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The Primary Study on Evaluating Index System of Energy Efficient Buildings

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ABSTRACT In the standards and criterions of many countries, the evaluating index of energy efficient buildings mostly comprises of two types, prescriptive index and performance index. Firstly , the concepts of each type were explained respectively in this paper , and several existed typical evaluating performance indexes and methods of energy2efficient buildings were introduced , also the characteristics of each index were presented. Furthermore , the evaluating indexes and methods used by existing design standards for energy efficiency buildings in China were briefly discussed and some elementary suggestions on the foundation of evaluating index system were analyzed. At last , based on the discussion , a suitable evaluating index system of energy efficient buildings for China could be established , as a result , the energy resources could be saved and the environment could be protected.

KEYWORDS
Energy efficient buildings
Evaluating index
Performance index
Design standard

1. Introduction

Since the last century, due to uncontrolled consumption of energy, so that the concentration of CO_2 and other greenhouse gases each year surge in global temperature will rise, causing the climate anomalies, ecological destruction and so on, so that the basic environment has been threatening human survival. In addition, with the continuous rise of oil, coal, electricity and other energy prices, energy conservation issues has also been placed in front of each industry, and energy consumption accounts for 30% of total energy consumption society is to become the focus of the construction industry energy saving target. To a small one, to a large city, and the whole construction industry, building energy efficiency has become imminent, urgent problem.

In recent years, a large number of new building energy-saving technology has been widely promoted and applied a series of energy-related standards, such as the 2005 March implementation of the "public building energy efficiency design standards" (GB5018922005) [1] and so on, have also introduced and implemented on a variety of building made energy requirements. Comparing the two and now advanced technology development is very fast, but with the corresponding standards and normative system is not very sound, is lagging behind, both appeared disjointed development [2]. Tsinghua University, Academician Jiang Yi has said, to make the building energy push mode really up and running, the key is to give the building energy consumption indicators, and establish building energy assessment system [3]. Therefore, the establishment of energy-saving evaluation system building construction is carried out on the basis of a comprehensive evaluation of energy-saving work, its scientific rationality directly affects the accuracy of the assessment results, thereby affecting the energy efficiency in buildings normative.

In the standard or specification of countries, the evaluation of energy-efficient buildings are divided into two categories: the provisions index (Prescriptive Index) and performance indicators (Performance Index). This paper describes the concept of these two indicators, highlights several typical energy-saving building performance evaluation index or method currently available, and analyzes their characteristics. Additionally, this article describes a simple method of evaluation and existing building energy efficiency design standards to be adopted and further improvement; by analyzing the actual situation in China, to

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establish a working building evaluation system of China's energy presents several Preliminary recommendations point. Finally, our energy-saving evaluation system should be set up conditions for the building.

2. Stipulating indexes

Stipulating indexes mainly for various energy systems, such as the building envelope (walls, roof, doors or windows) of the heat transfer coefficient, shading coefficient glazing and heating, air conditioning and lighting equipment minimum energy efficiency indicators, as defined a limit. Those who meet the requirements of the construction of all these indicators, the runtime consumption is relatively low, it can be identified as energy-efficient buildings. Parameters belong to such indicators are the building shape coefficient, window to wall ratio, the heat transfer coefficient of various parts of the building envelope K (i.e. many European countries referred U2 Value) or thermal resistance R, glazing shading coefficient SC , air conditioning system SEER S EER (Seasonal Energy Efficiency Ratio), the heating season performance factor HS PF (Heating Season Performance Factor), an integrated part load value IPLV refrigeration unit (Integrated Part Load Value), energy efficiency EER (Energy Efficiency Ratio) and coefficient of performance COP (Coefficient of Performance) and the like.

Currently, more applications such indicators in the evaluation of the energy-efficient buildings, especially in measuring the energy efficiency of residential buildings, often will use envelope heat transfer coefficient, building shape coefficient, window to wall ratio specified index. However, today's architectural design is becoming more diverse and personalized, many buildings are often not fully meet the requirements of these provisions of the indicators, such as the south wall with large windows will cause the complex to the south window to wall ratio exceeded, building shape shape coefficient will lead to too big. Thus, the provisions of this sub-index because of too specific, and independent of each other between the various indicators, the lack of effective association, it cannot carry out a comprehensive analysis of the various parts of the energy consumption of buildings. In addition, since each index specified was too rigid, but also limit the architect's design freedom and creativity to a certain extent.

