Study on Low-Carbon Transport City Evaluation: Case Study of Xi'an City

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***Abstract*—The paper combines with actual characteristics of Chinese city, discusses about and builds a Low-carbon transportation city evaluation index system, and puts forward a set of simple and practical evaluation methods and standards evaluation system; with case study of Xi'an City, this paper also conducts empirical evaluation of current development level in 2013 and planning level in 2020 respectively, and verifies scientific validity of the index system.**

Keywords-Low-carbon transport city; evaluation index; transport; Xi'an.

I. INTRODUCTION

Transportation is basic cause, leading industry and service industry of national economy and social development, and is also one of industries with intensive resources and great influence on the environment [1]. At the end of 2012, China's total transport energy consumption and carbon emissions were 454 million tce and 926 million CO2, accounting for 12.67 percent and 12.19 percent of total energy consumption and carbon emissions respectively [2]. It is of important strategic and practical significance to realize low-carbon development with rapid expansion of city scale and significant improvement of service capacity, which has become a severe challenge for the modernization of Chinese cities.

The remainder of the paper is organized as follows: Section 2 is the Literature Review. Section 3 introduces about evaluation index system. Section 4 studies on empirical evaluation with typical case of Xi'an Transport; Section 5 is the conclusion and implication

II. LITERATURE REVIEW

For the development of low-carbon cities, scientific evaluation and policy guidance are critical and essential. Currently, domestic and foreign scholars have done a lot of researches on low-carbon evaluation system [3], and evaluation methods mainly include input-output, analytic hierarchy process (AHP), fuzzy comprehensive evaluation, data envelopment analysis (DEA), and principal component analysis (PCA) etc. [4-5]. For example, Shimada et al (2007) constructed a method to analyze the long-term development scene of regional low-carbon economy [6]. OECD (2008) builds core environmental indexes to measure the influence on environmental development by environmental pressure index and direct and indirect indexes of environmental conditions etc. [7]. Fu et al, (2010) constructed a low-carbon economic development level evaluation system with low-carbon output, low-carbon consumption, low-carbon resources, low-carbon policy and low-carbon environment [8]. Dagoumas and Barker (2010) analyzes carbon emission of UK by E3MG (Energy Economy Environment Model), and puts forward some suggestions about its decarburization paths [9]. Peng (2013) constructed an urban low-carbon traffic evaluation indicator system including low-carbon technology, demand management and organization efficiency [10]. Existing researches study on single index system or plan. This paper combines evaluation index system with management of low-carbon cities in order to provide reference benchmark and evaluation basis for cities throughout China to strive for Low-carbon transportation city, builds a low-carbon index system which is consistent with China's actual development in order to provide important basic support for scientific formulation of Low-carbon transportation city strategic planning and policies.

III. EVALUATION INDEX

A. Evaluation Framework and Index Selection

Low-Carbon transportation city is a systematic concept (Figure 1), the framework of evaluation index system includes:

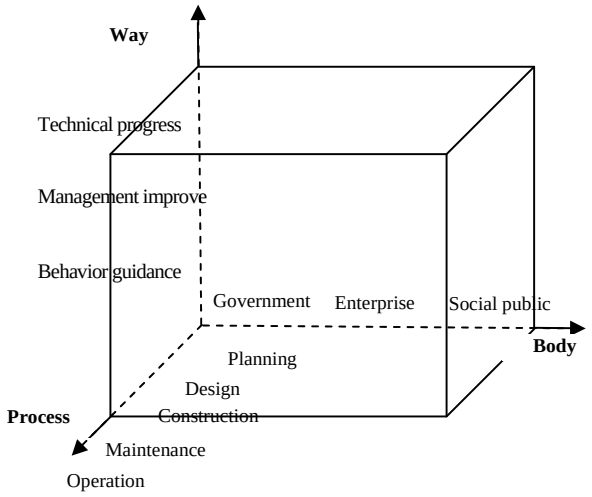

FIGURE I. LOW-CARBON TRANSPORT CITY MODEL

(1) Vertical structure of index system: 1) overall score, which mainly reflects the degree of coordinated development of relations among evaluation indexes; 2) evaluation category, which sorts and integrates comprehensively a large amount of

relevant information, and forms a sub-category index with clear significance; 3) evaluation content, which mainly reflects factors that shall be considered in each category, finds and seeks appropriate content to reflect characteristics of the development of low-carbon city comprehensively and specifically; and 4) evaluation indexes, which mainly reflect specific content of factors.

