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Research on the prospects of low-carbon economic development in China based on LEAP model

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Abstract

Scenarios prediction provides an important reference for the Chinese government to develop low-carbon economy. Four critical factors, the per capita GDP, energy consumption, energy structure, and CO_2 emissions,are mainly considered as the indicators to measure the level of low-carbon economic development. Meanwhile, based on LEAP model,the base scenario, low-carbon scenario,and frustrated low-carbon scenario are formulated to simulate China's low-carbon economic development level in 2050. The results show that the total terminal energy demands in the three kinds of scenarios are respectively 6.095 billion tons of standard coal, 5.236 billion tons of standard coal, and 6.239 billion tons of standard coal in 2050. The study indicates that China has achieved a considerable decrease in its CO_2 emissions mainly due to improved energy intensity.In addition, fuel switching and renewable energy penetration also exhibit positive effect to the CO_2 decrease.It is a more effective guarantee for achieving the goal of low-carbon economy to adjust the industrial structure, fully develop clean coal and coal technology, and improve energy efficiency.

Keywords: Low-carbon economy; Scenario analysis; LEAP; Development strategies

1. Introduction

Under the background of global warming, low-carbon economy whose core concept is low power consumption and low pollution turns into a global hot spot [1]. The statistics from IEA show that amount of the total CO_2 emissions and energy consumption in China has surpassed the U.S., and become the most

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in the whole world. Because of this, China has become the focus of world attention. In the 21st century, Chinese government begins to attach great attention to energy and environmental issues, and takes a series of measures, and makes a commitment that compared to 2005, CO_2 emissions per unit of GDP in the year 2020 will decrease by 40% to 45%. Since 2002, elasticity of energy consumption has always been between 1.0 and 1.57, which indicates that growth of Chinese economy increasingly depends on the quantity of energy consumption rather than the quality, and Chinese economy shows the characteristics of excessive dependence on resources. Therefore, the primary task placed in front of Chinese government is to adjust the industrial structure, develop new energy, and improve energy efficiency [2]. Combined with the LEAP model, this paper applies scenario analysis to quantitatively describe the level of low-carbon economic development in future, and investigates the development path of low-carbon in China.

2. Basic Theory and Methodology

2.1. Scenario analysis

Scenario analysis is a kind of multivariate analysis method, combined with the probability of occurrence of various possible scenarios set, to study the possible impact of various factors when they work together at the same time. In the scenario analysis process, we should pay attention to consideration on the interrelationships and interactions among various factors [3].

2.2. Long-range Energy Alternative Planning system (LEAP) model

LEAP (Long-range Energy Alternative Planning system) is an econometric model developed by the Stockholm Environment Institute and Boston University in the USA. As an energy-environment modeling tool based on scenario analysis, it can be used for analysis of energy demand, corresponding environmental impact analysis and cost-benefit analysis. The model can be used mainly to formulate medium and long-term energy and environmental planning of the countries and cities. In addition, it can be used to predict medium and long-term energy supply and demand in the whole society under the influence of different driving factors, and calculate the amount of atmospheric pollutants and greenhouse gas emissions in the process of energy circulation and consumption.[4].

3. Scenario analysis

3.1. Indicators for the level of low-carbon economy development

Selection of evaluation indicators for the level of low-carbon economy development is a complex and controversial issue. Based on the references [5] [6], this paper selects per-capita GDP, amount of energy consumption, energy structure, and amount of CO_2 emissions as the evaluation indicators with consideration of the level of difficulty for obtaining the corresponding data.

3.2. Scenario analysis framework diagram

Low-carbon economy is an integrated and complicated system, involving such as policy, economy, environment, technology, management and many other areas. Based on this, combined with the national conditions, this paper seeks the critical barriers to influence China's low-carbon economy development in 2050. This paper selects the macro socio-economic factors and policy factors which have a significant impact on the supply and demand for energy and environmental protection. Through analysis and

summary on these factors, four dominant driving factors are considered, including Rough type of economic development(RTED), Lacking of a complete low-carbon policy framework(LCPF), Population and Lack of low-carbon awareness (PLLA), and Lacking of research personnel or trained manpower (LRTP). In addition, Measure tools to be adopted include intensive economic structure, the support from tax policy and low interest loans policy, low-carbon policy and regulated emissions standards, low-carbon research and development (R& D), carbon credit construction, renewable energy rationing system, low-carbon lifestyle changes, construction of low-carbon personnel system, etc. Figure 1 is the Scenario analysis framework diagram based on China's low-carbon economy development in 2050.

