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Transportation Model Application for the Planning of Low Carbon City -- Take Xining City in China as Example

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Abstract

The low carbon development is the important trend of Chinese urbanism, and the gap between transportation infrastructure resource and travel demand induces to the transportation problems, such as congestion, energy, and safety. There is a missing connection with the Demand-Oriented Planning and Low-Carbon-Oriented Planning, since most of our discussion in the Urban Comprehensive Planning Proceed is focusing on the commuting congestion in the peak hour. This paper discussed the benefits and problems of the three solutions of transportation, based on the Transit Priority Strategy in China, including the transportation policy research, smart transportation research, as well as planning and design research. A further Model exploration and application for the smart low-carbon transit and non-motorized transportation system construction strategic decision making is discussed. The result shows around 30% energy consumption and CO_2 emission could be waived if we choose the low-carbon city development mode. The solution and case study apply the Unit City mode and City Intelligent Energy Network technology in Xining City Comprehensive Planning to find out how to form the future development in the cities in China.

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Keywords: Transportation Model, Low-carbon Travel, Unit City; Transit Priority Strategy; Smart Transportation; City Intelligent Energy Network;

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1. Introduction

As the economic and social activity branch demand, travel and mobility request induce the widespread congestion, energy consumption and safety problems in the Middle and Small Scale cities in China. How to model our transportation congestion and energy consumption in cities to support our future development is the big issue for the City governments, especially for the planning bureau. The decision making process for the low carbon city development in transportation facet is connected with the factors, including traffic congestion reducing, travel safety increasing, and trip quality improving. Transit Oriented Development Strategy is an obviously solution to reduce the usage of private car, especially for the Chinese cites which have large amount of commuting residents and high density land-use mode, by transferring car use trips to transit.

The Transit Oriented Development Strategy face the two major challenges in China, one is the development of private car market with the rapid increasing almost 20% per year from 2008-2012[1], making the gap between infrastructure and car travel demand becoming wider; the other one is the missing connection with the nature pattern of urban development, since most of the city is constructed already and maybe not suitable for transit at all. So the solution for the future development could be two ways in China, when we use the Unit City mode and City Intelligent Energy Network technology, from the starting point of City development.

The Unit City mode for the future development is a mode which focuses on the balancing of Job and Work amounts in the land-use planning level. The City Intelligent Energy Network is a system which using the IOT (Internet of Things) technology to check the dynamic data and forecast the managing bottleneck for the city government, including the smart transportation system as the major part. A transportation model is developed already to test how this Unit City mode and City Intelligent Energy Network technology affecting our city, especially in transportation facet. The rapid increasing of the private car and travel demand is considered as one of the mobility change within the urban structure, land-use mode, and road resource, when widespread the considering about the low carbon development of the city life systems including the water system, energy using system, waste system, ecology system and other [2].

This paper is discussing the three solutions of the transportation last decades in China, and pointing out the major problems when they considering the low carbon developing. A strategic of the smart transit and well-designed non-motorized system is induced to support the Unit City mode and City Intelligent Energy Network technology, when we apply the whole model to describe the congestion and energy consumption together. Xining City is used as the case study to find out how the process done.

2. Literature Review

By the end of 2011, the urbanization rate of China has turned to the 50% limestone [3]. As the important 18th 5-years report pointed out, the new type of industrialization would adhere to industry revolution, information technology application and agricultural modernization [4]. Urbanization is repeatedly stressed as the greatest potential for expanding domestic demand [5]. Take the European Union as example, in 2007 the overall urbanization rate of 72%, while 85 per cent of its GDP came from the city [6].

Therefore, the new circle of the future Chinese urbanization, focusing on the Middle and Small Scaled cities, would push the further development combining the four issues of China, when city becomes the basement of urbanization, industrialization, information technology and agriculture modernization. That would raise the mobility in these kinds of cities and dramatically change the travel behavior and modes for the new and old residents, which could be concluded as the experiences from the big cities

development in China, that the transition from original non-polluting travel modes such as walking, cycling, to the fast, efficient public transport, taxis, and private cars.

