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Approaches to Realizing Low Carbonization of Industries in the Western Region of China and Building Evaluation Indicator System

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Abstract

China is undergoing the development of industrialization and new-type urbanization, during which period the conflict between the economic development and environment and resources is very prominent, and during which time the economy is showing high-carbon characteristics. However, low-carbon economy is to abandon the traditional "high-carbon" development model, and is to achieve comprehensive development of society, economy and ecology. Based on the theory of low-carbon economy, this paper identifies two dimensions of industrial low carbonization, that is, horizontal dimension and the vertical dimension, then it tries to build an indicator system for evaluating the low carbonization of industries. Besides, the paper proceeds from the evaluation indicator system and from the circumstances of Chongqing city to explore the approaches to realizing the low-carbon value of industries in the western region of China, thus providing implications for the low-carbon development of industries in western China and for enhancing their core competitiveness.

Key words: Western region; Low carbonization of industries; Evaluation indicator system; Realization approaches

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INTRODUCTION

Energy is the important source of and guarantee for the economic development, so the development of energy plays a huge role in promoting economy. Nevertheless, energy is a double-edged sword. In the process of exploiting and utilizing energy, we find that energy has not only produced power to stimulate economic development, but also has caused huge environmental pollution. Absence of resources is also remarkable. Moreover, with the continuous development of modern industrial civilization, population rockets, coupled with the immense increase of carbon dioxide caused by humans' unlimited demand for and unreasonable use of energy resources, especially the fossil fuels. All these have contributed to global warming, have severely harmed the ecology system, and even have posed a threat to the survival of human beings. In response to the energy crisis and global warming emerges a brand-new mode of production and lifestyle that is in line with the ecological civilization—low-carbon economy, which is an economic development mode characterized by low energy consumption, low pollution and low emission by means of technological innovation, system innovation and other means to reduce energy consumption and carbon dioxide emissions.

The key to the development of low-carbon economy is to change the mode of economic development, and to reduce the dependence of economy on coal, oil,

natural gas and other fossil fuels, so that the economy could develop in a mode of "low-carbon economy" instead of "high-carbon economy" (Wu, 2011). For this reason, the promotion of low carbonization of industries has become a top priority to change the mode of economic development. Low carbonization of industries is to actively promote industries to change their development mode from being high-carbon to be low-carbon by virtue of technological innovation. It emphasizes "carbonization", which means that low carbonization of industries has to undergo a dynamic process (Luo & Zhou, 2012); therefore, it should include energy conservation and emission reduction, industrial restructuring and low-carbon or carbon-free energy structure, and so on. All these are related to various aspects of industries. However, the connotation of industrial low carbonization referred to in this paper is divided into two parts. The first one means a process in which market participants, in compliance with the requirement of conserving energy and cutting emissions, make use of new idea, new technology, and new energy resources to organize low-carbon production, as well as offer low-carbon products and services; the second one refers to urging governments to formulate and implement policies in terms of industrial low carbonization based on policies and customers' demands, and guiding consumers to cultivate the concept of low-carbon consumption, and the concept of consumption of low-carbon products, and help them develop a habit of low-carbon consumption, thus motivating the low carbonization of assignment and consumption (Liu & Zhang, 2013).

The western region of China is rich in energy resources, which provide good driving forces for the West Development, but it also poses a potential threat to the ecological development of the western region. The western region referred to herein is in accordance with the economic and administrative division of China's territory, including 12 provinces, municipalities and autonomous regions such as Chongqing, Sichuan, Guizhou, Yunnan, Guangxi, Shaanxi, Gansu, Qinghai, Ningxia, Tibet, Xinjiang, Inner Mongolia and others. This paper selects Chongqing City as its research target.

Located in the upper reaches of the Yangtze River, Chongqing is the only municipality in the western region. Chongqing boasts rich natural resources and energy. More than 40 kinds of minerals have been discovered and exploited, accounting for 27% of the world's known minerals. Besides, 25 kinds of minerals have proved reserves. In particular, coal, natural gas, bauxite, salt, and other minerals in Chongqing have a more distinct advantage than the rest China in terms of reserves and quality, of which the 320 billion cubic meters of natural gas reserves is the national key mining area; moreover, bauxite reserves totals 74 million tons, which ranks first in the whole country; furthermore, the ore reserves of manganese and barium ranks second and third, respectively. Apart from those mentioned above, rivers crosslink with each other; in this sense, Chongqing is abundant in water and hydropower resources. The city's average annual total of water resources reaches to 500 billion cubic meters. Although rich in energy resources, Chongqing does not enjoy a rational energy consumption structure. As shown in Table 1, in 2008, Chongqing's coal consumption accounted for 69% of its total amount of energy consumption; in 2012, the coal consumption accounted for 67% of the total energy consumption. Although the proportion of coal had declined, the energy consumption structure of Chongqing was still mainly dominated by coal, supplemented by oil, coupled with certain development of natural gas and electricity. Such fossil-based energy structure had exerted immense negative impact on the environment, so this energy structure over-relying on coal energy is not reasonable, which needs to be optimized. In recent years, Chongqing has seen rapid economic development, but the technology of using energy is backward; efficiency is rather low; a lot of energy is wasted in the process of energy development and utilization. In this sense, we have good reasons to believe that the coal-dominated energy structure of Chongqing has remarkably polluted the environment and is not given adequate attention, and that there is a lack of measures to curb environmental pollution.

