CHEMICAL ENGINEERING TRANSACTIONS
VOL. 51, 2016
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Tichun Wang, Hongyang Zhang, Lei Tian

ISBN 978-88-95608-43-3; **ISSN** 2283-9216
DOI: 10.3303/CET1651040

Description of Jilin Province Public Building Energy Efficiency Index Evaluation System

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According to present situation of buildings energy conservation home and abroad, the analysis of influencing factors on public building energy consumption, combined with year-round climate of Jilin Province, according to the relevant state building energy codes, standards, and the suitable climate of Jilin public building energy efficiency evaluation system has been established. Taking Jilin sunshine department store architecture for example to provide practical checking system for the establishment of Jilin Province, and then build energy efficiency evaluation system to set up a theoretical basis and technical support.

1. Introduction

With the rapid economic development and improved living standards, the increasing number of public buildings, and the construction of energy-saving technology is not perfect, public buildings have huge energy consumption (He and Li, 2014). Related survey shows that China's building energy consumption accounts for about 1/3 of total energy consumption (Guo and Chen, 2013). Under the same climatic conditions, China's building energy consumption per unit area 1-2 times higher than in developed countries (Yan and Gao, 2013), the total world energy consumption 1/4 (Gu and Yu, 2011). Energy efficiency in buildings is imminent (Liu, 2013), and the long and cold winter in Jilin Province, a long heating time, a large heat demand of geographical features, the building energy-saving potential. Currently, people are still in the building energy efficiency evaluation based on subjective judgment stage, the lack of a sound, scientific, rational building energy efficiency evaluation system. EEB established evaluation system can be evaluated not only energy saving in construction in the region, the diagnosis of the cause of building energy efficiency (Bensenouci and Benchatti, 2009), while the development of Jilin Province EEB technology and the popularization of EEB consciousness play a role in promoting, and for local government building energy efficiency work has a certain role (Chen and Li, 2006).

2. System summarizes

Two categories: depending on the implementation of building energy efficiency standards, the public buildings are divided into two categories: Category A and B building construction;

Two phases: the process of building evaluation includes two phases-qualitative evaluation phase and quantitative evaluation stage;

Two levels: qualitative evaluation and quantitative evaluation stage respectively are composed of two levels by level indicators and secondary indicators in the two systems, each one contains a number of secondary indicators index. Among them, the qualitative evaluation phase consists of five-level indicators, including the building envelope heat transfer coefficient, window wall area ratio, building shape coefficient, and building envelope construction, operation and management situation; the quantitative evaluation phase consists of four-level indicators, including walls, window, roof, the amount of cold air infiltration.

Three phases: evaluation phase and quantitative analysis and evaluation stages of a right to secondary indicators of weight in accordance with the qualitative analysis, stepwise by summing the scores and weights product to give a total score of building energy consumption, according to the final scores will be construction division three levels.

Please cite this article as: Zhan N.Y., Wang J.H., Lu H.J., Liu Y.D., 2016, Description of public building energy efficiency index evaluation system, Chemical Engineering Transactions, 51, 235-240 DOI:10.3303/CET1651040

3. System structure

According to scholars established public building energy efficiency evaluation system, and referred to the domestic latest norms and standards existing relevant cold area public building energy efficiency class: "Green Building Evaluation Standard" (GB / T 50378-2014)(MOHURD, 2014), "Cold and Cold Region Public Building Energy Efficiency Design Standards "(JGJ26-2010)(MOHURD, 2010)," Public Building Energy Efficiency Design Standards "(DGJ08-107-2012)(MOHURD, 2012)," Public Building Energy Efficiency Testing Standard "(JGJ / T177-2009)(MOHURD, 2009), "Jilin Public Building Energy Efficiency Design Standards" (DB22 / 436-2007)(MOHURD, 2007), "Green Building Evaluation System and Its Application in Engineering Practice"(Frank T, 2005) et al, in accordance with the scientific, objective, system , level principles for public building energy efficiency indicators to filter the energy-saving targets into building envelope heat transfer coefficient, window to wall ratio, building shape coefficient, and building envelope detail structure, operation and management of five-level indicators, each index consists of a secondary indicators. Evaluation system shown in Table 1, Table 2 below:

Table 1: Jilin province public building energy efficiency index evaluation system of qualitative index

Numerical order	First class indicator	Numerical order	Second class indictor
1	envelope heat transfer coefficient	1-1	outside the window heat transfer coefficient
		1-2	facades heat transfer coefficient
		1-3	roof heat transfer coefficient
		1-4	doors heat transfer coefficient
2	Window wall area ratio	2-1	North window wall area ratio
		2-2	East window wall area ratio
		2-3	South window wall area ratio
		2-4	West window wall area ratio
3	Building shape coefficient	3-1	building shape coefficient
4	building and construction details	4-1	envelope transparent windows and outside walls airtight Ratings
		4-2	Architectural detail structure
		4-3	Envelope construction details
5	Operations Management	5-1	Operations Management Measures

Table 2: Jilin province public building energy efficiency index evaluation system of quantitative index

Numerical order	First class indicator	Numerical order	Second class indicator
1	Wall	1-1	East
		1-2	South
		1-3	West
		1-4	North
2	Window	2-1	East
		2-2	South
		2-3	West
		2-4	North
3	Roofing	3-1	Roof
4	cold air infiltration	4-1	East
		4-2	South
		4-3	West
		4-4	North

4. Research methods

The approach mainly include the following methods: experimental testing, modeling and expert verification, evaluation indicators are supported by the index weight, each with its index score weighted sum of products, get the final score of the participating buildings, according to the final score of the division level.

