

# Low-Carbon Urban Planning from an Ecosystem Perspective

HE Meimei, LUO Hong

Chinese Research Academy of Environmental Sciences, Beijing, P.R.China, 100012

vicky.mmhe@gmail.com

**Abstract:** Low-carbon city is a hotspot under the background of climate change. Current problem on low-carbon urban planning was analyzed based on low-carbon city development practices. Low-carbon urban planning methods were studied from an ecosystem perspective, and new pathways for low-carbon city construction were suggested. Low-carbon development should be carried on from four aspects: urban structure, urban function, urban energy flow and urban material flow. The integrity and character of low-carbon city should be highlighted. Meanwhile, low-carbon city should be sustainable with a rapid urban economic development and increasing carbon emission reduction.

**Keywords:** Low-carbon city, City ecosystem, Urban structure, Urban function, Energy flow, Material flow

## 1. Introduction

Nowadays, climate change is a significant challenge we face, and low-carbon development has become a hotspot under this background. Since the industrial revolution, modern city has been the carrier of economics and culture where population, buildings, transportation, industry are gathering. City is also a place with high energy consumption and carbon emission. According to UN data, more than 50% world population live in cities<sup>[1]</sup>, and the green house gas emission by cities took up 75%. Because of aggregation effect, city highlights some environmental problems such as ecological patterns variation, huge resources consumption, greenhouse effect and so on. However, the aggregation effect also strengthens energy control and policy-making, which could be the advantages for developing low-carbon economy in city. Therefore, city is key arena for carbon emission reduction and low-carbon economy developments<sup>[2]</sup>, and urban planning is very important to achieve this goal.

## 2. Developing Situation of Low-carbon City

### 2.1 Concept and definition

Low-carbon city leads low-carbon economics and aimed at a sustainable developing pattern. Those city residents lead a low-carbon living, and city government also targets to construct a low-carbon society. There are two aspects in low-carbon city conception. One is the low-carbon production, which means low-carbon economics; another is low-carbon consumption, which means changing lifestyle and consumption habits.

From the first aspect, low-carbon economics suggests increasing energy efficiency and reducing carbon emission<sup>[3]</sup>. It is based on high material civilization with high efficiency, and it is an important path for realizing sustainable city<sup>[4]</sup>.

From the second aspect, low-carbon consumptions suggest reducing carbon emission from all aspects of city living, the lifestyle should be frugal and recyclable, while luxury and waste is not the character of low-carbon. Meanwhile, low-carbon lifestyle also means protecting natural environment, maintaining green areas in city, and increasing carbon sink. That is living in harmony with nature<sup>[5]</sup>.

### 2.2 Low-carbon city construction experiences

The “low-carbon city” idea got world-wide attention at 2007, a few pioneers has been exploring low-carbon measurements on city energy, transportation, building and lifestyle, such as London, Leeds, Bristol, Tokyo and Melbourne.

Some experiences on low-carbon city are focus on policy, regulation and action plan projects. Take London as example, London had made green initiative in a climate change action plan that aims to reduce London's emissions by 60% from 1990 levels, by 2025<sup>[7]</sup>. Also, London modified its planning, in order to promote sustainable building design, and set up energy category based on carbon emission, which emphasized on low-carbon development of city construction and traffic.

The majority low-carbon urban planning put energy on primary. Measurements aimed at energy conservation and new energy utilization had been designed to greatly reduce carbon emission. For example, Manchester controlled energy supply and consumption in several important fields, and making specific energy-saving targets on commercial, accommodation and transportation in order to reduce carbon emissions. Another example is Baoding, China. This city has been developing new energy and clean energy industries, and forming six systematic industry included opto-electrical, wind power, power saving, electricity storage, power transmission and electrical Automation. Baoding is famous as “Chinese power valley” and “Solar energy city”.

Otherwise, some low-carbon urban planning put efforts on industrial restructuring. Melbourne is an excellent example in this aspect. Melbourne has been promoting cooperation between government and enterprises, and trying to form new industry pattern which is export-oriented. Meanwhile, Melbourne made policies related with carbon emission and water management, also promote energy-saving buildings by solar power, higher energy efficiency and water recycling<sup>[8]</sup>.

Moreover, a few low carbon cities like Tokyo and Boddington emphasis concept of “low-carbon society” and “low-carbon community”<sup>[5]</sup>. The principle ideas of low-carbon community include zero carbon, zero waste, sustainable transportation, local material and food, biology conservation, fair trade and healthy lifestyle. Low-carbon communities should be able to utilize energy and waste by recycling.