Table 1
Energy Consumption Structure of Chongqing City Between 2008 and 2012 (unit:10,000 ton)

Year	Total	Coal	Natural gas	Crude oil	Electricity
2008	5895.10	4048.95	648.38	600.57	597.20
2009	6431.63	4499.83	657.82	619.73	654.25
2010	7117.41	4857.64	750.39	741.20	768.18
2011	7951.12	5338.03	819.81	912.06	881.22
2012	8284.94	5521.11	941.24	933.99	888.60

Note. Data sources: Chongqing's Statistics Yearbook (2013)

1. BUILDING THE EVALUATION INDICATOR SYSTEM

1.1 Dimensions

In order to evaluate the low carbonization of industries, we must first analyze the dimensions of the low carbonization of industries. This paper is to analyze the low carbonization of industries from both horizontal and vertical dimensions, as shown in Figure 1.

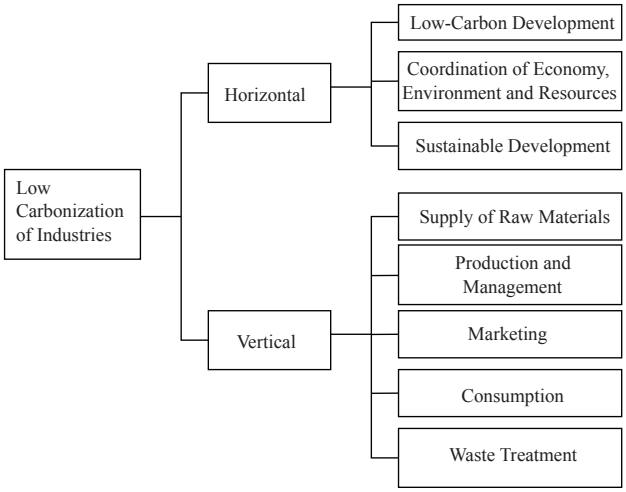

Figure 1
Dimensions of Low Carbonization of Industries

From the horizontal view, the dimensions of low carbonization of industries mainly include low-carbon development, coordination of economy, environment, and resources, and sustainable development of industries. Low-carbon development means to enhance the capacity and overall competitiveness of industries by utilizing new energy and renewable energy and through technological innovation as well as by virtue of development and use of low-carbon technologies. Coordination of economy, environment, and resources refers to the unity of industries' economic interests with the interests of environment and resources. It emphasizes the optimal allocation of resources, and stresses the relationship between environmental protection and the regulation of the mode of economic development (Wang, Yuan, & Chen, 2008) [4]. Sustainable development means that industries will be in a dominant position and enjoy sustainable development in a long run after enhancing their core competitiveness; they will attach more importance to balancing and coordinating their development from the perspective of time (Zhang & Wang, 2010). The ideal state of industrial low carbonization and sustainable development is to produce green and low-carbon products that could be maximumly utilized with the least energy resources and ecological costs under the circumstances of continuous technological innovation and mechanism innovation.

With the rapid development of technology and with the further refinement of the social division of labor, the production process is divided into a series of associated production phases. In order to ensure smooth production activities, industrial chain has been formed, that is, every production department, based on certain economic and technological connections, is engaged in its activities in accordance with specific logic, in specific places, and at specific time, which objectively forms chain-linked connections. In order to fully assess the low carbonization of industries, the paper thus tries to place it in each phase of production, namely, the paper analyzes the low carbonization of industries from five sub-dimensions including the supply of raw materials, production and management, marketing, consumption, and waste treatment (Chen, Liu, & Yuan, 2010).