5. Study procedures

In accordance with the multi-stage weighting system of scoring methods for the contestant buildings for energy. The classification is calculated by checking the simulation, the eventual establishment of evaluation system database.

5.1 Phase compartmentalize

Through qualitative analysis of the various factors affecting the energy saving in construction, on-site investigation, expert evaluation, the qualitative and quantitative evaluation process is divided into two phases. Quantitative indicators can be obtained by direct field measurement data, and qualitative indicators can be the text description of the objective situation. The qualitative assessment as a first stage, after the qualitative index meet energy efficiency design standards, re-entering the quantitative evaluation stage. It will terminate the building evaluation as qualitative stage does not pass; if by qualitative evaluation, the qualitative evaluation phase is entered.

5.2 Qualitative indicators determining the weights

5.2.1 Qualitative indicators weight settings

Qualitative indicators weight used Hierarchical analysis method. Analytic Hierarchy Process was, that proposed by the famous American operations research experts T. L. Saaty in the mid-1970s, a hierarchical structure right decision for repeated delivery method (Saaty, 1990,). This method would be combined with qualitative analysis and quantitative calculation, after in-depth analysis of the problem, the problem to be solved step by step detailed decomposition, formation of objectives, guidelines and programs and other levels, at all levels and to determine the weight of each index value is calculated by layer by layer analysis .

Qualitative indicators weight settings are using Hierarchical analysis method (DESPSTER, 2010), using the Hierarchy Process of Delphi Analytic for reference, not only to play the advantage of AHP, to take advantage of a number of experts, foster strengths and circumvent weaknesses, leak fill a vacancy, that can be avoided the one-sidedness of weight data, and improved the randomness of subjective weights quantifying methods.

5.2.2 Method of qualitative evaluation phase

According to existing national and regional public about the cold energy efficiency design standards, and acceptance of energy efficient building assessment standards mandatory provisions of the construction quality energy-saving projects or important provision, the second-tier index score is divided into three levels: 10 points, 6 points, 0 points; according to two indicators is given second-tier level of satisfaction index score. In accordance with the weight of each secondary indicator of weight, and the weight multiplied by the score and then progressively summing to obtain a total score of building qualitative evaluation phase.

5.3 Qualitative indicators determining the weights

5.3.1 Qualitative indicators weight settings

Quantitative indicators are quantitative indicators calculated reanalysis traditional rights have a certain subjective factors in it; highlight the index itself is not entirely quantitative. Therefore, this study quantitative index weights, no longer using the analytic hierarchy process, and rely on quantitative indicators themselves qualities, by the ratio of the total energy consumption of each quantitative indicators to calculate the magnitudes of the index weight. Specific methods: After using simulated and measured means for calculating the energy consumption of each quantitative indicators, the index calculated by the total energy consumption of the scale factor as the weight of the building of the quantitative indicators weight, calculated as shown below, since the quantitative indicators identified as 4, wherein i represents quantitative index i = 1, …, 4.

$$\eta_i = \frac{Q_i}{\sum_{i=1}^{4} Q_i} \tag{1}$$

Where η_i is the weight of each quantitative indicator; Q_i is the consumption of each quantitative indicator; $\sum_{i=1}^{4} Q_i$ is the quantitative index of total energy consumption. By the above formula, select a representative architecture used in the calculation, the energy consumption is calculated on the basis of various quantitative indicators all quantitative indicators building right weight, the right to reforming aggregated the final quantitative indicators available for each building right weight.

5.3.2 Method of qualitative evaluation phase

The method of quantitative evaluation is proportion of summation, progressively one by one to score. The 6 is the basic (standard building), the max point is 10 and the minimum is 0. If a building's score is higher than 10, the score is 10; When one's score is lower than 0, the score is 0. According to the indicators' weight, summation of score multiply the weight, the score of a building can be listed. And then classify their level on the basis of score. The concrete scoring method is as follows:

$$\theta_i = \frac{Q_i' \quad Q_i}{Q_i} \qquad (i = 1, \cdots, 4) \tag{2}$$

Where Q_i is the mean value of the actual radio coefficient of energy consumption and Q_i is the mean value of the first level indicator consumption of meet the requirement, Q_i' is the the building's indicator consumption. Actual radio coefficient of energy consumption (θ_i) is the basis of getting score, the definition is the radio of the standard building first level indicators consumption and the difference between the building ready to score and the standard building.

$$T_i = 6 \times (1 \quad \theta_i) \tag{3}$$

where T_i is the quantitative index score and $\theta_i$is the mean value of the actual radio coefficient of energy consumption

$$T = \sum_{i=1}^{4} T_i \cdot \eta_i \tag{4}$$

where T is total score quantitative index evaluation and $\eta_i$is the primary index weight.