(2) Horizontal structure of index system: this structure mainly includes index category hierarchy, index name and meaning, calculation method, index weight and evaluation standards, mainly based on four categories of indexes namely intensity indexes, system indexes, support indexes and characteristic indexes etc., each of which reflects a certain aspect of Low-carbon transport city.

B. Evaluation Methods and Standards

(1) Evaluation methods. Intensity indexes are comprehensive quantitative indexes, set main index energy saving and emission reduction standards for competent port departments, calculate rate of reaching the standard and score; system indexes mainly include quantitative indexes; support indexes are mainly qualitative and score implementation of support work during construction of Low-carbon transportation city; for characteristic indexes, city could select autonomously according to their conditions, and shall better select quantitative ones.

(2) Evaluation basis and standards: primary data of evaluation indexes mainly comes from China Transport Statistical Yearbook and Collection of National Transport Statistical Data; statistical data of transportation of provinces or cities; major enterprise monitoring and typical survey data etc. Determine score standards of sub-indexes, measure average level, advanced level and backward level of indexes in terms of the country, provinces (municipalities, autonomous regions) and main cities respectively, benchmark international advanced level, and further determine evaluation scores of each category of cities. See table 1 for details of specific calculation.

C. Evaluation Index System

Evaluation system consists of four evaluation categories (intensity indexes, system indexes, support indexes and characteristic indexes), see Table 1.

TABLE I. LOW-CARBON TRANSPORT CITY EVALUATION INDEX SYSTEM

Index category		No.	Index name	Weight (Scores)
Intensity Index (40 scores)	**Energy Intensity**	1	Unit energy consumption of operational vehicles, unit: kgce/hundred ton km	5
		2	Unit energy consumption of operational ships, unit: kgce/thousand ton km	5
		3	Integrated port unit production energy consumption, unit: tce/ten thousand ton throughput	4
		4	Urban passenger transportation(City bus) unit passenger energy consumption, unit: tce/ten thousand person-time	3
		5	Urban passenger transportation(taxis) unit passenger energy consumption, unit: tce/ten thousand person-time	3
	CO_2 Intensity	6	Unit CO_2 emissions of operational vehicles, unit: kg CO_2/hundred ton km	5
		7	Unit CO_2 emissions of operational ships, unit: kg CO_2/thousand ton km	5
		8	Integrated port unit production CO_2 emissions, unit: tCO_2/ten thousand ton throughput	4
		9	Urban passenger transportation(City bus) unit passenger CO_2 emissions, unit: tCO_2/ten thousand person-time	3
		10	Urban passenger transportation(taxis) unit passenger CO_2 emissions, unit: tCO_2 /ten thousand person-time	3
System Index (30 scores)	**Infrastructure**	11	Construction of comprehensive transportation hub	3
		12	Proportion of special public lane in urban road	3
		13	Proportion of crawlway in urban road	3
	Transport Equipment	14	Proportion of energy-saving and environment-friendly vehicles	3
		15	Proportion of energy-saving and environment-friendly ships	3
	Organization Patter	16	Proportion of water transportation and railway cargo transportation	3
		17	Sharing rate of buses in motor traveling	3
		18	Proportion of multimodal transport in transportation turnover	3
	Intelligent Port	19	Application of public traveling information service system	3
		20	Coverage rate of logistics public information platform	3
Supporting Index (20 scores)		21	Establishment and operation of organizations and institutions	6
		22	Energy saving and emission reduction evaluation system	6
		23	Technological innovation mechanism	4
		24	Energy saving and emission reduction promotion training	4
Characteristic Index (10 scores)			Self-defining items can be set according to city characteristics and project innovation situation, and explain application reasons and scores. Set 2-5 items, each of which shall not have above 5 scores with total scores of 10.	10

