The exploration of concepts and methods for Low-Carbon Eco-City Planning

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Abstract

The establishment of low-carbon eco-city planning in the pattern of low-carbon economic development and the low-carbon society consumption with cities as a unit can remove the bottleneck for urban development, promote sustainable urban development and provide ample opportunities for industry upgrading and transformation in cities. The paper highlights the low-carbon eco-city planning ideas and development strategies and introduces the practical exploration of the planning with the new eco-city of Tianjin as an example.

Keywords: Low carbon; Eco-city; Planning

1. Introduction

Cities as an important carrier of economic society and culture in the age of industrial civilization are central for creation of material and spiritual wealth made by human. They are also burdened with most issues of resources and environment. Since founding of PRC, China has made remarkable achievements in the urban development, but the rapid development of economy leads to the accelerated urbanization, increasingly prominent position and role of cities as well as particularly pronounced conflict between resources and environment. The construction and management of a city is primarily dependent on the scientific and rational urban planning which serves as the basis for guiding its construction and development. Due to expanded scale of economic activities and the complex functions of urban system as a whole, the requirement for the urban planning is constantly increased and the importance of urban planning is more prominent. The low-carbon eco-city construction theory is incorporated into the urban planning to achieve coordinated development among economy, society, population, resources and environment of cities and promote sustainable development on the whole. It is a key link in the development of urban planning theory with Chinese characteristics and an important way to avoid all kinds of negative effects during the national urbanization occurred in advanced countries.

A series of issues remain unresolved at present like how to establish and build a guiding ideology and planning methodology compatible with the requirement for the low-carbon eco-city, how to ensure the shift of urban development from extensive to intensive pattern in the planning link, how can resources and environment, as the constraints for urban development be effectively utilized in the urban planning. The urban planning proposed in the paper should follow an idea and low-carbon ecological development strategy which can be used as an effective way for sustainable development and construction of ecological cities.

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1.1 Practical Problems Confronting the Sustainable Development of Cities in China

Since founding of PRC, China has made remarkable achievements in urban development. While the urbanization and industrialization of the conventional development pattern lead to increasingly severe resources and environmental problems and has restricted the sustainable development of cities in the future. China In the future for a long time is still at the stage of rapid urbanization confronted the problems and challenges presented by the sustainable development as below:

1.2 Challenges for the Coordinated Development of Urban and Rural Areas

The orderly facilitation of urbanization is effective for balanced development of the areas, ease of the conflicts arising from the dual structure and a solution to numerous social and economic issues during the development and also signifies dramatic changes to be made in the urban and rural structure. The development of cities and towns will lead to changes in the pattern of land use, population shift from rural production and life style to urban production and life style which will have a profound impact on the ecological environment of the whole country.

1.3 Resource and Energy Shortages Have Become the Bottleneck of Urban Development.

China is burdened with relatively scarce natural resources, low utilization efficiency, increasingly pronounced inconsistency between supply and demand. Resources like energy, land and water have become crucial factors for constraining the urban development accompanying the development of industrialization and urbanization. The area most appropriate for living across the country occupies only 19% of the total land, which is the optimal and most densely cultivated land. [1] Therefore the urbanization will be restricted by the shortage of land resources. China's per capita water resources per capita is about one-fourth of that of the world, coupled with the uneven spatial and temporal distribution of water resources, low efficiency and other reasons. From late 1970s to 1980s people suffered the severe shortage of water due to the accelerated urbanization and economic development. Currently among over 600 cities across the country more than 400 cities are deficient with water and 110 cities with serious water shortages. On the other hand, the serious pollution of urban water has not only affected the water quality and endangered human health, but also intensified the contradiction between water supply and demand. China's energy is featured by abundance of coal and shortage of oil and gas. China’s total production of energy ranks second in the world yet with serious shortage of per capita resources. Cities are a major energy consumer, as the total energy consumption of over 287 prefecture-level cities in 2006 totaled 1.366 billion t of standard coal, accounting for 55.48% of total energy consumption in China. The energy shortage is now a major challenge for the future urban development.

1.4 Ecological Environmental Problems Seriously Affect the Life Quality of Urban and Rural Residents.

Expansion of urban scale, population growth and industrial agglomeration have drastically changed the original regional ecological patterns and results in heavy emissions of pollutants which has seriously affected the ecological environment and threatened the quality of life and survival of urban and rural residents. According to the survey, 90% of rivers passing cities are severely polluted and 75% of the lakes are eutrophicated. A considerable portion of the city's drinking water is not up to quality standard; there are other environmental concerns like garbage surrounding the city, noise nuisance and urban heat island.

