

# Analysis and Evaluation of Carbon Emission in Materialized Stage of Prefabricated Building Based on Environmental Emission Reduction Strategy

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## Abstract

In recent years, due to the ecological quality requirements and environmental capacity constraints of prefabricated buildings in the economically developed southeast coastal areas, the transformation of traditional energy cooperation mode to new energy cooperation mode has been promoted. In the process of environmental energy saving prefabricated buildings emission reduction, the partners of cooperation shift from primary energy to secondary energy, and the carbon emission from energy processing mainly stays in the energy output prefabricated buildings. In today's world of total energy consumption control, the carbon emission right is closely related to the regional development right, and the traditional horizontal ecological compensation has not yet covered the compensation of carbon emission, so it is of far-reaching significance to study this. Based on the carbon compensation framework in energy cooperation and the carbon emissions generated, this paper discusses the carbon emissions generated by energy output prefabricated buildings and energy input under different energy cooperation forms.

## Article History

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## 1. Introduction

Global warming and the greenhouse effect are serious challenges facing mankind. More and more serious in recent years, global warming, low carbon environmental protection has become a human continuously in the pursuit of goals, and carbon emissions control has become the basic consensus of the international community, on the one hand, from the international point of view, the intergovernmental panel on climate change has been committed to the solution of global warming, actively carry out climate talks and negotiations about carbon reduction, also made a prominent contribution for the global greenhouse effect. Both developed and developing countries are actively fulfilling their responsibilities. The CDM project of the clean Development

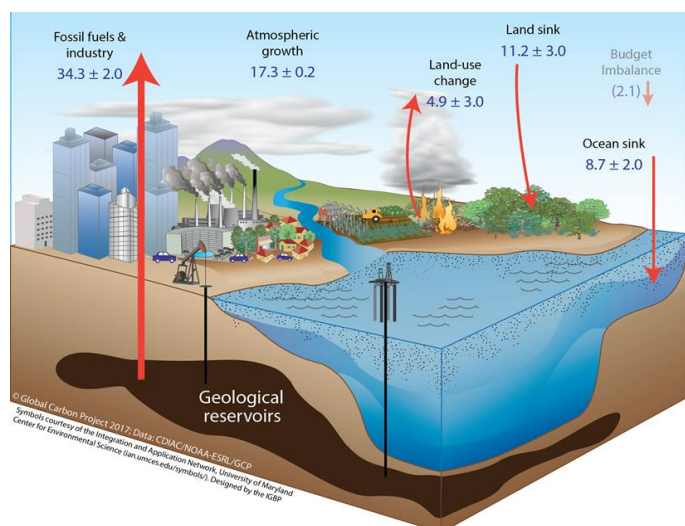
mechanism, the joint implementation mechanism between developed and developing countries and the emission trading mechanism are of great significance to the development of global emission reduction and energy conservation<sup>[1]</sup>. Looking at China's domestic situation, although China, as a non-Annex I country, does not undertake international emission reduction obligations at present, China is also actively participating in international negotiations and international cooperation on climate change, and fully participating in the negotiations of the United Nations Framework Convention on Climate Change as the main channel<sup>[2, 3]</sup>.

## 2. Based on the horizontal carbon compensation theory of environmental energy conservation and emission reduction projects and its practical basis

### 2.1. Definition of relevant concepts of carbon compensation

#### 2.1.1. Carbon offsets

Carbon offsets in the Oxford English dictionary are defined as follows: the so-called carbon offsets, refers to the people to calculate their daily activities directly or indirectly manufacture of carbon dioxide emissions, and calculate the offset the carbon dioxide needs, economic cost and individual pay specialized enterprises or institutions, by their offset by planting trees or other environmental protection projects corresponding carbon dioxide in the atmosphere, it is also a kind of universal environmental action. According to the PA S2060 Carbon neutral commitment issued by The British Standards Institute (BSI), carbon neutral refers to a state in which global greenhouse gas emissions reach zero net increase. The conceptual diagram of carbon offset is shown in Figure 1 below:



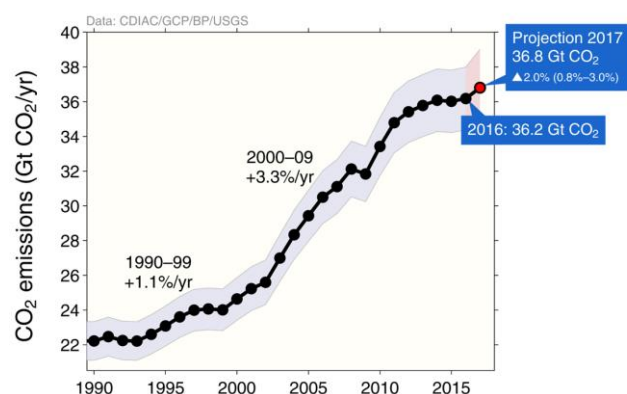
**Figure 1.** Global carbon emission and compensation structure from 2007 to 2016.

