Integrated Development Management Strategies of Transportation and Land Use Based on Low-carbon Concept

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***Abstract*—Carbon emission in urban area mainly comes from urban transportation and land use development. Urban transportation development strategies, land use strategies, and corresponding synergic and integrated development are discussed in this paper, which are expected to contribute to the construction of low-carbon city. Firstly, urban transportation development strategies are proposed including construction of low carbon comprehensive transportation system, promotion of low carbon transportation mode, and distribution system of road space resource. Secondly, according to three different functional types of land use including residential land use, industrial land use, and public facility, corresponding low carbon land use strategies are proposed. Thirdly, the integrated development management strategies for urban transportation and land use under the low-carbon concept are proposed.**

Keywords-low carbon, transportation mode, land use, integrated strategies

I. INTRODUCTION

With growing population and economic in the world, high energy consumption leads to serious environmental problems. People already begin to realize the threat from global climate change and energy consumptions. Low carbon economy has been accepted by the whole world. Low carbon economy (LCE) refers to the economic system with litter or no emission of greenhouse gasses, or the economic system with few or no carbon footprint. City is the carrier of economy, so low carbon city is the necessary choice of LCE. Also low carbon city is the direct means to realize LCE. Low carbon city is proposed based on low carbon development mode, which is characterized by economic growth modes with high energy efficiency, low energy consumption and carbon emission.

II. URBAN TRANSPORTATION DEVELOPMENT STRATEGIES BASED ON LOW-CARBON CONCEPT

Through the overall forecast and judgment of future urban transportation development trend, transportation development strategies master the macro focus and direction of urban transportation development. The core content of urban transportation development strategies is to construct comprehensive transportation system. Under the guidance of low-carbon concept, the urban transportation development strategies (table I) are formulated to provide planning principles in transportation network and facilities.

A. Construct Low Carbon Comprehensive Transportation System

According to the objective of reducing carbon emission, the comprehensive transportation system focusing on public transit shall be constructed. Comprehensive transportation system includes three aspects: facility, operation and management. Efficient urban transportation relies on the close combination of facility, operation and management. Low carbon comprehensive transportation system focuses on the integrated connections of different transportation modes, transformation of transportation operation, and integration of transportation facility.

1) Transportation connection system based on public transit hub is constructed.

By means of the layout of hub facilities and stations, convenient transfer settings should be provided to passengers. Effective transfer between public travel modes and individual travel modes can be realized through “park and ride” facilities, which are car parks with connections to public transport that allow commuters and other people to go to city centres by transferring to bus or rail system (rapid transit, light rail, or commuter rail) instead of by car.

TABLE I. LOW-CARBON TRANSPORTATION DEVELOPMENT STRATEGIES

level	Instruments
Comprehensive system	➢ Transportation connection system ; ➢ Low carbon transfer; ➢ Land use combined with public transit
Traffic mode	➢ Public transit; ➢ Non-motorized traffic ; ➢ Mass Rapid public transit;
Road space distribution	➢ Exclusive public transit road network; ➢ Transfer facility; ➢ High density of urban road network

2) Low carbon transfer is promoted.

Transfer is key link to realize connection with various transport modes including rail system, bus, car, bike and walking. During the process of constructing transportation system, low carbon transfer chain shall be formed with the connection and transfer of various transportation modes. Car parking lot can be arranged in line with railway (metro and light rail) stations and bus stop hubs; bus stops and railway stations shall be closely connected; public transit and non-motorized modes are combined to optimize the layout of public transport stations. In this way, passengers can take mass transit nearby. A safe environment is created for short-distance bike driving. In addition, with the combination of transfer hub, the bike parking lot can be constructed for the convenient transfer from bike to public transit.

3) Combine land use planning.

Land use planning influences urban transportation modes. On the contrary, urban transportation also influences land use. Therefore, transportation planning shall be in accordance with land use planning of low carbon.

B. Promote Low Carbon Traffic Mode

Traffic mode structure that is the proportion distribution of various traffic modes is generated from land layout, population density, economic level, and specific condition. The core content of low carbon traffic mode includes the enhancement of the proportion of public transit, the increase of the proportion of walking and bike and optimization of traffic mode split.

4) Public transit mode

Public transit development strategies of shall be firstly promoted. The concept of public transit first shall be established. The relation among different traffic modes in and out of the city shall be coordinated. Urban comprehensive transportation system led by public transit shall be constructed.

5) Non-motorized traffic mode

Walking and bike are encouraged; bike and sidewalk shall be maintained and extended; efficient and excellent non-motorized transportation shall be constructed; good transportation environment for walking and bike shall be created.

6) Mass rapid urban traffic mode

Mass rapid urban public transit system shall be accelerated to solve the problems including singleness of public transit structure and lag of urban development. During the steady development of regular public bus, the mass rapid public transit system including urban mass transit and bus rapid transit shall be promoted. Comprehensive application of transit system, bus rapid transit and regular bus shall be encouraged to improve the coverage rate of public transit.