In terms of ambient air quality, the high energy consumption results in heavy emission which in turn directly affects the air quality and endangers human health. In 2006 the discharge of carbon dioxide in 287 prefectural-level cities across the country reached 2.916 billion tons, accounting for 54.84% of total emissions. Among 559 cities under supervision in 2006, only 4.3% of the city met grade one of national ambient air quality standard, 58.1% of cities met grade two, while 37.6% of the city were in moderate or severe pollution. According to the survey, China's air pollution led to more than 30% of incidence of respiratory diseases.

2. General Idea about Development of China's Low-Carbon Eco-City

2.1 Coordination between Eco-City Planning and Development Goal of “Energy-Conservation and Environment-Friendly Society”

“Carbon Emission Reduction” and “Carbon Offsetting” are carried out with some focus in cities (city is a unit for the activities) in a phased manner and stepwise manner based on the overall national development strategies. Efforts should be made to minimize carbon emission in the short term and to keep in the mid and long-term greenhouse gas...
emissions growth rate less than economic growth rate; efforts should be made to integrate the low-carbon target with eco-city construction and establish an urban development pattern featured by low energy consumption, low pollution, low emission, high performance and high efficiency; efforts should be made to optimize the industry arrangement, structural adjustment and upgrading, promote the development of low-carbon industries and spearhead low-carbon consumption pattern; efforts should be made to strengthen technical exchanges and cooperation among advanced countries in Europe and the United States and gradually establish and improve a low-carbon eco-city construction management system.

2.2 The Establishment of a Classified and Dynamic Evaluation System of Low-Carbon Eco-City with Different Types in Different Regions for Leading City Innovation.

Efforts should be made to build different types of low-carbon eco-city process models and a dynamic integrated evaluation index system and conduct grading evaluation of low-carbon eco-city according to levels of sustainable development; Efforts should be made to guide urban governments and the citizens for cultivating the sense of innovation in construction of the eco-city and gradually encourage the competition of such cities in the construction of eco-city.

Efforts should be made to establish a co-operation mechanism participated by various stakeholders, give full play to all the enthusiasm of all sectors of society, raise the awareness of and adaptability to climate change through advocacy, education and training and achieve the consensus towards a low carbon eco-city planning. There are no successful examples of low-carbon eco-city to follow and we need to pay attention to the innovative ways of “bottom-up” from the model of “learning by doing”.

2.3 Full Use of Chinese Traditional Ecological Thinking and Creation of a Low Carbon Eco-City with Chinese Characteristics

Oriental Nationality’s unique concept of “Harmonious Development between men and nature” is conducive to the implementation of eco-city development model; in traditional Chinese culture people hold an original ecological awareness of worshipping, following the movement of heaven; tens of thousands years of farming culture has enabled all Chinese nationalities to practice original ecological civilization in which people and heaven are believed to be made from same materials with same natures, therefore they should be integral.

Eco-city with sound design and careful management should be visually attractive and suitable for living with good services, all-around facilities and social harmony.

Low-carbon eco-cities should be affordable in construction costs, replicable in the development model and sustainable in its own development. The practices of such "pioneer" city can guide other cities in their development models.

3. Development of Low-carbon Eco-City Strategy of Sustainable Development

The effective implementation of the eco-development concept and low carbon development model are crucial for positive influence on the successful transformation of China's development model and whether China's development can reverse the global ecological situation.

Only through construction philosophy of "low-carbon eco-city" and the use of ecological principles we can understand a city through the complex ecosystem which is composed of society, economy and nature. Efforts should be made to implement the urban development with low-carbon development pattern and human settlements of sustainable development as an objective under the balance and check of the complex ecosystem. Its main characteristic is reflected in the economic growth pattern featured by high energy-efficiency, low power consumption and low carbon emission; organic integration of people and society and overall coordination and common development of the symbiotic structure; human settlements area with virtuous cycle of natural ecology, economic efficiency and social harmony based on the harmony of natural systems, human and nature.

The core of low-carbon eco-city development is the intensive use of resources which consist of land, water, forest, energy, mineral, species, resources, climate, tourism and human. In order to have a clear understanding of the intensive use of resources of top ten strategies for sustainable development in the above listed master plan. Table 1 indicates the cross-analysis of sustainable development strategies and resources of various types, in which "¥" indicates that the strategy for sustainable development of the planning in the corresponding row can promote the intensive use of resources [2]. It can be seen that the incorporation of sustainable development into the planning
could ensure the intensive use of resources by cities. Below is the detailed introduction of the top ten strategies for sustainable development.

