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Will China make a difference in its carbon intensity reduction targets by 2020 and 2030?

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HIGHLIGHTS

- China could achieve its 2020 and 2030 carbon intensity reduction targets under current policies.
- The energy efficiency in the tertiary industry remained unimproved in the last decade.
- CO_2 emissions will be 1.64 times that of 2005 in 2020 and 1.69 times in 2030.
- Carbon emissions fail to meet the 450 ppm scenario in 2020 and 2030.

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ABSTRACT

The Chinese government has made ambitious commitments in terms of its carbon intensity reduction targets for 2020 and 2030. Whether China will achieve these targets remains uncertain, especially under the context of increasing consistency in carbon emissions cut globally. This study decomposed total energy consumption into five types and modeled each of them with its influential factors based on the stochastic impacts by regression on population, affluence and technology (STIRPAT) model. Carbon emissions were predicted by combining economic growth forecasting, industrial structure and energy structure projections. The results show that the estimated CO_2 emissions in 2020 were 10.05 gigatonnes (Gt), with a 52.8% reduced intensity compared to 2005. And the predicted CO_2 emissions in 2030 were 10.39 Gt, with a 70.0% reduced intensity. China's carbon intensity reduction targets in 2020 (40–45%) and 2030 (60–65%) can be met under current policies. However, the total CO_2 emissions fail to meet the 450 ppm scenario (8.4 Gt in 2020 and 7.1 Gt in 2030) only by the improvement of industrial structure and energy structure. New policies such as carbon trading market (CTM) and carbon capture, utilization and storage (CCUS) technology need to be developed in depth to further mitigate CO_2 emissions.

1. Introduction

The IPCC (Intergovernmental Panel on Climate Change) fifth assessment report indicated that human activities are extremely likely to be the main reason causing global warming and climate change [1]. The report confirmed the necessity of limiting the temperature rise to 2 °C in the 21st century. Of all the factors leading to global warming, greenhouse gas (GHG) emissions contribute the most. Since 2005, China has emitted more carbon than any other nation. In 2009, the Chinese government made a commitment in the United Nations Framework Convention on Climate Change (UNFCCC) conference in Copenhagen to reduce its CO_2 intensity by 40–45% in 2020 compared to that in 2005. And in 2015, the Chinese government made a new declaration in the UNFCCC conference in Paris to reduce the carbon intensity by 60–65% in 2030 compared to 2005. To achieve these goals, a series of measures have been taken to decrease the consumption of fossil fuels and develop cleaner energy such as hydropower, wind energy, nuclear power [2]. Whether China will fulfill these carbon intensity reduction targets remains a question worth studying.

Economic growth and energy consumption are two main factors influencing carbon emissions. The GDP of China has been increasing in the past forty years (Fig. 1), whereas the annual growth rate of GDP has been fluctuating and has exhibited a declining trend in recent years. The annual economic growth rates for 2013, 2014 and 2015 were 7.7%, 7.3% and 6.9%, respectively. China is ranked as the second largest economy behind the USA since 2010. However, after

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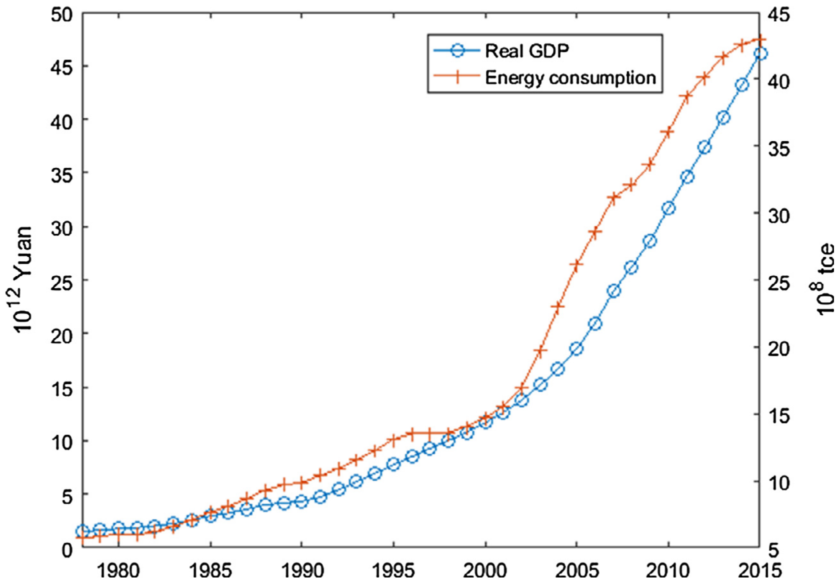