As shown in Figure 1, carbon compensation aims to achieve zero carbon emission through carbon emission reduction and carbon compensation based on the measurement of carbon emission. Liu Believes that the connotation of the concept of carbon neutrality is greater than carbon compensation,

including carbon compensation and carbon emission reduction. First of all, carbon emission reduction should be carried out by using renewable energy and improving efficiency. If the emission reduction cannot be achieved by existing technologies or the cost is too high, zero carbon emission should be achieved by purchasing carbon compensation<sup>[4]</sup>.

#### 2.1.2. Horizontal carbon compensation

Now, although the academic study of transverse had certain ecological compensation, but the academic study of transverse offset is still in a state of almost blank and transverse carbon offset is a relatively new idea, so the transverse offset hasn't a clear definition, this article only on the basis of the definition of carbon offsets, and combined with lateral the connotation of ecological compensation, lateral offset is defined as: Based on the determination of carbon emission responsibilities of "prefabricated buildings for energy production" and "prefabricated buildings for energy consumption", the subject and object of carbon compensation are defined, and the standard of carbon compensation is determined, and the form of horizontal financial transfer payment as shown in Figure 2 below is constructed.



**Figure 2.** Data deduction of carbon compensation from horizontal Angle.

In addition to the above 2 of this form of statistical inference, can also horizontal development project in the form of compensation of prefabricated building energy consumption through funds, elements of compensation, compensation policy, carbon emission rights to compensate for the way such as energy production of prefabricated building certain

compensation, so as to complete the prefabricated construction between the transverse carbon offsets, and implement the "justice" of carbon between the two prefabricated buildings<sup>[5, 6]</sup>.

## 2.2. Theoretical basis of horizontal carbon compensation based on environmental energy conservation and emission reduction projects

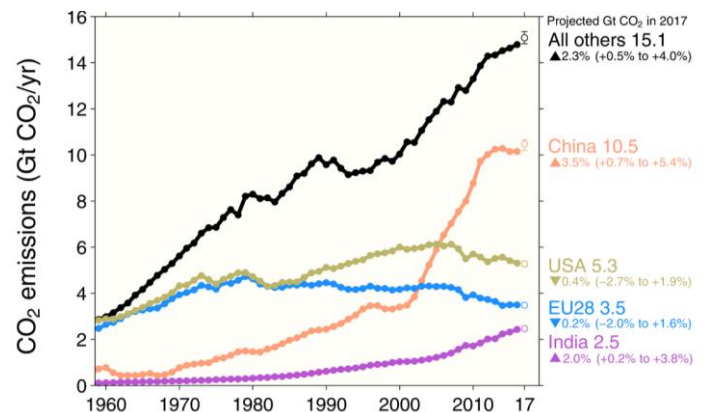
In the research process of horizontal carbon compensation mechanism based on environmental energy conservation and emission reduction projects, the main theoretical bases include: public goods theory, protection means and externality compensation theory, ecosystem service function value and ecological capital theory, efficiency and equity theory.

### 2.2.1. Theory of public goods

In economics, goods that meet both non-competitive and non-exclusive requirements are called public goods. Noncompetitive means that more people consume without increasing their marginal cost, or that the marginal cost is negligible, so that one person's consumption of a product does not prevent others from consuming the same product at the same time. Non-exclusivity is the inability to consume, or the high cost of charges, so that people can consume a commodity without paying a price. Public goods are provided to people at zero marginal cost, and no one is excluded from consumption.