3. Performance indicators

Performance indicators are not specified in the local building thermal performance, but required to meet the requirements in the overall comprehensive energy consumption, a saving can be achieved through various means and technical measures to achieve. It allows designers to have a breakthrough on a link, giving the designer greater freedom to play space, to encourage innovation, to meet the designers the freedom to design and building energy efficiency specifications control requirements in two ways. Such indicators of the overall heat transfer envelope value OTTV (Overall Thermal Transfer Value), perimeter annual load factor PAL (Perimeter Annual Load), air-conditioning energy consumption coefficient CECПAC (energy consumption norm Coefficient of Energy Consumption for Air Conditioning) and energy cost budget method used and number evaluation index mark. Specifically, the first three indicators should be subject to the general load calculation, and the last indicator is usually given occupant density and activities carried out by the simulation software simulation. Therefore, the performance indicators considered the former combination of a number of parameters, mainly for the system (such as an entire building envelope or air conditioning system, etc.) or a plurality of components which can be called partial performance (Partial 2 performance); the latter Performance class index is basically considered the amount of energy the building and its equipment as a whole consumed, it brings greater design flexibility, can be called global performance (Full 2 performance) [4]. Here are some typical performance evaluation indicators and methods currently more concerned.

3.1. Envelope overall heat transfer value OTTV

OTTV The concept was first proposed by the United States ASHRAE, now China's Hong Kong and some Southeast Asian countries (such as Singapore, Thailand, etc.) are assigned their own OTTV standards. OTTV is made into the interior of the thermal envelope of opaque passing through glazing thermal and heat gain through windows of three parts consisting of solar radiation, OTTV entire envelope structure can be determined for each component area weighted average [5]. Since the provision is the total heat transfer envelope, and therefore in conformity with the standards, architects still have room to play and adjust. OTTV focus on the thermal envelope and heat gain by solar radiation brought, compared with a standard building insulation in cold regions, this concept seems more suited to the climatic conditions in tropical regions [6]. And overall, OTTV as a relatively simple evaluation method was widely applied in developing countries.

3.2. Perimeter annual load factor PAL

PAL perimeter annual load factor in 1980 by the Japanese, is a reflection of the structure of the building envelope to reduce energy loss energy-saving targets, which are defined as follows:

PAL = annual heating load (MJП years) around the building area around the building area of the building area (m^2)

PAL building load calculation of the following:

(1) Formed in the outer wall of indoor and outdoor temperature and windows of heat load;

(2) Through the outer wall and windows shot day heat;

(3) Indoor heat surrounding area;

(4) The formation of new wind [5].

Annual load is calculated according to the time of use and the use of the room respectively, and the cooling load and the heating load totals together.

3.3. Air-conditioning energy consumption coefficient CECПAC

Air conditioning energy consumption coefficient CECПAC by the Japanese Society for air conditioning and sanitation workers proposed in 1980, it is air-conditioning system energy efficiency of decision criteria. It is equal to one year's air conditioning energy consumption compared to the total hypothetical annual total value of the air-conditioning load, therefore the smaller the CEC value, indicating that the higher energy efficiency of air conditioning equipment.

CECПAC = annual primary energy consumption air conditioning systems (MJП years) ÷ Hypothetical annual air conditioning load (MJП years)

CECПAC = [Σ (heat source energy consumption) + Σ (fan and pump energy consumption)] ÷ [Σ (heating load) + Σ (cooling load) + Σ (new wind load)]

In Japan, engineers after completion of the air conditioning system design, CEC coefficients must be calculated. If the CEC coefficient greater than the calculated value of building permits, the air conditioning system design must be modified again until meet benchmarks. For example, Japanese published specification office building CECПAC reference value must reach 115 [7].

Japan has a complete system of standard equipment energy efficiency in buildings, except for the air conditioning system CECПAC indicators, as well as CECПV (Coefficient of Energy Consumption for Ventilation), CECПL (Coefficient of Energy Consumption for Lighting), CECПHW (Coefficient of Energy Consumption for Hot Water Supply) and CECПEV (Coefficient of Energy Consumption for Elevator), etc., and is not explained one by one.

