Chapter 6
Measures of Developing Low-Carbon Building in China and Analysis of the Relative Evaluation Indexes

Jun Yang

Abstract It is very difficult to develop low-carbon economy in China, and it is an important part of decreasing the carbon emissions of the construction industry. For better development of low-carbon buildings, this paper puts forward some measures including developing low-carbon technology, perfecting legal system constantly, introducing necessary economic measures, advertising and promoting low-carbon life, strengthening low-carbon consulting services. This paper also points out that it is necessary to establish a reasonable housing security system to guide the healthy development of real estate industry. This paper suggests to overall considerate the development of low-carbon building by bringing building into the community or town category. Finally we discuss the relevant evaluation index of low-carbon building.

Keywords Low-carbon building • Measures • Evaluation index

6.1 Introduction

As the continuous growth of global population and economic scale, the environment problems due to energy use are recognized unceasingly. Especially the global warming becomes a serious threat to human's survival and development, and reducing carbon emissions has become a global target. The United Nations puts forward to cut 60 % of the carbon emissions by 2050.

China has paid much attention to the work about climate change, and has issued a series of laws and regulations. The *2009 China's Sustainable Development Strategy Report* by Chinese Academy of Sciences in March 2009 proposes that

J. Yang (✉)
School of Construction and Environmental Engineering,
Shenzhen Polytechnic, Shenzhen 518055, China
e-mail: tritonyj@yahoo.com.cn

J. Wang et al. (eds.), *Proceedings of the 17th International Symposium on Advancement of Construction Management and Real Estate*,
DOI 10.1007/978-3-642-35548-6_6, © Springer-Verlag Berlin Heidelberg 2014

China's energy consumption of per unit GDP will reduce 40–60 % in 2020 than in 2005, and CO_2 emissions of per unit GDP will reduce 50 % or so (with an average annual 3.33 % reduction) [1]. China's task of developing low-carbon economy is very difficult.

The construction industry is one of the main industries which consumes resources and energy, and is also an important cause of the greenhouse effect. At present the building energy consumption accounts for one third of the total energy consumption of the whole society in China, and it is already become the three major energy consumptions together with industrial energy consumption and traffic energy consumption. China's level of building energy conservation is far behind the developed countries, and 99 % of the existing nearly 43 billion m^2 building is belong to high energy consumption building. Now more than 95 % of the new building is still belong to high energy consumption building. If strong measures were not taken, China's building energy consumption will be three times higher in 2020 than now. Research shows that the potential of greenhouse gas emission reduction is huge and the cost is lower in the construction industry. Developing low-carbon building and promoting low-carbon development of real estate industry have positive role to reduce carbon emissions and reduce global warming, and it becomes an important aspect of developing low-carbon economy in China.

6.2 Measures of Developing Low-Carbon Building in China

6.2.1 Pay Special Attention to Basic Work of Low-Carbon Building Development

1. Vigorously develop low-carbon technology

   The development of low-carbon building first needs the support of low-carbon technology. The life cycle of building consists of materials production, construction design, construction, use and the demolition. Development of low-carbon building needs technological change of the upstream and downstream relevant work. As the idea of low-carbon building is new, the level of low-carbon technology in China is still in the primary stage, and has a large gap with the developed countries. The government should advocate and support the research of low-carbon technology, encourage building materials enterprise to improve energy efficiency by improving existing energy technology, and promote using low-carbon materials and equipment; strengthen international exchanges and cooperation, research in low-carbon design and construction technology; develop solar energy, wind energy, biomass energy, geothermal energy and other new energy technology according to local conditions, and increase the use of renewable energy; study energy saving transformation technology of

old buildings, and decrease the cost of reform. Through establishing good cooperation mechanism between research institutions and related enterprises, speed up the transformation and application process of low-carbon technology. These areas of technology development can lay solid foundation for the development of low-carbon building.

2. Constantly perfect the legal system

   The United States, Japan, the European Union and other countries have issued relevant laws and regulations, and let them land on feet to promote the sustainable development of buildings [2]. This provides a good reference for China to promote low-carbon building. At present only related laws and regulations on building energy efficiency and green building are issued in China, almost no special laws or standards on low-carbon building are issued, therefore a set of perfect low-carbon building legal system is needed to set up. First, the authentication and evaluation system of the low-carbon building materials and equipment is needed; secondly, we need to design standards, construction and acceptance standards of low-carbon building, then to promulgate evaluation standard of low-carbon building, and strengthen the approval and supervision in building land supply, planning and design, select of material and construction [3]. Rewards and punishment on low-carbon building should be issued to clear the responsibility, right and interest of the participants of low-carbon building. Clear laws and regulations are needed to effectively provide proper guidance for real estate developers and the ordinary citizen, and promote the development of low-carbon buildings.