### 2.2.2. Pigou method and externality compensation theory

If a person or an enterprise brings harm or benefits to other individuals or society when engaging in economic activities, but they do not pay corresponding remuneration for this, economics calls it externality, also known as externality theory, and its impact on the change of carbon emissions is shown in Figure 3 below:



**Figure3.** Illustration of externality compensation theory based on Pigou method.

As shown in figure 3, externality refers to the situation where an individual or an enterprise does not have to fully bear the cost of its decision or cannot fully enjoy the effect of its decision, that is, the cost or benefit cannot be fully internalized. Externality is divided into two types: negative externalities and positive externalities, individuals or firms do not have to bear the cost of its behavior is negative externalities, their behavior when to bring some benefits to themselves or to meet, to others or social interests in different degree of negative impact, but don't have to bear the cost of this kind of negative effect completely, thus constitute a negative externalities. To solve external problems, non-market approaches including government intervention are usually adopted.

## 3. Research on ecological compensation of prefabricated buildings and the dilemma of horizontal carbon compensation at home and abroad

### 3.1. Analysis of carbon emission compensation characteristics of prefabricated buildings based on energy cooperation

At present, there are two traditional ways of environmental energy conservation and emission reduction in China. One is to plan coal-fired power generation in energy-importing provinces; the other is to sign thermal coal contracts with energy-rich buildings to guarantee regional energy and power supply. But as the national energy consumption and

emissions control, further improve the energy conservation and emissions reduction requirements, the limitation of environmental capacity, the southeast coastal economically developed provinces from the beginning of the "11th five-year plan", actively promote the environment change the way of energy conservation and emissions reduction, some provinces began from the procurement of coal energy resource is scarce to rich in energy resources construction & coal mine, building pithead coal-fired power plants and coal gas project, thus formed the "positive output" clean energy, emission source "reverse migration" the characteristics of the data using the following formula can effectively analyze the compensation characteristics of the carbon emissions:

$$\text{CO}_2 \text{ emissions generated by activities} = \text{activity data} \times \text{emission coefficient (1)}$$

Among them:

Heavy oil discharge coefficient = 2.991 kgCO<sub>2</sub> /L

Diesel emission coefficient = 2.778 kgCO<sub>2</sub> /L

C2H<sub>2</sub> emission coefficient = 3.3846 kgCO<sub>2</sub> /L

Gasoline emission coefficient = 2.361 kgCO<sub>2</sub> /L

In the above formula, firstly, although co-construction of coal-burning power plants in pithole can reduce coal transportation and environmental pressure, the energy-exporting provinces leave the pollution of coal-burning power plants' production process behind. The second is the co-construction of a coal-to-natural gas project, in which coal is gasified into syngas and then methanated to produce alternative natural gas.

### *3.2. Challenges faced by horizontal carbon compensation between prefabricated buildings in energy cooperation*

Foreign scholars of prefabricated construction based on project transverse carbon offsets studies have been more thorough, the three mechanisms in Kyoto clean development mechanism (CDM) and joint implementation mechanism are based on project

research category of prefabricated construction of transverse offset, but energy cooperation are just part of the content, so the existing theoretical framework and the analysis method is not entirely suitable for our country energy cooperation between prefabricated construction of transverse offset problem.

### *3.3. Research on ecological compensation of prefabricated buildings*

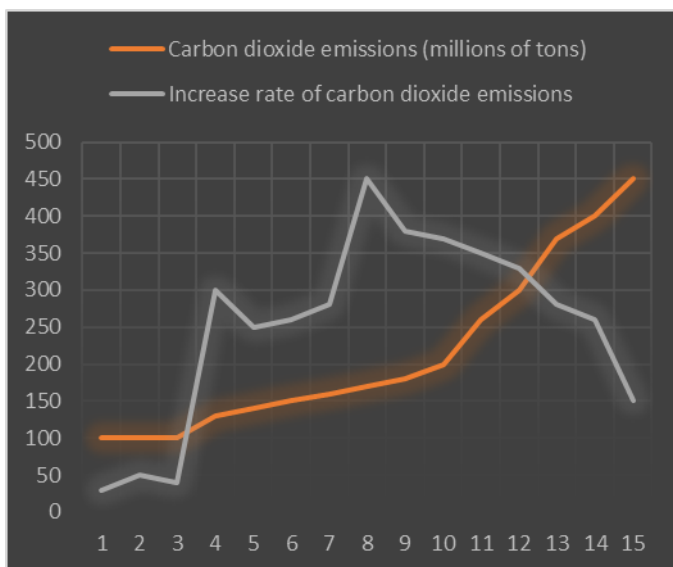
The Kyoto Protocol has established three flexible mechanisms: the joint implementation mechanism, the Clean Development Mechanism and the international emission trade. Among them, the CLEAN Development Mechanism refers to the way that developed countries provide funds and technologies, cooperate with developing countries, and implement GHG emission reduction projects in developing countries by means of funds and technologies, so as to reduce the GHG emissions of developed countries. Therefore, the CLEAN Development Mechanism, on the one hand, can reduce the cost of emission reduction for developed countries, on the other hand, it can also help developing countries to achieve sustainable development and contribute to the ultimate goal of the Convention. The joint implementation mechanism means that annex I countries offset their own carbon emission reduction obligations by comparing the lower domestic costs and then going to other Annex I countries to implement man-made projects that can reduce greenhouse gas emissions and enhance sink removal. The joint implementation mechanism is also a win-win mechanism. On the one hand, it can reduce the cost of emission reduction in one country, and on the other hand, it can help other Annex I countries to achieve emission reduction.