C. Construct road space resource distribution system in line with low carbon traffic mode

The key for the development of sustainable low-carbon transportation modes is to appropriately distribute road space resource. Through computer analysis on traffic in central areas of metropolises, even all constructions in central areas of metropolises are transformed into motorways, traffic jam cannot be avoided. Therefore, during the construction of road facilities, the public transit facilities shall be firstly arranged and guaranteed, so the road use right should be firstly distributed to public transit, and exclusive public transit road network should be constructed. Meanwhile, in the aspect of land use layout, land use for urban infrastructure shall be guaranteed to enhance the transfer facility of large traffic hub and promote the development of public transit. The high density of urban road network can reduce the possibility of detour and increase the transportation efficiency. In this way, the energy consumption of traffic and carbon emission can be reduced.

III. LAND USE LAYOUT STRATEGIES BASED ON LOW-CARBON CONCEPT

Land use layout stategies (table II) based on low-carbon concept are discussed with three main types of urban land use, including residential, industial and public facility land.

A. Residential land layout based on low-carbon concept

1) Residential Land Arrangement in Urban Land

Residential land use shall form certain scale, which shall not scattered in the city and shall not be distributed continuously and centrally in certain area of a city. The former layout will reduce the efficiency of public services and facilities, resulting in waste of energy and resources. The latter commonly leads to single function residential area. The separation of residential area and working area will lead to pendulum model of transportation, increasing traffic distance and times and depending greatly on the automobile, especially car. On the other hand, the residential area shall be close to the working center with the connection of efficient and rapid public transit.

2) Internal structure and organization of residential land

Inside the residential area, the diversification of land functions shall be increased to form a complete community of complex functions. Three-dimensional multifunctional comprehensive areas (work, school and entertainment) should be formed, focusing on public service place and green land. People will reduce the traffic distance and reduce energy consumption with complete service facilities.

TABLE II. LAND USE DEVELOPMENT STRATEGIES

Type	Instruments
Residential	➢ Close to the working center; ➢ Diversification of land functions
Industrial	➢ Combination of research design department and education facilitates; ➢ Combination of sales department and business district; Closed layout of the similar enterprises; ➢ Connection between the main road ; ➢ Facility sharing
Public facility	➢ Connection with public transit, rail transit, bike and walking; ➢ Functional complex of public center; ➢ Based on the public transit station ➢ Microclimate of large mass building complex

B. Industrial Land use Based On Low-carbon concept

The promotion of industrial optimization and upgrading is to gradually remove the resource-intensive industry and transfer to knowledge-intensive and technology-intensive industry. During the process, industrial upgrading promotes the separation of three factors in space (manufacturing, research and design, and sales). The combination of research and design department and education facilitates to promote the scientific achievements to enter the market. The combination of sales department and business district helps the enterprise to faster acquire market information and feedback, which is good for overall sustainable development.

In accordance with the cooperation relation, proximity layout is applied to arrange the similar enterprises and enterprise of downstream and upstream relation, which facilitates the material exchange and disposal of byproduct and waste. The connection between the main road in the industrial zone and the road out of the industrial zone shall be paid attention to. In addition, convenient connection with port, railway station, and main warehouse shall be constructed. Sharing facilities shall be located in the place with convenient traffic. Facility sharing is the characteristic of higher economic and ecological benefit in the industrial zone, which reduces the consumption of energy and resource. These public facilities include: sewage disposal facility, solid sewage recycle and use center, fire-fighting facility, and comprehensive service center.

C. Low Carbon Layout of Land use for Public Facility

Since land use for public facility is for vast non-specific users, its urban functions are diversified and complex. Thus, there are three characteristics of public facilities: firstly, for the hierarchy of public facilities, different lands have different standards. According to the hierarchy of the urban land use structure, public facilities can be divided into three levels: municipal level, residential level, and community level. Secondly, for the flowing users, public facilities usually locate in the place with convenient traffic and concentrated population. Thirdly, due to the publicity of activities, public facility buildings, especially for business and service building, usually are large mass buildings, which undertake high urban economic activities, thus leading to high land use degree.

1) Connection with public transit and rail transit system

Land use layout for municipal, residential, and community public services shall be combined with urban public transit and rail transit. Traffic hubs, transfer stations, and subway stations in the urban center shall be the ideal places for public facilities, including large gyms and exhibition centers. The public facilities shall be connected with main public transit road. Community public services shall be planned in accordance with urban road system, and combined with sidewalk system in the residential zone.

2) Combination with walking and bike system

The layout of public services is combined with walking and bike road system to create pleasant urban plaza and comfortable environment for walking. Classic American Rockefeller Plaza is located in the high-density urban center, which combines different public spaces together. By means of hall, plaza, staircase and road in the building, the rest zone for people is designed to expand the urban walking space. The setting of business facilities can also be connected with walking road and bike road to form walking business street. Residential and community public services including primary school, kindergarten and outpatient service shall be connected with walking and bike road system to encourage and guide the low carbon traffic.