### **2.3 Problems on current low-carbon urban planning**

First, low-carbon urban planning is lacking of innovation, without suitable developing patterns according to specific urban character. Under the background of low-carbon hotspot, copycat phenomenon exists among current low-carbon cities. Many urban planning and researches are too much macroscopic or superficial. Some cities even took “low-carbon” and “sustainable” as a fashion label, the presentation outweighs substance. This situation can not promote development, but even hinder low-carbon city development. It should be noticed that copy phenomenon was common among Chinese cities decades ago, which made a lot of cities are extremely similar. These cities have similar looks, similar buildings and even same squares. Small cities copied big cities, and big cities become the “experiment field” of foreign architectures. If the similar situation happened in low-carbon city development, those cities would not only lose their character, their culture, but also lose their specific functions. “Low-carbon city” build under copy phenomenon would be a violation towards the original low-carbon concept which is efficient, economic and developing.

Secondly, low-carbon urban planning is lacking of systematical and integrity. Since city is integrate and systematic, low-carbon city construction is a complex project refers many fields such as economics, society, population, resources and environment. The internal driven force and mechanism of low-carbon pattern were rarely studied, and current low-carbon urban planning are usually focus on certain aspect, such as low-carbon building, low-carbon transportation, especially on energy saving and energy planning. Although Low-carbon planning on certain aspect is needed, but it is insufficient for a huge system like city, researches based on more systematical view are necessary. Low-carbon concept should be applied on every aspect of city developments, and should be used in land use, transport pattern, industry development, facility construction and life styles.

Third, low-carbon urban planning is lacking of methodology. Current low-carbon methodology are mainly on new energy utilization and energy conservation, while there are rare basic and key studies on low-carbon urban planning. For example, there isn't low-carbon evaluation method in China which hinders low-carbon developing. Meanwhile, carbon emission statistical research is insignificant, which cause problem in qualifying the relationship between carbon emission and land use or urban structure. In

general, the methodology of low-carbon urban planning is still on primary stage, and key technologies are still uncertain.

### **3. Urban Ecosystem and Low-carbon Conception**

#### **3.1 Urban ecosystem**

From the perspective of ecosystem, city is an artificial system formed by city residents and environment. City system has intensive population and is strongly depend with outside. Meanwhile, city system has intensive logistics, energy flow, information flow and currency flow. It is an ecosystem with high energy and mass materials. The component of urban system includes human, social economics and so on, these components connect each other by energy flow and material cycling. Besides, city is the central of region, and most material and energy are input from outside, thus, material and energy flow in city in linear but not cycle<sup>[11,12]</sup>.

Therefore, city is a complex and huge system viewed from ecosystem aspect. Technology method of energy saving is far more than sufficient to solve all problem in urban low-carbon developing. In order to realize sustainable and low-carbon targets, scientific urban planning should based on inner mechanism of low-carbon transition and low-carbon economics idea should be applied into practices.

#### **3.2 Low-carbon city and ecological city**

In china, urban planning ideas such as “ecological city”, “ecological garden city” has been developing from last two decades, which indicate the important position for sustainable development and environmental protection. Low-carbon city is closely relevant with ecological city in some extents, such as sustainable, resources saving, recycling, environment-friendly consumption and lifestyle. However, the ecological city planning put emphasis on natural environment, while low-carbon city is aimed at reducing carbon emission specifically. In this aspect, low-carbon city is the extension of ecological city in carbon reduction. Thus, although low-carbon urban planning is at the started stage, the ecological city should not be abandoned at all. Experiences of ecological city practices are references while studying low-carbon urban planning.

### **4. Key Ideas for Low-carbon Urban Planning from an Ecological Perspective**

#### **4.1 Low-carbon development on urban structure**

Urban structure could be divided in to economic-social structure and spatial structure. Urban economics structural optimization under low-carbon conception is the need for sustainable development, while spatial structure not only reflects but also interacts with the economic-social structure. Therefore reasonable spatial structure planning is an important basis for city development. Moreover, spatial structure could optimize urban economic-social structure. It should be noticed that industry adjustment and technology innovation can not solve energy consumption and carbon emission brought by transportation, which is one result of urban spatial pattern. While urban planning has long-term effects on this aspect and hardly can be changed, it is also known as “lock-in effect”. Because urban transportation consume more energy and cause higher carbon emission, urban sustainable development would be restricted if there are no strategic spatial urban planning. Therefore, key point and main target of low-carbon urban planning is promoting spatial structure, and further prompting economic-social structure.

Developing urban structure needs to control disarrangement urban extension by adjusting city growing pattern. The relationship of urban density, shape and carbon emission should be researched, and low-carbon development in urban land use is important. Since reasonable urban structure need corresponding transportation, the traffic system is also key point of urban structure researches.

#### **4.2 Low-carbon development on urban function**

The urban function is influenced by history as well as social economy development, and it is a city attribute. Under the rapid development of economy-society, urban function diversification has decided reasonable low-carbon function area should be divided.

Low-carbon function zones have effect on urban transition and sustainable development. While the process of low-carbon development, different pathways are needed according to different districts which have varied function and urbanization. Leading mode should be fit in specific functional zone, such as urban central area, urban fringe, inner city area, industry area and suburbs need different developing patterns and policies. Low-carbon development on urban function will optimize city scale and lead to an intensive urban growth.