Fig. 1. The energy consumption and real GDP of China between 1978 and 2015.

a long time of rapid economic growth, unbalanced social and economic development existed among areas. The central government of China has adjusted the economic policy from "fast and sound" to "sound and fast" to ensure high-quality economic growth. Based on "*The 13th five-year plan*", China's economy is planned to keep an annual growth rate larger than 6.5%. The energy consumption of China showed a substantial increase during 1978–2015. However, China slowed its energy demand growth rate in recent years, largely resulting from the low economic growth rate, improvement of energy efficiency and upgrade of industrial structure [3].

In 2014, the State Council of China announced the "*Energy development strategic action plan 2014–2020*", defining the total target, policy, and mission of energy strategy for the next stage. China will make efforts to improve the proportion of non-fossil fuels in the total energy consumption, expecting to reach approximately 15% by 2020. The shares of coal and natural gas consumption will be below 62% and approximately 10%, respectively. In addition, the use of cap-and-trade emission trading schemes (ETSs) is another way conducted by the Chinese government to mitigate carbon emissions [4]. In 2011, China proposed establishing a domestic carbon trading scheme in order to effectively cope with climate change not only by relying on administrative measures, but also more through market-based mechanisms [5]. Seven pilot cap-and-trade ETSs across the country were successfully implemented between 2013 and 2014. The national carbon trading scheme, which will be launched in 2017, will probably make a difference in China's CO_2 reduction.

The prediction of energy consumption and carbon emission is helpful for decision makers to make appropriate environmental and economic strategies. There are numerous methods to model and calculate carbon emissions according to the literature. Xiao et al. [6] divided these models into three categories: top-down, bottom-up and hybrid models. The top-down models, with particular attention on the connection between energy production and consumption in the departments of the national economy from the viewpoint of an economic model, are mainly used to analyze macro economy and energy policy [7]. The key technology parameters related to energy production and consumption are regarded as exogenous variables. The bottom-up models consider the economic impact of technological alternatives in a partial equilibrium framework [8]. As the top-down and bottom-up models have their own advantages and weaknesses, hybrid models were developed to link and narrow the gap between the two models [9]. However, many uncertainties exist in the economic and technological parameters of these models. Some other models, such as kaya identity [10], the Log-Mean Divisia Index (LMDI) [11] and STIRPAT [12], focus on influencing factor decomposition and are also widely used for energy and carbon emission analysis. However, it is difficult to apply these decomposition methods to prediction as many of the influencing factors are unpredictable. In addition, there are also some general forecasting techniques such as the autoregressive integrated moving average (ARIMA) [13], grey model (GM) [14] and artificial neural networks (ANNs) [15] that can be used for prediction. For these general models, the data size and quality are important factors influencing the forecasting results. The grey system is used to solve problems with uncertainty, a small data size and a lack of information. High accuracy can be achieved for short time predictions [16]. As our data covers a short period of time, therefore, this study employed the grey model to forecast economic growth for the *13th five-year* period of China.

Many of the existing literatures employed the econometric theory to model the relationships among carbon emission, energy consumption and economic growth [17–21]. Ozturk and Acaravci [22] studied the relationships between economic growth, carbon emissions, energy consumption, foreign trade, and employment in Cyprus and Malta based on the autoregressive distributed lag (ARDL) bounds testing and causality models. Alshehry and Belloumi [23] used cointegration theory to investigate the relationship between energy consumption, CO_2 emissions, and economic growth. Hassan [24] studied the relationship between economic growth, CO_2 emissions, and energy consumption in five ASEAN (Association of South East Asian Nations) countries by the panel smooth transition regression model. In spite of these studies, industrial structure and energy consumption structure that can significantly influence carbon emissions were not well considered. Although the relationship among carbon emission, energy consumption, and economic development can be modeled by the econometric method, the underlying factors influencing these variables such as energy consumption structure, economic growth types, population, and technology were not well studied.

A number of researches have focused on China's commitment in its carbon intensity target. Yuan et al. [25] suggested that the 45% reduction in China's carbon intensity target coincided with its socioeconomic development planning without further efforts in