China has the following characteristics: diversity of heating energy species, heating mode closely related to life style, different combination of heating and combustion equipment and so on， which increase the difficulty of in - depth research and analysis. Thus reasonable and

* Corresponding author. Tel.: 18686891786; fax: 0451-86282123.
E-mail address: huanhuan@hit.edu.cn

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objective evaluation of residential heating energy consumption is extremely difficult. It has been necessary to select the appropriate factors and indicators to comprehensively evaluate and reflect the real level of residential heating energy consumption through the scientific method. The objective judgment and analysis on heating energy consumption of residential building has important significance for improving the development of rural building energy saving.

There are many evaluation and research methods on urban heating energy consumption[1][2], however application on the rural heating energy consumption is very seldom. Research on heating energy evaluation of rural residential buildings in China cold zone is particularly necessary.

To calculate and analyze the heating energy consumption is to determine the key factors and the weight coefficient of factors At present, there are weight coefficient methods as following: expert scoring method, survey method, sequence synthesis method, equation method, mathematical statistics method, analytic hierarchy process （AHP） and complexity analysis. AHP，solving multi-objective decision analysis method，is the combination of qualitative and quantitative analysis of complex problems. The advantages of AHP analysis method are systematic and practical. The disadvantages are less quantitative data and qualitative composition, which is not easy to be convincing. Reasonably quantify the qualitative factors is to play the advantages of AHP and overcome its shortcomings，which will make the improved analytic hierarchy process to a wide range of applications.

2. Method

The improved AHP is very suitable for residential heating energy consumption .The weight coefficient of indicators and factors are determined by reasonable structuring the comparison judgment matrix with statistical correlation analysis of strength calculation results.

Key factors that affect heating energy consumption are selected according to the variance analysis of the existing residential building heating energy consumption statistical results by the software SPSS [3]. The omega square coefficient（ω^2），the strength of association，has been applied to estimate the strength relationship between the dependent and the independent variables in statistics The determination of key factors depends on the value of ω^2 with mean difference test statistics method，and the consideration of future residential heating energy development. Key factors are grouped into five indicators.

By using the AHP method，evaluating the heating energy consumption, can be roughly divided into the following four steps: establishing the hierarchical structure model, constructing judgment matrix, calculation, and consistency test. The energy consumption evaluation hierarchy model（$HE \rightarrow HE_i \rightarrow HEF_j$） is as shown in Table 1

The weight coefficients K_j and K_{HEi} can be derived according to judgment matrix by the improved AHP method.

3. Discussion

3.1. Two-stage evaluation index system

The statistical and regression analysis results based on 200 questionnaire survey samples can be used to explain differences in residential heating energy use. The study results suggest that the key factors in three levels affecting the energy consumption of heating residential building have statistical significance to analyze the heating energy consumption. Consequently, heating energy consumption index （HE） can be evaluated by heating energy consumption indicators（HE_i，i=1—5)and heating energy consumption factors （HEF_j，j=1—20）.

3.2. Determination of Key factors Tables

Therefore, the five indicators containing 20 key factors affecting rural residential heating energy consumption were divided into three grades(★, ★★,★★★) as star system description ,as shown in Table 1.

Table 1. Residential heating energy consumption factors and indicators.