Table 1 List of Analysis of Intensive Utilization of Low-Carbon Eco-City Development of Strategic Resources

| No | Sustainable Development Strategy | Types of Resources |
|----|----------------------------------|--------------------|
| 1  | Determine the nature and positioning of the city consistent with its own conditions and regional development | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| 2  | Determine the size of cities consistent with their resources and environment carrying capacity | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| 3  | Identify and determine scientific direction and layout of urban space | ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ |
| 4  | Protect historical and cultural heritage of years | ✓ |
| 5  | Establish an industrial layout of Circular Economy Plan a regional and urban transport system of sustainable development | ✓ ✓ ✓ ✓ ✓ ✓ |
| 6  | Plan a regional and urban transport system of sustainable development | ✓ ✓ ✓ ✓ ✓ |
| 7  | Arrange systematic and intensive municipal infrastructure | ✓ ✓ ✓ |
| 8  | Quantify the space-based ecological infrastructure | ✓ ✓ ✓ ✓ |
| 9  | Carry out systematic and comprehensive plan for disaster prevention and mitigation | ✓ ✓ ✓ ✓ |
| 10 | Study systematic resource conservation, protection and utilization | ✓ ✓ ✓ ✓ |

3.1 Determination of the Nature and Positioning of Cities consistent with its own conditions and regional development

The nature and development positioning of the city is the primary elements to be determined for the urban development. The incorporation of the low-carbon eco-development theory into the process of determining the nature and development positioning for the sustainable development of cities can be ensured from the global angles. At this stage reference should be made to the sustainable development strategy from the following aspects: through comprehensive analysis of regional scale of economy, society, resources environment, determination of the nature and development positioning of the city in order to achieve the goal of regional coordination and sustainable development; deep understanding of objective conditions of cities like topography, availability of resources, size and distribution of available construction land, offering the nature and positioning of cities consistent with their own conditions for the development and refraining from being impractical.
3.2 Determine the Size of Cities Consistent with Their Resources and Environment Carrying Capacity

The size of city is generally reflected in the city’s population and the construction land. Only on the basis of determining the city size, can the planning of urban space and the corresponding infrastructure be conducted. In the process of determining the city size, we should refer to the several aspects of sustainable development strategy as below: implementation of the concept of regional balance; determination of population magnitude based on the ecological carrying capacity; reasonable determination of the size of urban construction land [3].

3.3 Identify and Determine the Scientific Development Direction and Layout of Urban Space

Based on the determination of the size of cities, we should determine that the most central issue for the low-carbon eco-city is the development direction and layout of urban space which should stick to the principle of priority on the ecology, scientific development and intensive use. During the specific planning process of direction and layout of urban space reference should be made to the following aspects of sustainable development strategies: paying great attention to infrastructure research of urban space development mode; sticking to the optimal principle of ecological service function; carrying out restricted division of regions; adhering to the principle of compact cities.

3.4 The Protection of Historical and Cultural Heritage for Many Years

To build a low-carbon eco-city, we should place the city's history and culture as a resource under protection and maintain the sustainable development of urban history and culture: correctly handling the relationship between protection and development, improving the protection system of historical and cultural resources and the natural landscape, insisting on the overall protection of the old city district, proactively exploring the municipal infrastructure mode for the protection and rehabilitation of old district.

3.5 Establish an Industrial Layout with the Concept of Circular Economy

In terms of industry planning, the focus of low-carbon eco-city planning should be made on the planning of industrial layout including the macroscopic industrial development strategy and the corresponding spatial distribution: establishment of an industry development pattern of sustainable development and adherence to the coordination principles of industries distribution in the region [4]. We may designate areas suitable for the development of industries based on the factors of ecological sensitivity, climatic conditions and environmental conditions for the guiding site selection of follow-up industrial projects, improving the rationality of industrial layout and promoting the industrial sustainable development from the source.

3.6 Establishment of Regional and Urban Transport System of Sustainable Development

The sustainable development of traffic system is an important component of building a low-carbon eco-city and always encountered during the urban development process at present. In the planning of traffic system, we should refer to following aspects of the sustainable development strategy: improving transportation capacity per unit of energy consumption, establishing an urban transport strategy in which the public transportation is the mainstay and the rail transportation is the backbone, strengthening coordination between land and traffic professional planners, facilitating the balance between transport facilities and land use and building a green passageway and a non-bicycle lane network for facilitating job and leisure[5].