3) Layout and traffic organization of urban public center based on low-carbon concept

The municipal public centers and district public center s can lay influence on the urban layout structure and road network system. The layout of urban public center shall be in accordance with the low carbon development from the three aspects. Firstly, the functional complex of public center: when the land use for public center is large, some residential land use shall be arranged to increase the intensity of land use, reduce pendulum model transportation, and decrease transportation energy consumption. Secondly, the location of public center shall be set based on the rail transit stations and bus stops to increase the accessibility of public space and attract residents to public space by public transit. In this process, the matching with the hierarchy of public centers and the hierarchy of traffic stations shall be paid attention to. Municipal and district public center setting shall be based on municipal and district transfer hub; residential and community public center shall be based on walking and bike network setting for the convenient walking and bike riding, which increases the low carbon traffic. Thirdly, public centers including business office and services are usually the concentration of commerce, information and assets, which are also dense and intensive space. The effects of large mass building complex on the microclimate in the urban center shall be considered. The analysis on microclimate shall be enhanced to offer the evidence for space design and architecture design of building group with orientation of reducing the demand for energy and energy consumption.

IV. INTEGRATED DEVELOPMENT STRATEGIES OF TRANSPORT AND LAND USE BASED ON LOW-CARBON CONCEPT

Integraed development strategies (table III) based on lowcarbon concept are discussed according to three traffic modes including rail transit, public transit and non-motorized traffic.

TABLE III. INTEGRATED DEVELOPMENT STRATEGIES

Traffic mode	Spatial level	Land use characteristic
Rail transit Public transit	Land use structure Station region	➢ Axial development based on transit network; ➢ Compactness; ➢ High density; ➢ Mixed Land use ; ➢ Integrated public space
Non-motorized traffic (walking&bike)	Community	➢ Good non-motorized traffic network; ➢ Pedestrian-friendly spatial size; ➢ Mixed-land use layout; ➢ Parking mode

A. Urban Space Structure Guided By Rail Transit

Optimizing space structure and increasing density of land use help to improve functional layout, transform the traffic distribution and influence traffic behavior. The intensity and density of land use development along the rail transit can be promoted appropriately. With full use of regional traffic advantage, compact axial center can be formulated. In the construction land, the land of higher carbon absorption ability such as green land and public open space can be encouraged to increase the regional environmental capacity. The land use development shall be guided by the public transit system, while the urban complex and public activity center shall be encouraged. The level and spacing distance of public stations as well as layout of rail transit stations shall be combined with public centers to increase the coupling degree between public activity centers and public traffic hubs.

B. Compact Development Mode around Transit Stations

The layout of urban rail transit stations shall be combined with urban land use and space structure. Layout of land use determines the traffic density and space distance structure. Thus, the interval setting of public transit stations shall meet the structure of urban space development. The excessively dense transit station setting is avoided, which can lead to urban sprawl, also the insufficient transit station setting is avoided, which can not satisfy the need of transport service. It forces passengers to choose private traffic mode. Besides, the hierarchy of stations shall be considered in addition to the development situation of the city. High level traffic hub shall be set in the region with large population and high density employment. The development of the surrounding of rail transit station is the focus of urban land use development. In the progress of the urban development, the development mode oriented by station shall be implemented to promote urban land use development around the traffic hub and transfer station and form the compact, high density, multifunctional urban space complex.

C. Residential Development Mode Guided By Low Carbon Traffic

The layout of residential land use determines the selection of traffic means. Walking, bike, and public transit shall be the main traffic modes of low-carbon residential area. Under such transportation condition, the key of road network design is to construct complete non-motorized road system and combine the non-motorized road network with public transit station, thus resulting in comfortable environment for walking and bike. Besides, the public services in the residential area shall be combined with the layout of public transit stations. In addition, the public transit stations shall be within the walking scope of residents for convenient delivery and transfer. Main characteristics of low carbon residential areas with the integration of transport and land use include: multifunctional space layout, complete residential public service facilities oriented by non-motorized traffic, appropriate walking scale and dimension, complete slow walking system, residential road network coordinated with urban network, land use mode in accordance with public transit development, reduction of internal parking, and static traffic mode of integrated parking lots.

V. CONCLUSIONS

Land resources are the material carrier of urbanization. Land use is the main source of carbon emissions. In the aspect of the decrease of carbon emission, land use strategies include the optimization of land use structure, the promotion of intensive land use and improvement of carbon sink effect. In addition, under the guidance of city sustainable development theories, some strategies are proposed, which are the reasonable organization of residential, industrial, public service facilities and road traffic, adjusting the layout and structure of land use.

Traffic emission ranks the third in urban carbon sources behind production and construction emission. In order to cope with the rapid growth greenhouse gas emissions resulted from fossil fuel consumption, low-carbon transportation development strategies are developed as the orientation of saving energy and reducing carbon, which are the construction of transport transfer system centered by public transit hubs, the implementation of green traffic mode, priorities of public facilities land use, and priority assignment of road right of public transit.

There is an interactive relationship between land use and traffic, thus the integrated development of both meets the needs of the development of low carbon city. The main strategies Include: urban space structure oriented by rail transit, axial direction of land use along rail corridor network, multifunctional, intensive and compact public space nodes around the rail transit stations, community development guided by non-motorized traffic and characterized by pedestrian-friendly and bicycle-friendly space.

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