IV. EMPIRICAL ANALYSIS

A. Data

Xi'an is an important economic central city and port city in the west of China, which had a GDP up to RMB 488.41 billion in 2014. Data of evaluation index system mainly comes from Collection of Transport Statistical Data, Xi'an Statistical Year-book by Xi'an Statistical Bureau, and data of transport energy consumption statistical monitoring and typical surveys etc. Reference period of evaluation of current level is 2013, and the target year of planning pre-evaluation is 2020. According to actual development of Xi'an transport, a total of 3 categories of and 27evaluation indexes are set, among which, characteristic indexes mainly include the promotion of public bicycles, filling station construction, the installation monitoring rate of operating vehicle GPS (BeiDou Navigation Satellite System) etc.

B. Evaluation Results

1) Overall evaluation results

Xi'an has superior basic conditions to create a Low-carbon transport city, and carries out a large amount of highly effective work, and obtains significant effects. It gets a total of 87 scores, and thus is a standard Low-carbon transport city, and has generally a leading domestic level and good demo effects (Table2).

TABLE II. EVALUATION RESULTS OF LOW-CARBON AND LOW-CARBON DEVELOPMENT STATUS AND PLANNING OF XI'AN

Index category		No.	Index name	Weight (Scores)	2013 (Current)	2017 (Target)	2020 (Target)
Intensity Index (40 scores)	Energy Intensity	1	Unit energy consumption of operational vehicles	5	5	5	5
		2	Unit energy consumption of operational ships	5	\	\	\
		3	Integrated port unit production energy consumption	4	\	\	\
		4	Urban passenger transportation(City bus) unit passenger energy consumption	3	3	3	3
		5	Urban passenger transportation(taxis) unit passenger energy consumption	3	3	3	3
	CO2 Intensity	6	Unit CO2 emissions of operational vehicles	5	5	5	5
		7	Unit CO2 emissions of operational ships	5	\	\	\
		8	Integrated port unit production CO2 emissions	4	\	\	\
		9	Urban passenger transportation(City bus) unit passenger CO2 emissions	3	3	3	3
		10	Urban passenger transportation(taxis) unit passenger CO2 emissions	3	3	3	3
System Index (30 scores)	Infrastructure	11	Construction of comprehensive transportation hub	3	3	3	3
		12	Proportion of special public lane in urban road	3	3	3	3
		13	Proportion of crawlway in urban road	3	3	3	3
	Transport Equipment	14	Proportion of energy-saving and environment-friendly vehicles	3	2	3	3
		15	Proportion of energy-saving and environment-friendly ships	3	\	\	\
	Organization Patter	16	Proportion of water transportation and railway cargo transportation	3	3	3	3
		17	Sharing rate of buses in motor traveling	3	2	3	3
		18	Proportion of multimodal transport in transportation turnover	3	0	3	3
	Intelligent Transport	19	Application of public traveling information service system	3	3	3	3
		20	Coverage rate of logistics public information platform	3	3	3	3
Supporting Index (20 scores)		21	Establishment and operation of organizations and institutions	6	6	6	6
		22	Energy saving and emission reduction evaluation system	6	3	4	5
		23	Technological innovation mechanism	4	2	3	3
		24	Energy saving and emission reduction promotion training	4	4	4	4
Characteristic Index (10 scores)		25	promotion of public bicycles	4	4	4	4
		26	filling station construction	3	3	3	3
		27	monitoring rate of operating vehicle GPS (BeiDou Navigation Satellite Sys-tem)	3	3	3	3
total				**100**	**87**	**96**	**98**

By comparing main score deduction items of evaluation indexes, current gap and deficiencies of Xi'an can be found. These deficiencies mainly include: The urban traffic is seriously jammed, the urban public transportation priority level is not high; the resistance to update the natural gas-powered vessel is increased, and the proportion of energy-saving and environment-friendly trucks is relatively low; energy audit system, energy consumption and carbon emission statistical monitoring and other basic capacity building are in urgent need of being strengthened; Low-carbon promotion shall be further promoted, etc. Xi'an shall accelerate construction of high-level, Low-carbon transport city from these aspects.

