

# Discussion on low-carbon economy and low-carbon building technology

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Received 11 May 2009; revised 20 May 2009; accepted 26 May 2009.

## ABSTRACT

The paper introduced low-carbon economy and low-carbon technology, and proposed the detailed technical measures of low-carbon building technology. Moreover, it has quantitatively calculated the “implicit” CO<sub>2</sub> emission of C40 and C50 concrete columns, aluminium curtain wall, wall paintings and common floor decoration materials. The calculation results show that it is preferable to use high strength concrete, reduce the usage of aluminium materials and use wooden floor according to location. The paper can be a reference for quantitative measurement to the low-carbon technology and energy efficiency.

**Keywords:** Low-Carbon Economy; Low-Carbon Technology; Building Technology; Quantitative Calculation

## 1. INTRODUCTION

The British energy white paper “Our Energy Future-Creating a Low Carbon Economy” firstly introduced the concept of “Low-carbon Economy” [1]. This concept means that the developed industrial country should use the production technology that reduces the emission of CO<sub>2</sub>, so as to protecting the environment while maintaining the economic growth. The CO<sub>2</sub> and ozone etc. in the aerosphere can absorb the radiant heat from sun and preventing its escape from the earth, therefore empowering the aerosphere of the natural greenhouse effect. When the density of greenhouse gases such as CO<sub>2</sub> raises, the absorbed radiant heat will increase and the heat given out by the earth will be reduced, thus resulting in global warming. Global warming will melt the glacier, raise the sea level, reduce the continental area, silt up harbors and destroy the marsh land and river plain, as a result bringing great negative effects to the eco-

nomics of coastland area. Moreover, global warming will shift the climate zone to high latitude, change the ecosystem in certain area and increase infectious diseases and the consumption of ozonosphere [2].

White paper: China's policies and actions on climate change [3] issued by the Chinese government has indicated that, the average temperature of the earth surface in China has increased by 1.1 °C during the last 100 years. For the last 30 years, the sea level has increased by 90mm on average. For example, the 《Assessment Report on Climate Change of Guangdong》 [4] issued by the weather bureau of Guangdong Province in 2007 forecast that, in the background of global warming, the emission of greenhouse gases such as CO<sub>2</sub> will be doubled in Guangdong Province, and the sea level will increase by 30cm (compared with the highest level in record), which is quite serious.

China is one of the first signing countries of 《Kyoto Protocol》, but it has not assumed its responsibility in reducing the emission of gas since it is still a developing country. However, China has a growing power in the economic world, and as a responsible major country China has to face the question of reducing the emission of greenhouse gases and develop a low-carbon economy during its economic growth.

The low-carbon technology has relationships with electricity sector, transportation sector, construction sector, chemistry industry and many other new technologies. Price L. *et al* [5] and Kim Y [6] have studied the energy demand and CO<sub>2</sub> emission of Chinese steel industry; and Yang J X [7] have conducted bill analysis over the life cycle of steel industry. Low-carbon building technology is a multi-disciplined subject. Based on the building design and selection of building materials, the paper adopts the life cycle assessment to quantitatively analyze the emission of CO<sub>2</sub> and studies the low-carbon building technology, in expecting to provide a brand-new angle for energy saving and green building.

