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Sustainable energy development scenario forecasting and energy saving policy analysis of China

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ABSTRACT

The development of renewable energy, which is an important way to solve the environmental protection, has now become a research focus around the world. As a developing country with rapid growth, China gains the rapid development of economy, but the environmental pollution is becoming increasingly serious in recent years. Electricity industry plays an important role for energy-saving and emission-reduction in China, in order to reduce the environment pollution, it needs to consider how the electricity consumption affects the carbon emissions. In this paper, a stochastic impacts by regression on population, affluence, and technology (STRIPAT) model was built, which estimates the relationship between the carbon emissions, population, GDP per capita, electricity consumption and energy consumption. It found that population, GDP per capita and the ratio of electricity consumption in energy consumption are change 1%, the carbon emissions will change 1.207%, 0.901% and −1.188% respectively. Based on the relationship, there electricity energy development scenarios were assumed and analyzed, and it found that the way to reduce carbon emissions should consider improving technical ability, which should accounting for improving the ratio of electricity power ratio in the energy consumption, improving the efficiency of using fossil energy and the development of renewable energy.

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1. Introduction

Energy and environment problems are two outstanding issues, which restrict the sustainable development of the world economy and society. Nowadays, greenhouse gas (GHG) emission, especially carbon dioxide (CO2) emission, attracts world attention because it causes the global warming phenomenon. As reported by Intergovernmental Panel on Climate Change (IPCC), the reason of global warming can ascribe to the human's behavior and the largest contribution of the behavior is combusting fossil energy. In order to reduce the threat of global warming, Kyoto Protocol, signed in Kyoto, has stipulated that national emission reduction targets is to limit greenhouse gas

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emissions decrease by 5.2% on the basis of 1990's in 2012. In the protocol, all countries will adhere to the principle of "common but differentiated responsibilities" in the union framework convention on climate change, and the EU as a whole should achieve the reduction of greenhouse gas emissions by 8%, Japan and Canada each cut 6% [1]. The nearest global climate assessment reports by IPCC has point out that climate change has already occurred, which is mainly caused by human activity and the growing pressure of environment protection is also increasing. It is also point out that the "Challenges To Maintain Global Warming Below 2 °C" can still achieve as a political objectives, and controlling CO_2 emissions have been attracted the world's great importance attention [2].

China has promised that by 2020 carbon dioxide emissions of per unit GDP should be reduced by 40–45% compared to 2005 in the climate conference in Copenhagen in 2009. This commitment shows China's determination to take the road of sustainable development [3]. However, in the past 10 years, China has maintained above 7% of GDP growth, which will bring greater energy demand and consumption. Therefore, controlling the emissions of greenhouse gas faces enormous pressures and special difficulties. According to the data issued by China energy statistical yearbook 2012 [4], coal is the main energy composition in the energy consumption. As illustrated in Fig. 1, coal always accounts for about 70% of total primary energy in China. In order to restructure primary energy, China issued the development program of shale gas in 2012, in which the production of shale gas will be 6.5 billion cubic meters in 2015 and 60–100 billion cubic meters in 2020. Although shale gas is considered the most possible alternative to effectively substitute for the fossil energy in the future, the substitution effect is trivial since the output of shale gas is very low compared with the total energy consumption in China. For example, China totally consumed about 3.25 billion ton of coal equivalent in 2010, of which coal accounted for about 68% (about 2.21 billion ton of coal equivalent). The shale gas of 6.5 billion cubic meters in 2015 and 60–100 billion cubic meters in 2020 can only substitute for about 5 million ton of coal equivalent in 2015 and about 46–77 million ton of coal equivalent in 2020, respectively. Therefore, the high-carbon energy of coal will still be the crucial primary energy in China in the foreseeable future. Although the difficulty of carbon emissions abatement is huge for the developing country of China, China government has committed to reducing carbon intensity by 40–45% by the year 2020, compared with 2005 levels.