To really resolve and prevent traffic congestion, energy consumption and safety issues in next round of Chinese urbanization process, the lessons from the experience of the development of big cities should be learned, where traffic jams and other problems is now widely accepted as normal issues of the development. That is the change idea from the determinate solution to the acceptation of problems. How could Middle and Small Scaled cities, especially the new town construction and planning lead the low carbon development, model analysis and strategic consideration within the basic information about its nature will be the way to go.

3. Theory and Mode of Low-carbon Transportation

In the beginning of the research, an urban structure and transportation development should be set. As congestion has become the norm, shows the gap between demand of travel and facility construction would not be able to solved recently, especially in the central city, since smart technology, policy, planning and design solutions only could reduce 20% -30% of the whole traffic congestion [6]. At the same time, the ownership of the private car would increase dramatically. As the data shows, the national ownership of private automobiles is 114 million in 2012, and 3,095 million in 2008 [1], with an increase of nearly three times.

Therefore, for the smart low-carbon transportation planning and research, three key factors should be considered, one is the balance of work and resident, the other is the transit priority, the third one is the prohibit of the usage of owned vehicles. Within these three keynotes simultaneously, Unit City Mode and City Intelligent Energy Network could be built and transfer one by one, to achieve the eco-developing [7] [8] [9]. Unit city is a new mode of Chinese urbanization development way, focusing on the non-motorized trip mode use and life quality improvement [10]. Unit city mode could be an effective pattern of land-use structure, which mentions building of transit hub in the central, comprehensive considering urban style, transportation, energy, water and waste system, creating a systematical, concentrated, distributed city [11]. The strategic of transportation is listed in Fig 1.

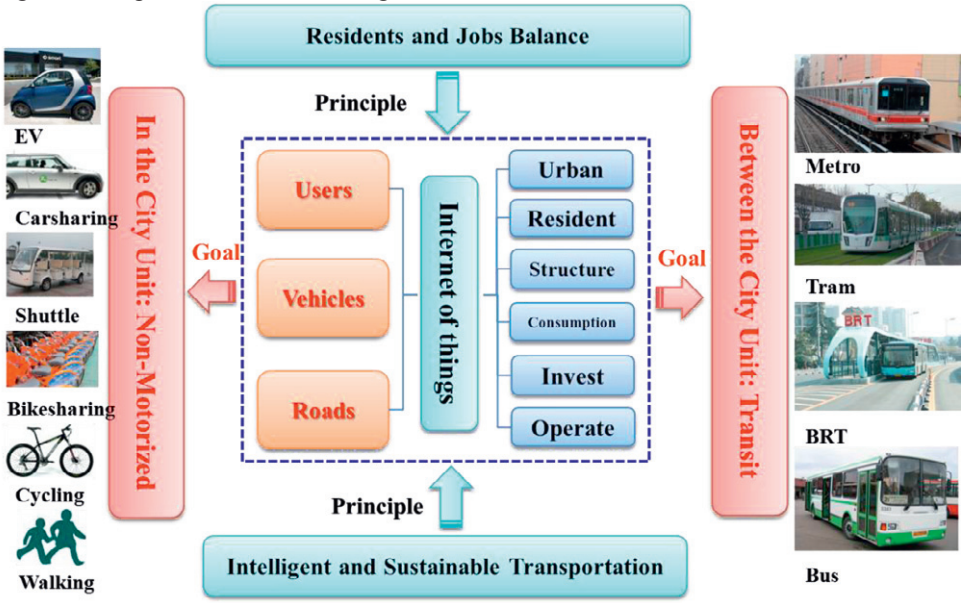


Fig. 1. Low-carbon City Transportation Network [12] [13]

In Unit City, transportation should be an efficient, safety and clean energy system that constructed as the Meshing network of the major transit system. The high density and huge capability of the transit system could be a great way to take the passengers from one unit city to another. In the city unit, bicycle and walking is the major trip mode, which is required a suitable non-motorized unit size and facility. Upon all the transit and non-motorized trip modes, an advanced smart transit and bike system would be applied to all the residents, which could mention the punctual transit in real-time, reduce the missing and long-time waiting of the bus. Further try would be happen in carsharing and bikesharing, which supply the shared-use of vehicles, and create a car-free community [14] [15].