1.2 Reasons for Selecting the Indicators to Evaluate the Low Carbonization of Industries

The indicators that could reflect the low carbonization of industries are complicated, which include both qualitative factors and quantitative factors. Moreover, different indicators have significant differences in terms of efficiency, effectiveness, capacity and weight and so on. The selection of such indicators for this paper is from the starting point of analyzing the features and dimensions of industrial low carbonization, coupled with referring to the relevant researches conducted by scholars at home and abroad. Besides, the paper takes the Key Performance Indicator Approach and other methods to screen the indicators. In this way, an indicator system for evaluating the low carbonization of industries has been established in a rational manner. It is worthy of noting that the Key Performance Indicator Approach has simplified the evaluation of industrial low carbonization into an assessment of several key indicators, and that it has regarded the key indicators as evaluation criteria, thus we could compare the low-carbon value just with the key indicators. In this way, the result gained from evaluating the low carbonization of industries has great links to the selected indicators, which will determine the final status of industries' low carbonization. Therefore, it is particularly important to select appropriate key indicators for the evaluation of the low carbonization of industries. Based on the eight horizontal and vertical dimensions, this paper is to establish an evaluation system.

1.3 Building an Indicator System for Evaluating the Low Carbonization of Industries

As far as what has been mentioned above, the writer has analyzed the dimensions of low carbonization of industries from different angles. These dimensions are believed to serve as crucial foundation for establishing an indicator system for evaluating the low carbonization of industries. To the end, we regard the low carbonization of industries as the target layer. After integrating the above-mentioned horizontal dimensions and vertical dimensions, we derive five first-class indicators which are low-carbon technology, low-carbon supply, low-carbon production, low-carbon marketing and waste treatment. Then on the basis of these five first-class indicators, we determine 15 second-class indicators as shown in the Table 2. The design of indicator system has taken into account the four phases of industrial low carbonization, so it is scientific, comprehensive, and the data is accessible.

Table 2
Indicator Systems for Evaluating the Low Carbonization of Industries

Target layer	First-class indicator	Second-class indicator
Low carbonization of industries	Low-carbon technology	Proportion of industries using clean production technology
		Market share of products produced by using low-carbon technology
		Proportion of R&D investment in low-carbon technology in GDP
	Low-carbon supply	The number of industries using low-carbon raw materials
		Reputation of suppliers who supply low-carbon energy
		Supply rate of low-carbon raw materials
	Low-carbon production	Profit to cost ratio of resources and environment
		Energy consumption of unit mass
		Transferring rates of clean production technological achievements
	Low-carbon marketing	Market share of low-carbon products
		Quickly and effectively identifying customers' low-carbon consumption demands
		Degree of satisfaction in terms of low-carbon consumption demands
	Waste treatment	The number of days of discharging "three wastes" in line with the standards in a continuous manner
		Reuse ratio of energy resources
		Utilization ratio of wastes

The nature of the low carbonization of industries determines that it is different from the development of other traditional industries, for it is the integration of low-carbon technology, energy and resource consumption, development potential and the overall benefits. The low-carbon technology indicator in this evaluation indicator system does reflect that the low carbonization of industries has to base on low-carbon technology; besides, the low-carbon production indicator and waste treatment indicator can also effectively assess whether the low carbonization of industries has achieved the dimension of consuming less energy and resources; To a certain degree, low-carbon production indicator and low-carbon marketing indicator are the touchstone that could test the potential of the low-carbon development of industries. Low-carbon technology, low-carbon supply, low-carbon marketing, low-carbon production, and waste treatment have comprehensively assessed the realization of industries' low carbonization. Besides, they have also evaluated whether the industrial low carbonization has gained its overall benefits. It should be pointed out that the design of indicators in this evaluation system is in line with the laws and characteristics of industrial low carbonization, and is suitable for industries who are transforming themselves into low-carbon industries.

Low-carbon technology is the important carrier and support for achieving low carbonization of industries. We can use three indicators to assess it which are proportion of industries using clean production technology, market share of products produced by using low-carbon technology, and proportion of R&D investment in low-carbon technology in GDP. The phase of supplying products is the material basis ensuring that industries will provide products and services to the society. We can also use three indicators to comprehensively evaluate the supplying capacity of industries who supply low-carbon energy resources which are the number of industries using low-carbon raw materials, reputation of suppliers who supply low-carbon energy, and supply rate of low-carbon raw materials. As for the low-carbon production indicator, we can use profit to cost ratio of resources and environment, energy consumption of unit mass, and transferring rates of clean production technological achievement to make an evaluation. Low-carbon marketing is the phase at which industries offer low-carbon products and services to the public society, and is also one of the important approaches to realizing low carbonization of industries. We can use market share of low-carbon products, quickly and effectively identifying customers' low-carbon consumption demands, and degree of satisfaction in terms of low-carbon consumption demands to make an assessment. The last indicator is the waste treatment. It is the indicator that gets closest to the connotation of low-carbon economy and industrial low carbonization. We can assess it by the use of three indicators including the number of days of discharging

"three wastes" in line with the standards in a continuous manner, reuse ratio of energy resources, and utilization ratio of wastes.