3.7 Arrange Systematic and Intensive Municipal Infrastructure

Municipal infrastructure planning mainly includes planning of urban water supply systems, rainwater drainage system, sewage treatment system, power supply, gas supply, urban heating, urban information and urban sanitation and others. Construction of municipal infrastructure is an important lifeline for low-carbon eco-city and should be promoted from the following aspects: scientific determination of the size of municipal infrastructure, integrated planning of water systems, combination with the city's natural topographical feature and climate characteristics, selectively carrying out ecological sewage disposal or construction of semi-ecological treatment facilities.

3.8 Quantify the Ecological Environment of Space-Based Facilities
When carrying out specific plans of ecological environment, we should focus on the implementation of planning of ecological environment facilities in specific areas, balance of control over non-construction land and scales and types of construction land to safeguard the improvement to ecological environment [6]. The specific strategies include: taking the ecological infrastructure as the specific target of ecological environment planning integrating traditional environmental pollution prevention planning with ecological landscape planning; dividing the ecological space into blue, green, gray and red space respectively corresponding to river water bodies, green land, abandoned land and urban construction land; formulating the plan of ecological infrastructure focused on ecological conservation, restoration and construction given characteristics of the above four types of ecological space, current ecological situation and problems.

3.9 Implementation of Systematic and Comprehensive Plan for Disaster Prevention and Mitigation

The urban disaster prevention and mitigation system is an important guarantee for the normal operation of the city and an insurance system for the city. The perfection of the system is critical for cities as a prerequisite for the overall sustainable development of cities. Therefore it is necessary to carry out a comprehensive, scientific and systematic urban disaster prevention and mitigation plan, which specifically includes flood control, earthquakes prevention, prevention of geological disasters, fire, civil defense, comprehensive disaster prevention of lifeline system and meteorological disaster prevention. Based on the prevention and control plan of a single disaster, we should speed up the establishment and improvement of city's comprehensive planning for disaster prevention and mitigation system to increase the ability of the city to increase the overall ability of cities to survive, prevent disaster and rescue.

3.10 Study systematic resource conservation, protection and utilization

Resource conservation, protection and utilization are most central elements for construction of a low-carbon eco-city, but the city is a major consumer of resources. Therefore the systematic study of resource conservation, protection and utilization is particularly important in the urban master planning from following aspects: in the overall urban planning, we should carry out an in-depth study of resource conservation, protection and utilization and make sure that planning results are reflected in the overall planning of the special plan, thus guaranteeing that resource conservation, protection and utilization are conducted in a scientific, systemic and sustainable manner; efforts should be focused on the proposition of resource conservation, protection and utilization plans based on the possession of its own resources and demand.
4. Practical Exploration of Eco-City in Recent Years

As people develop a deep understanding of eco-city concept and low-carbon development model, the relevant practice and demonstration construction are also underway in the context of the world. There are some cases of great significance like Berkeley's eco-city plan (1992) in Cleveland and Los Angeles, U.S., Halifax Eco-City in Australia, Curitiba in Brazil, Freiburg and Erlangen in Germany, Kyushu, Osaka and Tokyo in Japan, Kalundborg in Denmark and Singapore, etc. [7].

After cooperation with a number of developed countries in recent years, China has also embarked on the plan and practice of building an experimental ecological city of small regional scale. The demonstration projects with the idea of "low-carbon city" are also implemented in succession. Among them, the Tianjin Eco-City can be regarded as the most typical case of eco-city planning.

![Fig. 1. The Layout of the Eco-city](image1)

![Fig. 2 Green traffic system of Eco-city](image2)
On November 18, 2007, Premier Wen Jiabao and Singaporean Prime Minister Lee Hsien Loong signed a framework agreement of eco-city construction in Tianjin. The "China-Singapore New Tianjin Eco-city Master Plan (2008-2020)" kicked off in November 2007 and the first phase of construction started in September 2008. The Tianjin Eco-city planning embodies the construction principle of eco-cities from aspects like indicator system, industry selection, ecology suitability evaluation, ecological pattern optimization, green transportation, ecological communities, historical and cultural preservation, efficient utilization of water and energy conservation. (Figures 1-3)

5. Conclusions
In the macro context of "development of ecological civilization", the concept of planning low-carbon cities is the inevitable trends of the whole planning idea and method transition rather than one school of planning discipline. The development and application of low-carbon energy technology and creation of low-carbon economy development model and low-carbon society consumption pattern with cities as unit can remove bottleneck for urban development, promote sustainable development and provide ample opportunities for industry upgrading in cities.

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