5.4 Standard of system score

Building energy-saving system can be divided into two phases; one is scoring for the qualitative indicator, called the first phase; the other one is scoring for the quantitative indicator, called the second phase. In the qualitative phase, the buildings whose score are more than 6 can go into the quantitative phase. The buildings whose score are 6 or less than 6, the buildings' energy-saving evaluation are over or go into the diagnostic phase. The details are listed in Table 3:

Table 3: Level standard of qualitative evaluation

Qualitative evaluation phase score	Result of evaluation
T>6	Go into quantitative phase
T≤6	Building's energy-saving evaluation is over or go into the diagnostic phase

Classification is based on a quantitative evaluation of the total index score based on scores of cases building energy efficiency rating is divided into three levels, as shown in Table 4 below specific classification:

Table 4: Jilin province public building energy efficiency rating

Score of phase in quantitative evaluation	Level of building energy-saving
T≥9	★★★
6≤T<9	★★
4≤T<6	★
T<4	No level and go into optimizing phase

5.5 Evaluation system database created

Through the establishment of public building energy efficiency evaluation index system, which was developed into the software, set up the database, making it a convenient way for general public building energy efficiency evaluation.

6. Case analysis

In order to insure the feasibility of the method, now analyses a building in Changchun in Jilin province, as shown in Table 5 below.

7. Epilogue

Through applying the system of building energy-saving evaluation, it can test and evaluate the building all-around and multilevel, not only completing the level test also diagnosing why the building is not energy-saving. At the same time, the system plays an important role in perfecting the effect. During the 'twelfth five-year', it also can have some influence on building energy-saving evaluation in north cold area. After establishing this evaluation, the building evaluation system can be set in other area in China, which in order to satisfying the different demand and adapting the different situation. Thus, the building evaluation system can be from specific to general, and may brighten the future development in building energy efficiency.

Table 5: Building energy efficiency evaluation system analysis

Position	Changchun, Jilin province	Type	Commercial	Age	5 years
Background of building	Material of construction and design are complete and mutual the same: the whole and the details of structure of the building meets the requirement of building energy-saving.				
Evaluation of the situation	1. Test on building in September 2014 2. Set up mathematical model and simulate from November 2014 to December 2015				
Qualitative Indicator					
	First level indicator		Simulation		
Qualitative indicator	Process is omitted				
Quantitative Indicator					
Quantitative indicator	First level indicator	Actual energy consumption radio coefficient calculation.		Indicator score calculation	
	Wall	$\theta_1 = \frac{\theta_1' - \theta_1}{\theta_1} = \frac{158993.73 - 166060.12}{166060.12} = -0.043$		T_1=6×(1-θ_1)=6×(1+0.043)=6.258	
	Window	$\theta_2 = \frac{\theta_2' - \theta_2}{\theta_2} = \frac{114032.82 - 120778.36}{120778.36} = -0.056$		T_2=6×(1-θ_2)=6×(1+0.056)=6.336	
	Roof	$\theta_3 = \frac{\theta_3' - \theta_3}{\theta_3} = \frac{88065.53 - 94355.93}{94355.93} = -0.067$		T_3=6×(1-θ_3)=6×(1+0.067)=6.402	
	The cold air infiltration	$\theta_4 = \frac{\theta_4' - \theta_4}{\theta_4} = \frac{26340.88 - 26340.88}{26340.88} = 0$		T_4=6×(1-θ_4)=6×(1-0)=6	
	The total score	Weight coefficient of wall is 0.4403. Weight coefficient of window is 0.2429. Weight coefficient of roof is 0.2439. Weight coefficient of the cold air infiltration is 0.0729. $T = \sum_{j=1}^{4} \eta_i . T_i$ =0.4403 $\times 6.258 + 0.2429 \times 6.336 + 0.2439 \times 6.402 + 0.0729 \times 6$ =6.29			
	Level energy-saving	9>T=6.29>6 is the ★★ energy-saving building			

8. Conclusion

By studying the example of special climate characteristics of Jilin Province, the in-depth understanding of public buildings and related forms of building energy efficiency evaluation system, the building energy efficiency evaluation index system in Jilin Province is established. Its establishment not only solves the problem of the wandering stage of qualitative analysis, but also evaluates the building energy saving effect, the causes of building energy conservation diagnosis. At the same time, it can play an important role on the popularity of energy-saving technology development in Jilin province construction and awareness of energy conservation of building.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (Grant No.51206061) and Jilin Province Department of Education Project [2015] (Grant No. 263) and Housing and construction department of Jilin province project.

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