6.2.2 Do Indemnificatory Work Well Which Is in Favor of Low-Carbon Building Development

1. Introduce the necessary economic measures

   Cost increasing is one of the main reasons why most domestic real estate developers don't want to develop low-carbon real estate. According to the measurement, developing buildings of 50 % energy-saving needs to increase 10 % of construction cost. At present in China, the construction fund of low-carbon building is paid by the developer, and because of market uncertainty, the investment of developer is lack of security. If there is not relevant policy guide and inspire, the developer's enthusiasm of investing low-carbon building cannot be aroused. The government shall develop policy and subsidies those economic subjects which actively construct low-carbon building. The government shall give taxation, finance preferential and support to low-carbon industry and enterprise, consider reducing real estate taxes fcbd or the residents who buy low-carbon building products, and encourage consumers to buy low-carbon buildings, so as to promote the spread and application of low-carbon building.

2. Advertisement and promotion low-carbon life

   Promotion of low-carbon building is inseparable from the extensive publicity. The government should propagate and promote low-carbon building, and make the idea of low-carbon life supported by most people, and improve social approval of low-carbon life. On one hand, it can improve the developer's social responsibility of constructing low-carbon building. On the other hand, it can improve the consumer's cognitive and approval degree on low-carbon building, and let them to take the initiative to buy low-carbon building. Thus it can guarantee a good development trend of supply and demand situation of low-carbon building. With the development of China's economy, people's living standards gradually improved, the carbon emissions of building have a growing trend in using stage. It is needed to popularize the related knowledge of carbon emissions in using stage, guide and encourage the residents to practice low-carbon lifestyle in daily life, so as to save resources and energy effectively and reduce carbon emissions.
3. Strengthen the low-carbon consulting services

   The government should foster low-carbon consulting services agencies to solve the issues on carbon emissions of the low-carbon building for all participants, including carrying on the consultation of national low-carbon policy for enterprise, providing low-carbon technology training and guiding the enterprises to choose low-carbonization solutions, evaluating the low-carbon level of enterprise, etc. At the same time the low-carbon consulting service agencies will also face ordinary citizens, and roll out low-carbon household consulting services. On one hand, they popularize the low-carbon knowledge, and on the other hand, they solve citizen's questions on carbon emissions in daily life, and help them to measure the carbon, and provide low-carbon technical services.

6.2.3 Optimize the External Environment for the Development of Low-Carbon Building

1. Establish a reasonable housing security system to guide the healthy development of real estate industry.

   The government should strengthen land supervision, restrain land speculation, and strictly control the land supply. It is necessary to adjust the land supply structure and give priority to ensuring the development of low-carbon building block [4]. Land vacant tax is needed to improve the investment cost of hoarding and encourage the holder to invest positively. Improve housing guarantee system, strengthen the construction of affordable housing, Do low-carbon building demonstration by popularizing and using low-carbon technology in the affordable housing first. Strengthen the supervision and management on allocation and using stage of affordable housing, and actively develop housing rental market to prevent overheating in housing prices and guide residents to consume rationally housing, and lower housing vacancy rate.

2. Overall considerate the development of low-carbon building by bringing building into the community or town category

   "The twelfth five years" Core Problem Research Report is released in Beijing on October 17, 2009 pointed out that low-carbon cities construction will guide direction for the city's development in "the twelfth five years" period.

   The Ministry of Finance, Ministry of Housing and Urban-Rural Development and National Development and Reform Commission jointly issued the notice about pilot demonstration of the first batch of green and low-carbon small towns on September 26, 2011.

   Construction of Low-carbon city is a systematic engineering, and it implies all aspects of human life. And healthy development of low-carbon construction industry is an important part of the construction of low-carbon cities. We should regard ecological city construction as the turning point, and actively promote the system construction and innovation of low-carbon building, and establish the dominant role of low-carbon building in the urban and rural construction in the future, and create good external environment for the overall development of low-carbon building [5]. In practice, the construction of low-carbon cities and low-carbon building should reference each other and promote each other.