2. APPROACHES TO REALIZE LOW CARBONIZATION OF INDUSTRIES

As can be seen from the evaluation indicator system, only by carrying out the low-carbon concept in every phase of industries' production activities can we realize low carbonization in the whole industrial system and can we meet the low-carbon demands of customers. Therefore, based on the indicators, the paper puts forward the following suggestions in terms of realizing low carbonization of industries.

2.1 Actively Implementing and Innovating Low-Carbon Technology to Motivate Low Carbonization of Industries

Technological innovation is the core element that could promote and support the low-carbon development of industries. In this sense, low-carbon and clean technology could determine the development of industries' low carbonization. Therefore, we must strengthen the technology innovation, regard the research of core technology as the starting point, highlight the dominant position of enterprises in the industrial innovation, pay attention to their interactions and cooperation with other social participants, and give full play to the self-regulating role of market system. Meanwhile, we should give play to the macro-control function of government, step up investment in researching and developing low-carbon technologies, and guide more special funds to be used in key areas of technological innovation and development of key technologies. Besides, we should foster cultural environment and innovation environment for industries, regulate the behaviors of related participants through institutional innovation, so as to ensure an effective flow of low-carbon technology and knowledge among industries, thus promoting the overall innovation of the whole industrial system. In October 2014, Chongqing introduced "The Program of Deepening Technological System", which pointed out that Chongqing will further start a series of major scientific projects in the future by means of eight reforming measures including deepening the reform of investment mechanism for research and development, innovating the development mechanism for science and technology and finance, deepening the reform of incentive mechanism for science and technology talents, and so on. These projects are built around industries featured by energy saving and environmental protection, new generation of information technology, new energy, new materials and others. According to the "Program", 80% of Chongqing's technology funds will be invested in developing low-carbon industries.

2.2 Establishing Low-Carbon Energy Industrial System and Optimizing the Industrial Structure of Energy Industry

Low-carbon industry must be based on a low-carbon or carbon-free energy basis. Therefore, we should start from two aspects: first, we should actively develop clean energy including renewable energy, build a new energy industrial system, and gradually change the energy consumption structure. Besides, we should spare no effort to develop low-carbon and carbon-free energy, promote the diversification of energy supply, and design a supply mechanism of low-carbon raw materials. Moreover, we should make full use of hydropower, wind power, solar power, tidal energy, nuclear energy and other low-carbon or carbon-free green energy, and gradually increase the proportion of new energy in the energy structure. At present, renewable energy including hydropower and wind power accounts for 7% of the energy used in the western region of China. According to the long-term energy plan, by 2020, this proportion will increase to 15%. In addition, the government should develop as soon as possible subsidy system for enterprises that develop and utilize renewable energy and resources, and set a reasonable price for renewable energy, thus enabling those enterprises make immense profits.

2.3 Vigorously Increasing the Low-Carbon Consumption Demand and Putting the Demand of Market as the Priority

Stable and promising market demand is the driving force of the low-carbon development of industries, and is also the basic guarantee for their sustainable development. China is undergoing rapid development of economy, whose consumer market is getting increasingly mature, and the huge market demand has become the comparative advantages of China's strategic emerging industries (Liu, 2011). Under such circumstances, orienting towards the market, making use of the comparative advantage and increasing the low-carbon consumption demand have become the important measures to accelerate the pace of industries' low carbonization. The Blue Book of Chongqing's Low Carbonization of Industries— "The Twelfth Five Plan of Chongqing's Science and Technology and Low-carbon Industry has clearly pointed out the need to promote the large-scale application of innovative products through major projects including the realization of green Three Gorges project to further strengthen the guidance of the demand for low-carbon industry market.

CONCLUSION

The evaluation of low carbonization of industries is a systematic and complex project. This paper proceeds from the connotation of industrial low carbonization. Then based on the circumstances of the western region of China, the paper puts forwards eight dimensions for

the low carbonization of industries from the horizontal and vertical perspectives, thus further suggesting specific indicators to assess industries' low carbonization. This paper also advises some approaches to realize low carbonization of industries. To some degree, these approaches will provide theoretical implications for the evaluation of industries' low carbonization. However, due to limited ability and energy, the writers have not conducted a quantitative analysis of the evaluation indicator system for low carbonization of industries, and also have not assessed the feasibility and effectiveness of this system by using empirical method, which are the gaps for the future research to bridge.

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