## 2. ENERGY SAVING AND EMISSIONS REDUCTION

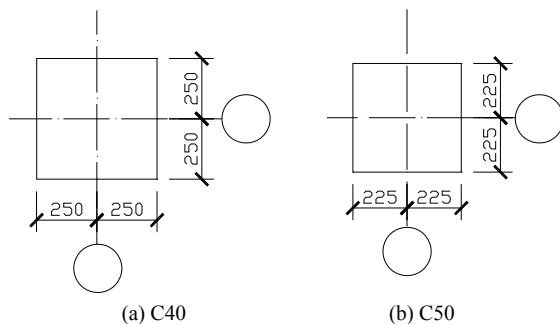
Energy saving in buildings relates to building planning, building design, retaining structure, heating system, air-conditioning system design, lighting system and many other sectors [8]. At present, many energy saving methods have been carried out in construction projects, including heat preventing technology in surrounding structure, usage of solar power and wind power, energy saving in temperature control, and enhancing energy saving management; they all have a positive impact on energy saving and emission reduction [9,10,11]. However, the author of this article feels that all these works are “explicit” energy saving and carbon reducing works; for example, the heat preventing technology in surrounding structure puts more attention to the energy saving during the running of buildings. But they have not considered the massive consumption of building materials and energy during the construction of the project, the massive emission of greenhouse gases such as CO<sub>2</sub> during the collection, artificial work and transportation process. Low-carbon emission measures should also be taken to them, and these measures can be called “implicit” carbon reducing measures. In this sense, low-carbon building technology should take into consideration of both the “explicit” and “implicit” low-carbon technology.

## 3. LOW-CARBON BUILDING TECHNOLOGY

From the point of low-carbon building technology, it should be taken into consideration of choosing materials and components with lower carbon emission during the designing and construction process.

### 3.1. Low-Carbon Technology in Structure Designing

The paper takes the ground floor structure of a five-story frame structure industrial workshop of a chemical factory as the example. It compares the C40 concrete with the C50 concrete through the PKPM structure designing software, both of which are under the same structure load and seismic designing requirement. And the change in sectional area are shown in **Figure 1**, when C40 has



**Figure 1.** Section of concrete columns.

been upgraded to C50 with the same amount of reinforcements; and the length of each side in section has been reduced by 50mm in most of columns.

The mixed ratios of concrete used by this article have been listed in **Table 1**. The CO<sub>2</sub> emission of concrete production is 1041.6kg CO<sub>2</sub>/t [12]. According to the investigation of building materials procurement in Wuhan, the transportation distance of concrete used by the concrete batching plant is 50km~200km; which is taken as 100km for the convenience of following calculation. The transportation distance for sand and gravels is 50km, and the distance for concrete from the concrete batching plant to the construction site is 50km; moreover, according to references [13], the energy consumption of sand and gravel is 13.89 kw·h/t, and that of concrete is 2 kw·h/m<sup>3</sup>. All the materials will be transported by 5 t trucks, and the amount of CO<sub>2</sub> emission during the transportation and electricity production is referred to reference [14]. The CO<sub>2</sub> emission calculation of 1m<sup>3</sup> concrete in using the bill analysis (a type of life cycle assessment method) under the two strength levels have been listed as follows.

Through the calculation, when the columns in ground floor using the C40 concrete, the quantity consumed is 30.996m<sup>3</sup>, and the CO<sub>2</sub> emission is 15994kg; when using the C50 concrete, the quantity consumed is 25.389m<sup>3</sup>, and the CO<sub>2</sub> emission is 15193kg. The consumption of concrete has been reduced by 5.607m<sup>3</sup>, or 18.1%; and CO<sub>2</sub> consumption has been reduced by 801kg, or 5.0%. In increasing the strength of concrete, the consumption of concrete and CO<sub>2</sub> emission can be largely reduced. Therefore, high strength concrete should be preferable, with the satisfaction to structure safety and designing requirement.

**Table 1.** Mixed ratio of concrete.

Concrete Strength Level	Cement grade	Mixed ratio/(kg/m <sup>3</sup> )			
		cement	sand	crushed rock	water
C40	525	460	720	1080	185
C50	525	540	655	1070	185

**Table 2.** CO<sub>2</sub> emission of C40 and C50 concrete columns(kg/m<sup>3</sup>).

Concrete Strength Level	C40	C50
Cement production	479.1	562.5
Cement transportation	1.1	1.3
Aggregate acquisition	28.5	27.3
Aggregate transportation	2.1	2.1
Concrete mixing	2.3	2.3
Concrete transportation	2.9	2.9
Total	516.0	598.4

### 3.2 Low-carbon Technology in Building Materials

The building components can be made from various building materials, while the “implicit” CO<sub>2</sub> emission differs during the production of different building materials. The paper adopts the BEES assessment software developed by National Institute of Standards and Technology to calculate the “implicit” CO<sub>2</sub> impact of different building materials. BEES (Building for Environmental and Economic Sustainability, BEES) is a comprehensive evaluation software over the construction environment and sustainability, and has been supported by the Association of American Environment Protection and U. S. Government [15]. It uses the Life Cycle Assessment (LCA) to quantitatively assess the environmental performance of building materials.