2) Sub-index evaluation results

a) In terms of strength indicator, the planning objective is completed comprehensively. The unit energy consumption of vehicles, bus and taxi operated in 2013 were reduced by 5%, 4.3% and 2.8% respectively, meeting the target requirements of the "Twelfth-five Year" Planning period.

b) In terms of system indicator, the work foundation is solid with a large improving space. On one hand, Xi'an prepared the comprehensive traffic planning and special planning, with bus special road accounting for 7.66% of the urban road, crawlway accounting for 96.42%, and hybrid power and natural gas passenger and cargo vehicles, urban buses and taxes respectively accounting for 1.6%, 97% and 99%, in which the natural gas taxes account for the largest proportion, and Xi'an transportation public information service platform and Xi'an logistics public information platform have been constructed; on the other hand, in terms of the proportion of buses in the sharing of motor traveling, the proportion of multimodal transport in the comprehensive transportation turnover should be further increased, and substantial breakthrough is to be made in the hybrid power and natural gas passenger and cargo vehicles.

c) In terms of supporting indexes, system construction is carried forward orderly. Establish specialized energy-saving and emission reduction management department, and specialized management staffs are equipped; energy saving and emission reduction goals responsibility evaluation and appraisal system is built, and evaluation results are linked with energy saving and emission reduction rewards and punishment; build an energy-saving and emission reduction technological innovation mechanism to reward achievements such as invention and creation, technical transformation, technical innovation and innovative application etc. including energy saving and emission reduction. Accelerate publicity and training of energy saving and emission reduction, and train all levels of environmental protection leaders and management staffs at least once each year.

d) In terms of characteristic indexes, there are distinct features and bright highlights. Besides the above general requirements, Low-carbon development of Xi'an transport has still some unique and highlighted practice with certain influence and comparative advantages at home and abroad, mainly including: Xi'an has been built 1146 public bicycle sites, put into 30400 bike, service area more than 550 square kilometers, the average daily use of more than 150000 people, Put into 83 CNG filling station, and the vehicle GPS installation monitoring rate is more than 41.51%.

V. CONCLUSIONS

This paper discusses about a Low-carbon transportation city evaluation index system, and conducts empirical research with case study of Xi'an, and reaches the following conclusions:

(1)Based on four categories of indexes such as intensity indexes etc., this paper discusses about and builds a Low-carbon city evaluation index system. Where: as comprehensive performance index, intensity index are in line with stage characteristics of the development of Chinese city, and play a strongly strategic guiding role; system indexes and support indexes are strongly systematical and unified, comprehensively systematical, simple, practical and convenient to operate; meanwhile, characteristic indexes can fully reflect development status, highlight Low-carbon transport city features, help stimulate exploration and innovation, and thus show good expandability.

(2)Empirical research indicates that Low-carbon transport city evaluation index system proposed in this paper has good practicability. Empirical evaluation of Xi'an shows that evaluation index system proposed in this paper has good practicability, as this system applies not only for objective evaluation of development status of Low-carbon transport city, summarizing effects, recognizing advantages, carrying forward experience, analyzing problems, finding the gap and making up for the deficiencies, but also for establishment of Low-carbon transport city strategic development planning goal system, realizing scientific anticipation of planning perspective, and thus taking targeted measures to "enhance the strong and make up for the weak, enhance advantages and avoid disadvantages".

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