#### **4.3 Low-carbon development on urban energy flow**

Urban energy flow has a close relationship with low-carbon city development. Energy in urban system is flowing one-way, which suggests low energy utilization efficiency will have a negative effects on low-carbon developing. Energy flow analysis is used for evaluating energy utilization, it quantitatively analyze energy input and output in a environment-economic system, and calculate energy input, transition, consumption and output<sup>[13]</sup>. Urban system change could be evaluated through energy flow analysis, and low-carbon development and urban system interaction could be further studied. This is one of the key points of low-carbon urban planning.

Low-carbon energy flow planning need to research energy consumption mechanism and pattern in urban system, identification of energy flow character should be made from multi-aspect and multi-level. Spatial and temporal changing pattern on production, human activity in city life could be studied through aspect of energy flow. Low-carbon urban planning need to integrate key energy saving field, and further analyze the carbon emission potential according to energy consumption unit from various categories such as industry, traffic, commercial, living. Meanwhile, theory of urban energy safety, energy efficiency, renewable energy and clean energy could be used to study those factors influencing urban energy flow. The analysis will clarify key point of energy saving and carbon emission, and further realize low-carbon on whole procession from energy source to final consumption.

#### **4.4 Low-carbon development on urban material flow**

From the perspective of ecosystem, city system is highly open. Like energy, material input and output of city are also depended on outside. Analysis of urban material consumption and transfer in temporal and spatial scale is one of key methods in urban study. Principle theory of urban material flow is treat city as an entirety based on law of conservation of matter, and studies the material input and output both temporally and spatially<sup>[14]</sup>.

Considered from material recycling, low-carbon city should be characterized by higher efficient material flow and lower carbon input, carbon consumption and carbon emission. Low-carbon urban planning could use the method of material flow analysis, indicating urban material metabolism patterns and study the interaction mechanism of variable material factors in city system. Material transfer and cycling pattern as well as driven force of material metabolism could be clarified; adjustment strategies could be designed to develop low-carbon economy in city development.

### **5. Conclusion**

City system has its integrity, while city character should be considered in urban planning for low-carbon development. In order to comprehensively develop low-carbon economy on urban production, lifestyle and consumption, basic theories and researches of urban planning need exploring new pathways. As a complex system similar to ecosystem, ecological analysis perspective could be used for urban development and sustainable planning. Low carbon development of city could be planned from four aspects: urban structure, urban function, urban energy flow and material flow. Intensive researches on above fields are needed for low-carbon city practices.

## References

- [1]. Christopher Kennedy, Julia Steinberge, Barrie Gasson, Yvonne Hansen *et al.* Greenhouse Gas Emissions from Global Cities. *Environ. Sci. Technol*, 2009, 43 (19), p7297–7302
- [2]. Betsill, M. M. Mitigating Climate Change in US Cities: opportunities and obstacles, *Local Environment*, 2001, 6(4), p393–406,
- [3]. Department of Trade and Industry (DTI). UK Energy White Paper: Our energy future — creating a low carbon economy, London: TSO, 2003
- [4]. Xia Kunbao. Developing low-carbon economics and realize urban sustainable development. *Environmental Protection*, 2008, (2A), p33–35 (in Chinese)
- [5]. Liu Zhilin, Dai Yixin, Dong Changgui *et al.* Low-Carbon City: Concepts, International Practice and Implications for China. *Urban Studies*, 2009, 16(6), p1–7(in Chinese)
- [6]. Edward L Glaeser, Matthew E. Kahn. The greenness of cities: Carbon dioxide emissions and urban development. *Journal of Urban Economics*, 2010, 67(3), p404–418.
- [7]. Ken Livingstone, The mayor’s climate change action plan, Greater London Authority, London, 2007
- [8]. Richard Reed, Sara Wilkinson. Moving towards a low carbon city: a case study of Melbourne, Australia.2009, RICS, London
- [9]. Zhang Kunmin. China's Role, Challenges and Strategy for the Low Carbon World. *China Population Resources and Environment*, 2008, 18(3), 1–7 (in Chinese)
- [10]. Aumnad Phdungsilp. Integrated energy and carbon modeling with a decision support system: Policy scenarios for low-carbon city development in Bangkok. *Energy Policy*, 2010, 38(9), p4808–4817
- [11]. William E. Rees. Urban ecosystems: the human dimension., *Urban Ecosystem*.1997, 1(1), p63–75
- [12]. J. Morgan Grove, William R. Burch. A social ecology approach and applications of urban ecosystem and landscape analyses: a case study of Baltimore, Maryland. *Urban Ecosystem*, 1997, 1(4), p259–275
- [13]. Liu Wei, Ju Meiting, Li Zhi *et al.* Energy Flow Analysis in Regional(Urban)Environmental and Economic System, *China Population Resources and Environment*, 2008, 18(5), p59–63 (in Chinese)
- [14]. Shi lei, Lou yu. Methodology and Procedure for Urban-Wide Material Flows Analysis. *Research of Environmental Sciences*, 2008, 21(4), p196–200 (in Chinese)