It is a huge challenge to fulfill the carbon reductions goals in conditions of maintained a rapid economic growth of China. This problem of energy saving and carbon emissions reduction of China has attracted many scholars' attention. They use the scenario analysis methods to trace the long-term trend of China's CO_2 reduction and find the main factors of the CO_2 reduction. The scenario analysis method can be divided into two types; one is long-run systematic energy analysis tools, such as system dynamic [5], LEAP [6] and so on. The long-run systematic energy analysis tools are more suitable for studying the CO_2 emissions by divided

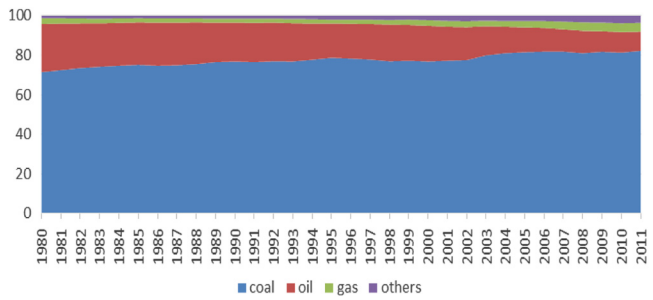

Fig. 1. Ratio of energy consumption in China, from 1980 to 2011. Source: China energy statistical yearbook 2012 [4].

the total CO_2 emissions into all parts of the system, such as industries, department and so on, it helps to decompose the CO_2 emissions into the divided parts and study the internal influence of the CO_2 emissions, however, the long-run systematic analysis needs huge details data support and computing resources, it is also difficult to identify the key factors of the trend of CO_2 emissions.

The other method is based on econometric modeling, which is useful to identify the key factors that influence the trend of CO_2 emissions and also can clearly show the path that each factor's effect exerts in every stage. One of the classical econometric methods is IPAT model, which considers the environment Impact is caused by Population, Affluence and Technology. The IPAT method and developed stochastic IPAT method called STIRPAT has analyzed the factors influence of the problem from the macroeconomic level. Di uses IPAT model to get the relationship between energy demand and carbon emissions, and indicates that the way to relieve pressure of CO_2 emissions is to optimize the energy structure, develop clean coal technology and new energy [7]. Yue points out that if China wants to achieve emission reduction targets, it is necessary to control GDP growth and reduce energy intensity as much as possible. In addition, other types of renewable energy's utilization rate must be more than 15% in 2020 [8]. In Meng's [9] and Li's [10] research, they have found the driving factors of China's CO_2 emissions are technologies, in which Meng [9] selects CO_2 intensity of GDP while Li [10] selects energy intensity. Otherwise, Tan [11] and Xu [12] have found that the energy consumption technologies can be evaluated by the energy intensity of GDP, which is well recognized as the most important factor that contributes to CO_2 emissions in China. In above researches, it can be found that the econometric modeling method only needs a few historical static data series, which can be easily found in Static Yearbook of a country, and the econometric scenario analysis can be obtain with a national development plan by government, the trends of CO_2 emission impact by population, affluence and technology can be easily analyzed by the econometric method.

Recently, more and more experts point out that the new energy has great potential in the area of saving country fossil energy and reducing CO_2 emissions for rural energy using [13]. In addition, many scholars points out that developing new energy and increasing the proportion of new energy is one of the important ways for China to achieve rapid economic development and low-carbon economy [14–16]. Developing new energy generation for adjusting energy structure is an important way for China to develop low carbon economy. In recent years, China has developed a series of incentive and hortative policies for new energy power generation [17], in order to support long-term healthy and stable development of new energy [18]. It is convenient and efficiency to transform new energy into the electricity power for people usage, and it is also a feasible way to reduce CO_2 emission with rapid energy consumption. It is foreseeable that the electricity power will occupy more and more proportion of energy structure in the future. In this paper, we want to examine the population, affluence and the electricity energy proportion development scenario forecasting of China and find out the influence of these factors to CO2 emissions, so we choose the advantage STIRPAT method to analyze the influences, and finally some policies recommendation are also given for reference.

2. China's CO_2 emission and energy scenario forecasting and analysis

2.1. Analysis model based on STIRPAT

IPAT model, proposed by Ehrlich and Comnoner, considered that the environmental impact is caused by population, affluence