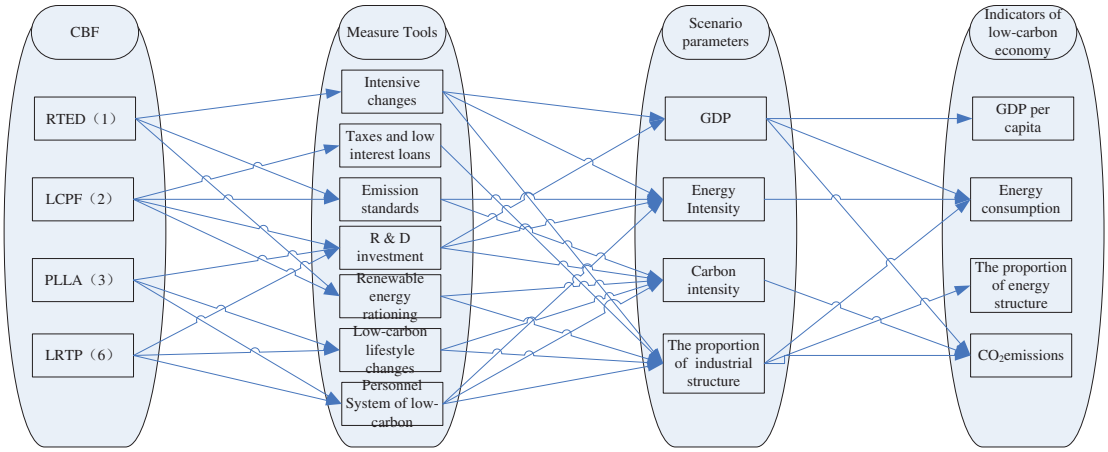

Fig.1. Scenario analysis framework diagram

3.3. Prediction results and analysis

According to the current development situation of china , three scenarios are set as follows:The first scenario is the base scenario (BS). The premise of this scenario is that low-carbon emission reduction measures are not taken into account in china, and the country always takes the simple indicator of economic growth as the main driving factor of development.The second scenario is the low-carbon scenario (LCS), that is, taking into the factors national energy security, natural environmental stress and low-carbon development requirements account, low-carbon emission scenario which can be achieved under the encouragement of the national policy on energy-conservation and emission-reduction, and the promoting of the introduction of relevant laws and regulations. The third scenario is the frustrated low-carbon scenario (FLCS). It is a kind of scenario that implementation of energy-saving and emission-reduction policies is not smooth, while the industrial restructure is also not desirable.

Through analysis of the affecting elements and calculation of LEAP model, it is obtained that the different calculation results of energy demand and carbon emissions in each period from 2005 to 2050 in china. Table 1 shows the final energy demand, amount of CO_2 emissions and per capita GDP in the three scenarios.

From Table 1, it is concluded that the total terminal energy demands in the three kinds of scenarios (BS, LCS, FLCS) are respectively 6.095 billion tons of standard coal, 5.236 billion tons of standard coal, and 6.239 billion tons of standard coal in 2050. It can be seen from Table 1 that amounts of CO_2 emissions in the three kinds of scenarios (BS, LCS, FLCS) are respectively 3.193 billion tons of carbon

equivalent, 2.592 billion tons of carbon equivalent and 3.608 billion tons of carbon equivalent in 2050. Compared to the base scenario, amount of CO2 emissions in the Low-carbon scenario will have a significant decline after 2030, reach its peak during the period between 2030 and 2040, tend towards stability and have a downward trend during the period between 2040 and 2050, and will decrease by 20% in 2050.