### **4. Overall characteristics of building carbon emissions in Shandong Province**

From 1998 to 2012, the building carbon emissions of Shandong Province increased year by year, From 104.8039 million tons in 1998 to 45.71 million tons in 2012, And it increased by 4.31 times in 15 years. The growth rate of carbon dioxide emissions has



experienced a trend of rising and then growing. Increasing rate of carbon emissions has been increasing continuously, from -1.93 percent in 2005 to 31.32 percent in 2005. From 2005 to 2012, the growth rate began to decline, 13. This is because the Shandong provincial government in the "Eleventh Five-Year Plan" and "Twelfth Five-Year Plan" overnight puts forward the requirements of energy saving and emission reduction. After the implementation of the policy, some achievements have been achieved. As shown in Figure 4.

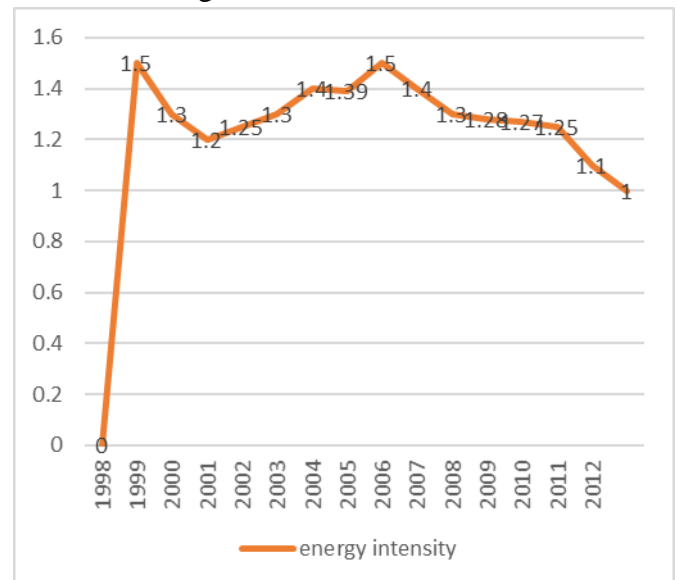


**Figure 4.** Total change of carbon emissions in Shandong Province.

Since 1998, it has not changed on the energy consumption structure of Shandong Province. According to the average proportion of energy consumption from 1998 to 2012, the proportion of coal, Thus oil and natural gas are 77.85%, 21.01% and 1.14% respectively. From the carbon emissions of the three major energy consumption in the past 15 years, the average carbon dioxide emissions from coal, Thus oil and natural gas combustion, they three-year for 79.23%, 20.64% and 0.13% of the total emissions. coal consumption is the main source of carbon dioxide emissions in Shandong Province.

From 1998 to 2005, the intensity of carbon emissions remained basically unchanged, between 118 tons/10,000 yuan and 139 tons/10,000 yuan. After 2005, the intensity of carbon emissions began to

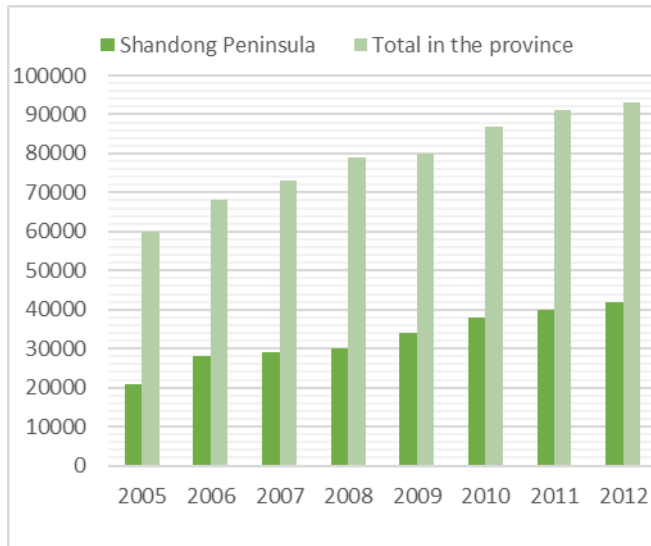
decline, The from 139 tons / 10000 yuan in 2005 to 81 tons / 10000 yuan in 2012. The Carbon emission intensity is usually regarded as an important indicator of technological progress, which are that since 2005, Shandong Province has begun to implement low-carbon technology, and achieved some results. As shown in Figure 5.