4. Transportation Model Combining Policy, Plan and Technology

4.1. Urban Mode Based Model

Transportation Model should calculated the policy factor, to get a comprehensive study and develop the corresponding urban congestion charges, parking restrictions, bus priority, the development of public bike policy in order to control congestion, reduce energy consumption emissions, improve security and urban management requirements. The processing of policy making and implementation is the combination of test running, feedback and adjusting.

It is important to model policy-making process, when the deepen control of the actual situation and survey analysis is the basic requirement for the deepen research. For example, parking restriction policy in the central city, which is considered as the policy to reduce the use of private cars and improve the transit accessibility, may raise the two conflicting results. Congestion could be well reduced in the central, when less people drive, but how could the problem be worse, if they drive and cannot find the parking lot? The opposite experts believe blindly parking restrictions could impede economic development. Like Wanda and other large commercial complex with large parking facility is an actual case of Parking-Oriented business model, when attracting high level and large amount business is basic consideration.

The transportation model should test the gravity of large amount of factors to reduce the side factors of new policy. Take the central city parking restriction policy as an example as well, the embarrassment of the Planning and Transportation departments on different areas of the building, which can be set up the basic safeguards number of parking spaces, but cannot limit the single building to increase parking configuration. Finally, the central area of parking restriction policy, and often can only proceed from the point of view of reducing the public parking, which reduce the effect of the implementation of policy but raise some controversy about the configuration of public funds.

4.2. Dynamic Data Based Model

Smart transportation system is way of Transportation Model data collection and analysis, if the impacts of Unit City and City Intelligent Energy Network could be calculated. Smart transportation system read, analyze and monitor the transport system dynamically from the various types of information acquisition devices, to touch and feel the situation, help to adjust and improve the efficiency traffic system. It is important to get the information of the ability of urban management, dividedly operation of the passenger and cargo, as well as reduction of the energy consumption, emission and noise. Through the traffic information from its transit, taxi system, and the moving devices such as pad or phone, Smart System could create a dynamic model, which could simulate the different sections of the driving conditions to determine the location of congestion and accidents, study the mode of travel and travel characteristics of residents in different time slots area. Combining with the land-use and geographic information data, you can build further 3D digitized city, as one of the application of Smart City.

Most of the application of Smart transportation system is mainly concentrated in big cities, where the subsidy of transit and management could cover the huge investment of Smart Transportation facility. Take the Intersection Signal Control System as example, it could setup the single intersection travel and

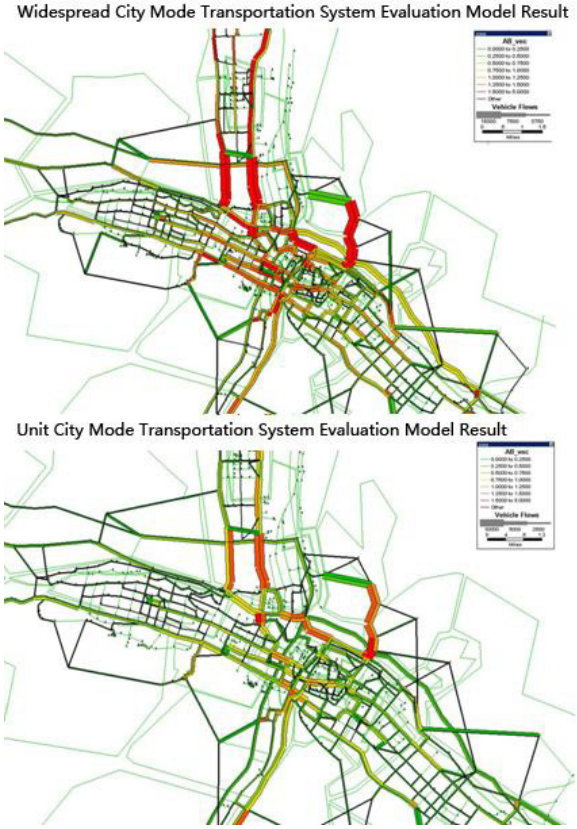
stop time control according to the real-time traffic situation and flow. An advanced system called regional traffic control system could share the information and tactics with the neighbor intersections. In the whole city case, the widely information collected by the road facility could create a network of intersection control system, and choose an optimized strategy, improving the travel efficiency, as well as reduce the delays and congestion. The smart system could also be transferred to parking system with the intelligent navigation, which could help the drivers to avoid the congested road. Smart transportation system is based on the well-designed infrastructure and personal vehicle modification conditions. Relatively speaking, smart transit system is easier to apply since most of transit systems in the middle and small cities are managed by one company. The transit based GPS system and real-time reaction system could reduce the congestion and improve the transit operating and scheduling punctuality, which is important for travellers.