Table 1 Prediction results of scenario analysis

		2005	2010	2020	2030	2040	2050
Base scenario (BS)	Per capita GDP	1703	3566	7520	14744	23810	34373
	CO_2 emissions (10^6t)	1184	1952	2511	2918	3278	3193
	Total energy consumption (Mtce)	1586	3021	4359	5082	5714	6095
Low-carbon scenario (LCS)	Per capita GDP	1703	3566	8745	17692	27451	39778
	CO_2 emissions (10^6t)	1184	1952	2331	2594	2624	2592
	Total energy consumption (Mtce)	1586	3021	4155	4670	5095	5236
Frustrated low-carbon scenario (FLCS)	Percapita GDP	1703	3566	6510	11435	19056	27498
	CO_2 emissions (10^6t)	1184	1952	2683	3172	3455	3608
	Total energy consumption (Mtce)	1586	3021	4421	5216	5965	6239

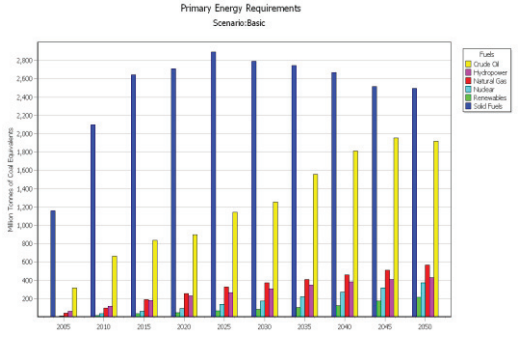

Fig.2. Histogram for Primary Energy Requirements in the base scenario

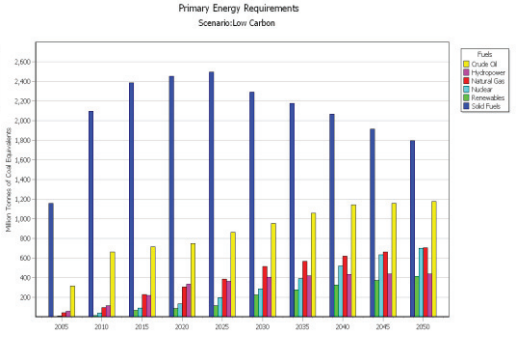

Fig.3. Histogram for Primary Energy Requirements in the low-carbon scenario

Figure 2 is the histogram which shows the changes of primary energy requirements in the base scenario. Amount of Coal demand has a rapid increase from 1.157 billion tons of standard coal in 2005, reaches its peak in the years 2020 to 2030, then the coal demand will have a slow decline, and locate above the level 2.4 billion tons of standard coal in a long period of time. Although the amount of other new energy demand such as hydropower, nuclear power, natural gas, and so on is also growing, the increase speed is so slow that the increase of new energy demand is far behind the increase in coal and oil. By 2050, coal accounts for 42% of primary energy demand, petroleum accounts for 32%, natural gas accounts for 9%, nuclear power takes a share of 6%, hydropower takes a share of 7%, and other new energy accounts for 4%.

Figure 3 is the histogram which shows the changes of primary energy requirements in the low-carbon scenario. Amount of Coal demand has a rapid increase from 1.157 billion tons of standard coal in 2005, and reaches its peak 2.495 billion tons of standard coal in the years 2020 to 2030. In the frustrated scenario, implementation of low-carbon strategy is not smooth, which leads to that the results are not as ideal as results in the base scenario, and coal and petroleum are still the main part of China's energy structure. In 2050, coal accounts for 47% of primary energy demand, petroleum accounts for 34%, natural

gas accounts for 7%, nuclear power takes a share of 5%, hydropower takes a share of 5%, and other new energy accounts for 2%.

4. Conclusion

Today China is in a critical transition period starting from a resource-dependent economy to low-car Today China is in a critical transition period starting from a resource-dependent economy to low-carbon economy pattern, and tremendous challenges and difficulties are posed to the policymakers.It is concluded as follows.

(1) Different economic development paths and policy orientations have a great impact on energy demand and carbon emissions. Energy demand and carbon emissions in future are very likely to fluctuate in a large range. Based on analysis of these barriers affecting low-carbon economy development, this paper develops different strategies and enforcement.

(2) It can be observed from the scenario analysis that the low-carbon scenario makes an optimistic suppose on optimizing energy structure, including development and utilization of hydropower, development of new energy sources, development of nuclear energy and wind, etc. However, due to the restriction of natural resources supply conditions and limitation of energy conversion technology, to ensure the adequate supply of clean energy is full of stress and difficulty.

(3) Seeking for the win-win breakthrough between energy saving and economic growth is one of the key issues in the development of low-carbon economy. From the energy consumption of different industries in the scenario analysis, it can be available that the service industry with low energy consumption is not only a new bright spot of economic growth, but also to solve employ ment problems of a large number of people, which is an important area for China's development in the coming decades.

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