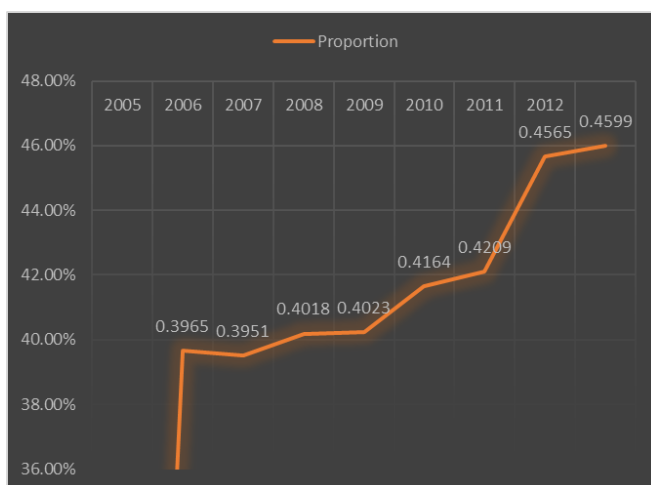
**Figure 5.** Change of Carbon Emission Intensity in Shandong Province from 1998 to 2012.

Total carbon emissions can intuitively reflect the low-carbon development level of a region. From 2005 to 2012, The carbon emissions of Shandong Peninsula and Shandong Province were increasing by year. In 2005, the carbon emission of Shandong Peninsula was 235.343 million tons, And that of Shandong Province was 593.586 million tons. In 2012, the carbon emissions of Shandong Peninsula would increase to 430.265 million tons, And that of Shandong Province would increase to 935.524 million tons. It can be seen that in recent years, the growth of carbon emissions is relatively fast. In addition, in 2005, Making Peninsula's carbon emissions for only 39.65 percent of Shandong's total emissions for three years. By 2012, Dry Peninsula's carbon emissions for three years of the province's total. From the growth trend, it can be divided into two stages. Before 2009, it remained about 40% on the proportion of carbon emissions in Shandong Peninsula. After 2009, this proportion began to rise

rapidly, especially in 2011. In this year alone, It increased by 3.56 percentage points on the proportion of carbon emissions in Shandong Peninsula. As shown in Figure 6 and Figure7.



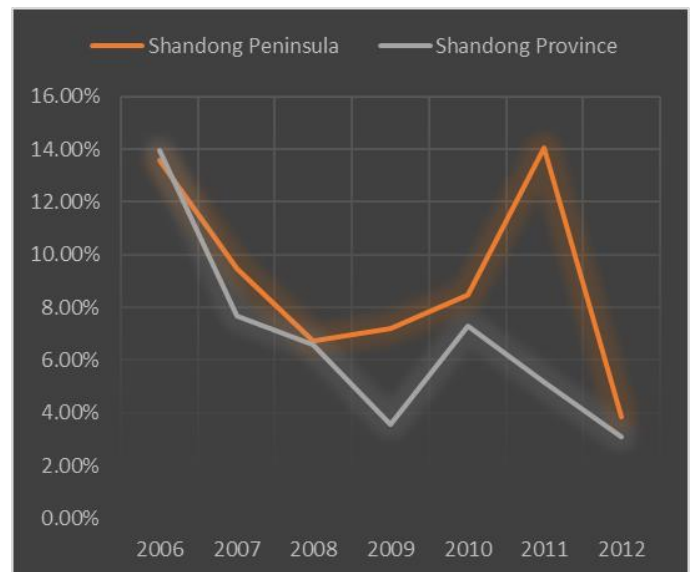
**Figure 6.** Total Carbon Emissions in Shandong Peninsula and Shandong Province.