4.3. Combined Model

The Urban Mode Based Model is based on the land-use data which is static, combining with the Dynamic Data Based Model which is based on the simulation of transportation system in the future. The congestion of transportation system is calculated by the TRANSCAD software, and further CO_2 emission and energy consumption is also calculated by EXCEL. The result of the Model is showed in Fig 2.

5. Results and Conclusion

With the help of transportation model based on the smart and low-carbon development policy, planning and technology, we could see the Fig 2 shows how Unit city and widespread urban structure affecting the travel length, travel time and level of service of the road transportation system.



Urban Structure	Unit City and CIEN with Rapid Transit System and Smart Transportation System	Unit City and CIEN	Widespread Mode
Travel Time	19.6min	26.0min	35.0min
Travel Length	6.03km	6.03km	8.57km
Trip Mode Split			
In the City Unit	Rapid Transit 10%. Bus 10%. Private Car 5%. Bicycle and Walking 75%	Bus 20%. Private Car 5%. Bicycle and Walking 75%	Bus 45%. Private Car 15%. Bicycle and Walking 40%
Between the City Units	Rapid Transit 15%. Bus 15%. Private Car 10%. Bicycle and Walking 60%	Bus 30%. Private Car 10%. Bicycle and Walking 60%	Bus 50%. Private Car 20%. Bicycle and Walking 30%
Between the Unit Cities	Rapid Transit 30%. Bus 15%. Private Car 15%. Bicycle and Walking 40%	Bus 45%. Private Car 15%. Bicycle and Walking 40%	Bus 55%. Private Car 25%. Bicycle and Walking 20%
Between the Major Cites	Rapid Transit 45%. Bus 25%. Private Car 20%. Bicycle and Walking 10%	Bus 65%. Private Car 25%. Bicycle and Walking 10%	Bus 60%. Private Car 30%. Bicycle and Walking 10%
Suburban	Rapid Transit 50%. Bus 23%. Private Car 25%. Bicycle and Walking 2%	Bus 68%. Private Car 30%. Bicycle and Walking 2%	Bus 63%. Private Car 35%. Bicycle and Walking 2%
Level of Service			
Branch Road 4 Lanes	3.3%	4.5%	6.10%
Sub Road 4 Lanes	3.3%	28.6%	38.30%
Major Road 4 Lanes	5.0%	9.8%	23.30%
Express Way 4 Lanes	15.1%	26.0%	45.00%
Sub Road 6 Lanes	14.6%	30.2%	50.70%
Major Road 6 Lanes	35.6%	49.2%	86.60%
Express Way 6 Lanes	3.3%	65.2%	97.80%
Major Road 8 Lanes	83.7%	105.1%	121.30%

Fig. 2. Unit City and Widespread Urban Structure Affecting Impact of Transportation

Fig 2 shows that with the Unit City and CIEN strategy, the travel length reduce to 6.03km from 8.57km, since Unit City mode create a transit support environment, and the balance of jobs and residents could also reduce the travel demand. In the same time, the advanced and low carbon urban structure and transportation mode reduce the travel time from 35.0 min to 26.0 min, when most of the roads LOV decrease 10-20%.

Most of the Planning is applied in the new town, when designing is both used in new town and old town. It is a little bit hard for the old town to reach the mandatory balance of work and residents through renovation and demolition, since most of the central city where old residents concentrated, is easily changed into new CBD, not combination of residents and business. It could widen the gap between jobs and live, increasing more commuting demand. More technology including the rapid transit system and smart transportation should be study and apply, if further congestion is expected to reduce. From the Fig 2, we also could find out the change with advanced transit and smart system. If the work and resident in actual region could be balanced, less travel demand will need. The other way could be the well-designed infrastructure which optimize the participant travel process and enhance the efficiency and safety, since half of the road capacity could be lost in the intersection, and the impact of the design of intersection could increase the 30% of the traffic capability [6] [16] [17] [18] [19].

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