3.4. Energy cost budget method

ASHRAE 9011 standards set forth in the energy cost budget method (Energy Cost Budget Method), based on the actual design of the building (Proposed Building) Constructs a reference building (Reference Building), and then calculate the design of the building energy simulation software respectively by annual energy costs SEC DEC annual energy costs and standard buildings. If the result of the analysis calculated to meet DEC ≤ SEC or E = DECПSEC ≤ 1, is considered to meet the requirements of; otherwise, you have to take certain energy-saving measures and energy-saving design method, modify the original design of the building designed according to the site conditions until the holds.

Since the standard of buildings with different designs and different buildings, annual energy cost indicators SEC standard buildings will also be with different designs and different buildings, rather than a fixed value, so this change Indicators of energy cost budget method has flexible, more reasonable advantage. Moreover, this type of evaluation method for building energy consumption per unit of time (such as annual energy consumption) has led to the entire building and construction equipment energy consumption accurately simulate possible. However, this index still has some shortcomings: (1) Only a more accurate approximation and prediction in an ideal parameter setting, does not reflect the situation of building energy consumption under actual operating state; (2) The calculation is too much trouble, a professional too strong; (3) Did not take into account differences in the price of energy and recycling, etc., we cannot measure the economy, environmental protection and sustainability.

4. Evaluation system of China's energy construction

Since 1986, the Ministry of Construction issued the "Energy conservation design standard" (heating residential buildings) (J GJ 26286) onwards, China has promulgated a number of energy-saving aspects of the building relates to national standards or industry standards, it has initially established building energy efficiency design standards. According to incomplete statistics, around the world more than 60 countries and regions have different levels of mandatory energy efficiency standards apply to new construction. Our country is one of the more complete. Reason to believe that, in the standardization of building energy efficiency, China is one of the countries in the world have conducted relatively good state [5].

Currently, in our existing building energy efficiency standards and regulations, and it have begun to adopt the provisions of the indicators and performance indicators combination of methods. For example, in the "hot summer and cold winter region residential building energy efficiency design standards" (J GJ 13422001) [8], and on the use of these two indicators to control the energy-saving design, by stipulating indexes specified in the region residential building envelope Heat transfer coefficient threshold, while through energy integrated indicators (i.e., performance indicators) provides the residential building construction area allowed per m2 at different heating degree days and the air conditioning heating degree days, air conditioning equipment energy consumption indicators. Again, in the "hot summer and winter region residential building energy efficiency design standards" (J GJ 7522003) [9], and not only with the above two indicators, the standard also uses a building's energy consumption relative to the reference value, instead of a region given a fixed per m^2 floor area permitted air-conditioning, heating equipment energy consumption indicators.

Nevertheless, from the establishment of scientific and comprehensive evaluation system of energy-saving building still some distance in the future work and research as well as several aspects of the problem needs to be improved and strengthened. For example, China is currently com-

monly used indicators and methods of these evaluations are also largely focused on considering insulation performance of the building envelope, doors and windows of airtightness and a certain kind of building equipment system independent runtime efficiency, for buildings and building equipment Contents overall system energy efficiency remains to be substantial, on building energy consumption and environment-friendly guidelines and evaluation system have not been more fully reflected, which limits the further development of building energy conservation theory and technology to some extent. In addition, our research on energy-saving air-conditioning system is also focused on the air-conditioning system of the monomer equipment (such as chillers, heat pump units, cooling towers, etc.) of energy efficiency, but the entire system (including the cold heat source equipment, fans , pumps, cooling towers, etc.), but also has never proposed a comprehensive evaluation.