6.3 Evaluation Indexes of Low-Carbon Building

1. The amount of CO_2 emissions reductions and CO_2 emission reduction rate in the total life cycle

   The amount of the total CO_2 emissions of the life cycle can be achieved by summarizing CO_2 emissions of each stage of low-carbon building life cycle. With reference building to the selected, calculating respectively CO_2 emissions of low-carbon building and reference building, CO_2 emission reductions ΔP of the low-carbon building in the total life cycle can be determined according to the difference. At the same time, CO_2 emission reductions rate R of the low-carbon building in the total life cycle can also be calculated.

$$\Delta P = P_0 - P \tag{6.1}$$

$$R = \frac{\Delta P}{P_0} \tag{6.2}$$

   In the formula, P_0 and P is respectively CO_2 emissions of low-carbon building and reference building.

2. CO_2 emissions of the unit area and annual average CO_2 emissions of the unit area

   CO_2 emissions of the unit area $\bar{P}$ is the ratio of the total Life cycle CO_2 emissions of building and the building area. Annual average CO_2 emissions of

the unit area $\bar{P}_a$ is the ratio of CO_2 emissions of the unit area and service life of building, and it brings service life of building into consideration range.

$$\bar{P} = P/S \tag{6.3}$$

$$\bar{P}_a = \bar{P}/n = P/(S \times n) \tag{6.4}$$

In the formula, P is the total life cycle CO_2 emissions of building; S is building area; n is service life of building.

3. Incremental cost for emission reduction

   Incremental cost for emission reduction is an index which can evaluate the effect of CO_2 emissions reduction of different low-carbon building schemes and help to choose the scheme with the minimum cost through cost analysis of all schemes that can realize CO_2 reduction target [6]. Incremental cost for emission reduction is the ratio of incremental cost and the amount of CO_2 emissions reduction in the total life cycle. It can evaluate an emissions reduction technology, and it also can evaluate the whole building.

$$C_i = \frac{\Delta C}{\Delta P} \tag{6.5}$$

   In the formula, C_i is the incremental cost for emission reduction; ΔC is incremental cost in the total life cycle; ΔP is the amount of CO_2 emissions reduction in the total life cycle. It states the cost of CO_2 emission reduction is smaller if C_i is smaller.

4. Relative CO_2 payback time

   Relative CO_2 payback time is the time with annual CO_2 emissions reduction in the using stage to counter increased CO_2 emission in the initial building stage [7]. The index can evaluate an emissions reduction technology, and it also can evaluate the whole building.

$$CPT = \frac{\Delta P_1}{\Delta P_2} \tag{6.6}$$

   In the formula, CPT is relative CO_2 payback time; ΔP_1 is increased CO_2 emission in the initial building stage; ΔP_2 is annual CO_2 emissions reduction in the using stage. Relative CO_2 payback time should be less than service life of building or equipment. It states the effect of CO_2 emission reduction is better if CPT is shorter.

5. Benefit of CO_2 emissions reduction

   Carbon budget can be stated by two methods. One method is to use the CO_2 emissions equivalent, and the other is to monetize the value of the carbon. With the implementation of the Kyoto protocol, carbon trading market is developing rapidly. It is predicted that the global carbon trading market will reach $3.5 trillion by 2020, and developing countries are becoming leading role of carbon

seller's market [1]. As China gradually assume corresponding obligation of carbon emissions reduction, it will be imperative to bring economic benefits of CO_2 emissions reduction into economic evaluation scope.

The benefit of CO_2 emissions reduction of Low-carbon building in the life cycle is monetized by calculating respectively CO_2 emissions reductions of each stage and combining carbon market price. The benefit of CO_2 emissions reduction of Low-carbon building in the life cycle I_{CO_2} is

$$I_{CO_2} = P_{CO_2}(\Delta P_M + \Delta P_P + \Delta P_C) + \sum_{j=1}^{n} P_{CO_2}(1+\beta)^j \Delta P_{Uj}(P/F, i, j) + P_{CO_2}(1+\beta)^n \Delta P_F(P/F, i, n) \tag{6.7}$$

In the formula, P_{CO_2} is the CO_2 market price in the initial building stage; β is annual growth rate of CO_2 market price(assume uniform growth); $\Delta P_M, \Delta P_P$ and ΔP_C is respectively the amount of CO_2 emission reductions in materials production and transport stage, design and construction preparation stage and construction stage; ΔP_{Uj} is the amount of CO_2 emissions reductions of the j year in use and maintenance stages; ΔP_F is the amount of CO_2 emissions reductions in demolishing and reclaim stage; n is service life of building.