**Figure7.** Total Carbon Emissions in Shandong Peninsula and Shandong Province.

In general, It decreased from 13.59% in 2006 to 3.86% in 2012 on the growth rate of carbon emissions in Shandong Peninsula. It is decreased from 13.97% in 2006 to 3.08% in 2012 on the growth rate of carbonemissions in Shandong Province. Both of them showed a downward trend. But with 2009 as the boundary, it is divided into two parts. Before 2009, it was basically the same to the growth rate of carbon emissions in Shandong Peninsula and Shandong Province. Since 2009, the growth rate of carbon

emissions in Shandong Peninsula is significantly higher than that in Shandong Province. Especially in 2011, The growth rate of carbon emissions in Shandong Peninsula is 8.88 percentage points higher than that in Shandong Province. This phenomenon is probably related to the proposal of Blue Economic Zone inShandong Peninsula. The Blue Economic Zone of Shandong Peninsula was officially proposed in 2009. In 2011, the State Council formally approved the Development Plan for the Blue Economic Zone of Shandong Peninsula. The construction of Shandong Peninsula Blue Economic Zone has formally risen to the national strategy. The accelerated economic development of Shandong Peninsula will inevitably bring about a rapid increase in carbon emissions. Therefore, Shandong Peninsula urgently needs to explore the path of low-carbon development. As shown in Figure8.



**Figure8.** Growth Rate of Carbon Emission in Shandong Peninsula and Shandong Province.

## 5. Conclusion

In recent years, due to the southeast coastal developed areas of ecological quality requirements and environmental capacity restriction, promote the environment change the way of energy conservation and emissions reduction, from coal conveying between prefabricated construction into building pithead coal-fired power plants and coal gas project, thus formed the "positive output" clean energy,

emission source "reverse migration" characteristics. As a direct result, the total carbon emission of buildings with energy output will increase and the environmental pressure will increase, while the pressure of ecological environment will be reduced for buildings with energy input. Therefore, the horizontal carbon compensation in the process of environmental energy saving prefabricated building emission reduction has attracted the attention of the academic circle, as well as the accounting of carbon emission in the process of cooperation and the allocation of emission rights and quotas.

Therefore, based on the quantitative accounting of carbon emission in the process of environmental energy saving prefabricated building emission reduction, we should formulate reasonable horizontal carbon compensation standards, study the horizontal carbon compensation mode and compensation approaches based on environmental energy saving and emission reduction projects, and then construct the horizontal carbon compensation mechanism based on environmental energy saving and emission reduction projects in China. However, since China's carbon emission trading market has not yet been formed, carbon compensation has not been promoted nationwide, and a scientific and reasonable carbon emission standard and accounting system has not been formed. Therefore, it is urgent and difficult to build a horizontal carbon compensation mechanism based on environmental energy conservation and emission reduction projects in China, which needs further in-depth study.

## References

- [1] Han Y, Long C, Geng Z, et al. Carbon emission analysis and evaluation of industrial departments in China: An improved environmental DEA cross model based on information entropy[J]. *Journal of Environmental Management*, 2017, 205(jan.1):298-307.
- [2] Feng D, Xiao-Yan L, Ru-Yin L, et al. Analysis of Carbon Emission Efficiency in China Based on Three-Stage DEA Model[J]. *Operations Research and Management Science*, 2014.
- [3] Ying-Bo J I, Qi Z, Fa-Dong Z. A Embodied Carbon Emission Calculation Model for China's Prefabricated Residential Buildings: A Process-Based LCA Method[J]. *Journal of Engineering Management*, 2017.
- [4] Sun Y, Liu J, Xia B, et al. Study on Carbon Emission Evaluation of Prefabricated Building at Materialization Stage[J]. *Shenyang Jianzhu Daxue Xuebao (Ziran Kexue Ban)/Journal of Shenyang Jianzhu University (Natural Science)*, 2018, 34(5):881-888.
- [5] Rong T, Zhang P, Jing W, et al. Carbon Dioxide Emissions and Their Driving Forces of Land Use Change Based on Economic Contributive Coefficient (ECC) and Ecological Support Coefficient (ESC) in the Lower Yellow River Region (1995–2018)[J]. *Energies*, 2020, 13.
- [6] Yamada K, Ishiyama S. 1499 Proposition of Evaluation Method Based on Materials Cost for Calculation of Carbon Dioxide Emission from Buildings[C]// *Summaries of Technical Papers of Meeting Architectural Institute of Japan A*. Architectural Institute of Japan, 2005.