5. Preliminary recommendation of building our energy evaluation system

China's vast territory, large differences in climate, in "civil thermal design specification" (GB 50176293) [10], our building is divided into five climatic zones: cold regions, cold regions, hot summer and cold in winter and summer Warm Winter Area and temperate regions. Depending on weather conditions, the demand for heating and air conditioning in all regions are different. At present, China has both the energy efficiency design standards, building envelope thermal performance of dispersion, the different methods used to calculate energy consumption, there are also differences in the way of building energy efficiency evaluation. Moreover, even if energy-saving building evaluation in the same area, also occur in spite of using the same envelope design, but because the building shape coefficient different reasons which led to some buildings meet the energy requirements, the situation of some buildings cannot comply. Therefore, the evaluation index system of energy-efficient buildings should be able to judge whether or not to give energy-saving and energy-saving building-specific evaluation of how much the actual situation, if necessary, the need for different situations (such as buildings in different areas where the different nature and the use of both new and Some different, etc.) were developed criteria and indicators. Secondly, the current application of building energy efficiency evaluation are also generally concentrated in the design stage, but I believe that a scientific evaluation methods and systems should be run through the building planning, design and construction until its completion, as well as operation and maintenance of the entire process. According to SETAC (Society of Environmental Toxicology and Chemistry) and ISO (International Organization for Standardization) and other proposed "life cycle assessment" (Life Cycle Assessment, LCA) concept evaluation system should also be energy-efficient buildings throughout the building. From cradle to grave and the entire life cycle. Moreover, due to the operational management of the construction equipment is also with some foreign countries there is a certain gap, resulting in many designed to meet the energy requirements of the building in the actual operation of the process did not meet the expected energy savings, even there is energy anomaly. Therefore, the evaluation index system of energy-efficient buildings should run through all stages of a building waiting for the design, construction and operation of buildings and related behavior can be made for energy saving requirements and constraints.

In addition, many developed countries as early as 1973 energy crisis began to focus on building energy efficiency, building energy efficiency standards, regulations and relevant policy-making, it is also a lot of work [2], the experience of our development related work There are a lot of inspiration place. However, in reference to foreign advanced experience, while also taking into account the basis of poor in some respects, a thin base, the actual situation, we cannot completely copy and use some evaluation abroad. With air conditioning energy consumption coefficient СЕСПАС example, when seeking a hypothetical annual air conditioning load, slightly algorithm has applications expand to survive method and experimental design of two ways. Application of law required to expand to survive two indicators: Heating expand survive (EHD) and Cooling Degree Days expanded (ECD), the specific values of each region of Japan EHD and ECD has given chart, while only some regions There are heating degree days, most regions have no detailed data cooling degree days. For experimental design was used in the calculation of the correction term is based on the large amount of data on the basis of investigation and sorting, along with the changes in the regional meteorological parameters and change, and China in this regard has not been thoroughly studied [11]. Therefore, the establishment of China's building energy efficiency evaluation system should not only draw reference to foreign advanced experience and technology, should fully carry out independent research and development with Chinese characteristics, the two try, cannot be neglected. In summary, the author of China's energy construction evaluation index establishes the Department made two preliminary recommendations for reference:

(1) Both in the transverse direction (different regions and use) or in the longitudinal direction (different processes and stages), can form a binding system having.

(2) Both draw reference to foreign advanced experience and technology, and fully carry out independent research and development with Chinese characteristics, the establishment of evaluation index system suitable for China's energy-saving buildings.

6. Conclusion

Today, the town in line with building energy efficiency

standards for buildings was less than 3% of the total, compared with developed countries, building energy consumption under the same conditions of our country to more than double. At present, China is in the heyday of urban construction, it is predicted that by 2015, more than 50% of urban buildings will be built in 21 century, and therefore promote a comprehensive variety of building new energy-saving technologies, new measures in the future new building, is the last opportunity for energy efficiency in buildings facing [3]. In order to make the building energy-saving work really good done, given the building energy consumption indicators, establishment of energy evaluation system will be a key building whole work. In recent years through a series of proposed introduction of a variety of building energy requirements of the standard, China has initially built a standard system of building energy efficiency design. Moreover, a lot of ongoing research professionals in this area but also to the establishment of energy-saving building evaluation system of our country brings some new ideas, such as a more reasonable and convenient EHTV indicators and energy consumption calculation method [12]. Although this article establish evaluation index system construction for China's energy made two preliminary recommendations, but its concrete expression and improve research has yet to be put in more work. Through a variety of evaluation as well as ideas and concepts to grasp the comprehensive application of these indicators, the eventual establishment of evaluation index system suitable for China's energy-efficient buildings, and in order to promote further development of China's building energy conservation work, to save energy and protect the environment play a positive role.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

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