Because international carbon market price is not stable and CO_2 market price and its annual growth rate have great influence on the benefits of CO_2 emissions reductions, sensitivity analysis should be did to these two aspects for better understanding the benefits of CO_2 emissions reductions.

6. The ratio of renewable energy in total energy

The ratio of renewable energy in total energy is the ratio of the total amount of used renewable energy and total used energy. The index can let users have direct-viewing understanding to the energy situation of the buildings, and it is good for users to accept and approve low-carbon building.

$$R_E = \frac{E}{E_n} \tag{6.8}$$

In the formula, R_E is the ratio of renewable energy in total energy; E and E_n is respectively the amount of used renewable energy and total used energy.

7. Per capita CO_2 emissions

The index compares the CO_2 emissions with personnel quantity. The index shows the fair between people, and helps people to choose the suitable low-carbon buildings.

$$\bar{P}_P = P/(N_P \times n) \tag{6.9}$$

In the formula, $\bar{P}_P$ is per capita CO_2 emissions; P is the total Life cycle CO_2 emission of building; N_P is personnel quantity of using the building; n is service life of building.

8. Cost savings amount of standard year in the using process of building and increased investment payback time of low-carbon technology

   Cost savings amount of standard year is the difference of every year cost between with low-carbon technology and without low-carbon technology in use process of the building. The index makes the benefit of low-carbon technology clear.

   Increased investment payback time is the needed time with saving of using cost by low-carbon technology to counter initial increased investment. It can measure investment profitability and capital recovery speed of the low-carbon technology. When annual saving of using cost is equivalent, it can be calculated by using the following formula (dynamic).

$$\Delta P_t^* = \frac{\lg \frac{\Delta C}{\Delta C - \Delta I \times i_c}}{\lg(1 + i_c)} \tag{6.10}$$

   In the formula, ΔP_t^* is dynamic increased investment payback time, ΔC is annual saving of using cost; i_c is benchmark discount rate; ΔI is the initial increased investment. Increased investment payback time is the shorter, the better.

6.4 Conclusions

It has becomes a global goal to decrease the carbon emissions in the global warming and shortage of energy resources. The potential is huge to decrease carbon emissions in construction industry and the cost is relatively low, and developing low-carbon building is an important component of developing low-carbon economy in China. In the current situation, China needs to take measures to ensure the good development of low-carbon buildings by developing low-carbon technology, and constantly perfecting the legal system, introducing the necessary economic measures, advertising and promoting low-carbon life, strengthening low-carbon consulting services. It is an important aspect to establish a reasonable housing guarantee system to guide the healthy development of real estate industry. China should take low-carbon cities construction as the turning point, and overall considerate the development of low-carbon building by bringing building into the community or town category. The evaluation index can provide important reference for people to choose and construct low-carbon buildings; the paper finally analyses and puts forward several relevant evaluation indexes of the low-carbon building.

Acknowledgments The research was supported by Guangdong Social Science Funds (GD10JYY04) and Shenzhen Polytechnic University Research Fund (2209S3080002).

References

1. Zeng J (2009) Strategic thinking of developing low-carbon economy. Theory Res 4:16–19
2. Liu X, Ren S, Xie J (2011) A comparative study of international experience on low-carbon buildings promotion mode. Ecol Econ 11:96–101
3. Zhang S, Zhao F (2010) A study of market operation mode of low-carbon building market in China. Constr Econ 2:50–52
4. Liu B, Xu W, Wang J (2010) An analysis of transmutation of real estate development in low-carbon economy. Bus Econ 10:1–2
5. Deli Y, Tong C (2011) Association study of low-carbon buildings and ecological city. Shandong Soc Sci 12:128–131
6. Liang Y-j, Fan J-c (2004) The benefit of renewable energy power generation technologies to the reduction of the greenhouse gas emission. Renew Energy 1:23–25
7. Ma M-z, Zhang X (2007) Research on the benefits of energy conservation and emission reduction of ground source heat pump using LCA method. Energy Conserv 8:8–9