#### 3.2.1. Comparison Between Aluminium Curtain wall and wall Paintings

There are enormous consumption of fossil fuel and CO<sub>2</sub> emission in the production process of aluminium materials, and the energy consumption is 435GJ/t while carbon emission is 8700kg/t; but the figures in the production of steel materials are only 35GJ/t and 700kg/t, both of which are 1/12 of that of aluminium materials [16]. Therefore, the usage of aluminium materials should be reduced, and other green materials should be adopted. This article has conducted a calculation over the aluminium curtain wall of a university refectory project, and has analyzed the difference of CO<sub>2</sub> emission by switching to common wall paintings.

The “implicit” CO<sub>2</sub> emission of 1m<sup>2</sup> aluminium curtain wall and common wall paintings have been calculated out by BEES software. For the convenience of calculation, it has been assumed that the transportation distance for both of them are 200km with a life span of 50 years, then the quantity of CO<sub>2</sub> emission are shown as follows.

As a result, the CO<sub>2</sub> emission of aluminium curtain wall is far larger than that of common wall paintings. The quantity of aluminium curtain wall in this refectory project is 2519m<sup>2</sup>, but if using the common wall paintings it will reduce 34476kg CO<sub>2</sub> with an 85% reduction rate.

**Table 3.** Comparison between aluminium curtain wall and wall paintings (gCO<sub>2</sub>/m<sup>2</sup>).

life cycle stage	Raw materials	Manufacturing	Transportation	Total
aluminium curtain wall	14131	1878	40	16050
wall paintings	1755	566	42	2364

**Table 4.** Comparison of floor decoration materials (gCO<sub>2</sub>/m<sup>2</sup>).

life cycle stage	Raw materials	Manufacturing	Transportation	Total
Composite marble tile	25953	334	1679	27966
Terrazzo flooring	26878	0	947	27836
Wool carpet tile	415673	2314	237	418213
Natural cork tile	6006	3262	301	9580

#### 3.2.2. Indoor Floor Decoration Materials

Floor decoration material has been a major part of the total consumption and cost of a decoration project, thus the choices of materials have a close relationship with the “implicit” CO<sub>2</sub> emission and indoor environment. This article has selected several common indoor floor decoration materials, and used the BEES software to calculate the “implicit” CO<sub>2</sub> emission of 1m<sup>2</sup> indoor floor decoration materials for 50 years life span. For the convenience of calculation, it has been assumed that, the transportation distance of the material is 400km with a life span of 50 years, then the quantity of their CO<sub>2</sub> emission are as follows.

It is obvious to see the advantage of wooden floor in carbon reduction, while other materials have given out much CO<sub>2</sub> in their whole life cycle; the animal-made materials have the most serious situation. Therefore, wooden materials should be selected if the local forests can sustainable provide the resources.

### 4. CONCLUSIONS

The paper has discussed the Low-carbon economy and Low-carbon building technology, and has proposed detailed technical measures of Low-carbon building technology. In satisfying the structure load and seismic designing requirements, the “implicit” CO<sub>2</sub> emission can be reduced by approximately 5% if replace C40 concrete by C50 concrete; the quantity of CO<sub>2</sub> emission of the aluminium alloy curtain wall during the whole life cycle is 15% of that of the wall paintings with the same area; wooden floor has a much smaller quantity of “implicit” CO<sub>2</sub> emission than other indoor floor decoration materials. The above measures and calculation results are of value as a reference for energy saving, emission reduction and low-carbon building technology.

### ACKNOWLEDGEMENTS

This work is supported by the Special Research Foundation of Doctoral Subjects in University of China (No. 20050487017).

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