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Strategy on China's regional coal consumption control: A case study of Shandong province

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ABSTRACT

Controlling coal consumption has become one of the critical energy and environmental measures in China, and Shandong province is the key area of coal consumption control. This study is based on three targets, including air quality improvement, water savings, and energy conservation and emissions reduction, and then adopts the LEAP (Long-Range Energy Alternatives Planning System) model to predict Shandong's total coal consumption and its emissions reduction in 2020. Furthermore, it measures the feasibility and concrete path to realize the coal reduction target from three aspects – coal reduction, clean coal utilization and coal substitution. Finally, the quota allocation method is used to breakdown the coal reduction target into various cities and major industries. The results indicate that improving air quality is the primary reason for coal consumption control; coal reduction, clean coal utilization and coal substitution can reduce 36.3, 3.4 and 37.76 million tons of coal equivalent (tce) respectively, thus revealing the possibility of realizing the target of reducing 20 million tce in 2020 compared to 2012. The quota breakdown scheme shows that four cities (Binzhou, Jining, Linyi and Zibo) and three industries (production and supply of electricity and heat industry, coal chemical industry, and ferrous metal smelting and calendaring industry) are the major focus for coal consumption control in Shandong. This study provides valuable suggestions to facilitate the control of coal consumption.

1. Introduction

As the largest coal producer and consumer country in the world, coal accounted for more than 60% of total energy consumption in China. The mass production and use of coal causes a rapid increase in carbon dioxide emissions. According to the Science Research Center of the Chinese Academy of Sciences, CO_2 emissions from coal consumption in 2011 accounted for more than 75% of the total CO_2 emissions in China; and coal consumption also caused haze, acid rain and other serious environmental problems. In recent years, the Chinese government has carried out a series of policies and measures to protect the environment, some of which include the Air Pollution Control Action Plan, the Energy Development Strategy Action Plan (2014–2020), and the total energy consumption control plan. According to the "13th Five-Year-Plan (FYP, the years of 2016–2020) about energy development", the total energy consumption should be no more than 5 billion tons of coal equivalent (tce), and the total coal consumption should be restricted to 4.1 billion tons by 2020. This task has been shared by the local governments in accordance with their social and economic development, energy consumption characteristics, the status of air pollution and other factors. Coal consumption control has become one of the country's vital means of energy saving and emission reduction.

Shandong is the third largest province of the Chinese economy after Guangdong and Jiangsu, and it is the key area of coal control. Its energy consumption accounts for about 1/10 of the total consumption of China, and its coal consumption accounts for about 80% of the total energy consumption. As early as September 27, 2012, the city cluster of Shandong has been listed as the pilot area of the coal consumption control. In December 2014, the National Development and Reform Commission, Ministry of Environmental Protection and other departments jointly issued the "Interim Measures" of the management of coal consumption reduction in key areas, which clearly requires the reduction of coal consumption by 20 million tons in Shandong in 2017 relative to 2012. Meanwhile, Shandong government issued "the air pollution control planning of Shandong province in 2013–2020", the action plan for air pollution control, the "coal consumption reduction

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alternative work program" and other documents, which clearly classified the annual reduction of coal consumption. The total amount of coal consumption must be reduced from 2016. In 2016, coal consumption in Shangdong should be reduced by about 10 million tons, which is lower than that in 2012. According to the actual situation of coal consumption, regional industrial structure and energy consumption, the Shangdong government requested each city to propose its own target. Therefore, it is crucial to conduct an in-depth study of Shandong coal consumption control target and make plan for coal reduction decomposition program for cities and key industries, while exploring a better way for coal consumption reduction. These have important significance for other high coal-consuming provinces in controlling their total consumption, preventing atmospheric pollution, and eliminating current serious haze and fog in large areas.

Energy consumption control is an important measure of dealing with climate change. Many scholars have proposed plans on carbon emissions control objectives and energy conservation goals to indirectly realize total energy consumption control (Tol, 1997; Torvanger and Godal, 1999; Schleich et al., 2009; Hsu and Feng-Ying, 2000; Chen et al., 2007; Xiang and Wang, 2014; Hashim et al., 2005). Tol (1997), Torvanger and Godal (1999) respectively used the model for an assessment of GHG abatement policy, analyzed the ways of reducing greenhouse gas emissions, and proposed reductions in fossil energy use as a priority for reducing greenhouse gas emissions. Schleich et al. (2009) analyzed the incentive mechanism for energy efficiency in the EU ETS; Taking Taiwan as an example, Hsu and Feng-Ying (2000) constructed the Leontief industrial model of multi-objective planning, and analyzed the impact of energy-saving policies on carbon emission reduction and industrial structure adjustment; By constructing the MARKAL, MARKAL-ED and MARKAL-MACRO models, Chen et al. (2007) studied the impact of China's carbon reduction strategy on the economy, and analyzed the impact of energy consumption on carbon emission reduction targets; Taking the energy structure in 2010 as the benchmark, Xiang and Wang (2014) built the energy structure optimization model under the constraints of internal substitution and supply, and demonstrated that China could achieve the goal of carbon intensity reduction and the energy total control target in the case of low speed growth in the economy.

In order to scientifically formulate the total energy consumption control target, many scholars have analyzed China's energy development strategy, energy savings target and potential (Xu et al., 2014; Lin et al., 2010; Xia et al., 2014; Dong et al., 2017; Yuan et al., 2014; Wang et al., 2014). Xu et al. (2014) firstly joined the energy conversion efficiency in the decomposition model, and analyzed the impact of energy conversion efficiency, energy utilization efficiency, industrial structure, energy structure on the total energy consumption and carbon emission reduction targets; By taking carbon dioxide emissions as the constraint of energy demand in China, Lin et al. (2010) established the optimization model, and obtained the optimal energy structure under the constraint of energy saving and carbon emission targets; By using the frontier analysis method, Xia et al. (2014) analyzed the energy saving targets, constraints and management strategies in four scenarios, and assessed the energy saving tasks in 30 Provinces; By building the CGE model of 30 provinces in China, Dong et al. (2017) analyzed the impact of carbon tax on carbon emissions and economic losses in seven scenarios, which showed that coal production/consumption and total energy consumption are the key factors of carbon tax impacting the carbon emission reduction; Yuan et al. (2014), Wang et al. (2014) analyzed the peak time of China's energy consumption, carbon emissions, and energy consumption structure.

Determining the driving factors and contribution degree of energy consumption growth is the key to the implementation of total energy consumption control. Ang (2004) considered that the LMDI method was preferred in energy analysis, Choi and Ang (2003) used the LMDI method to decompose the total energy demand from two measures of ratio and difference; Based on China's regional and provincial level, Xue et al. (2016) used the LMDI method to analyze the impact of total energy consumption, energy structure and SO2 emission treatment technology on total SO2 emissions; By using the semi-parametric trend panel model and LMDI method, Some scholars studied the influencing factors of China/JiangSu Province total energy consumption (Wang and Ying, 2014; Wang, 2013; Wang et al., 2014; Kang, 2015; Yue and Long, 2010), and proposed the provincial total energy consumption distribution method based on information entropy (Liu et al., 2014).

In recent years, under the goal of total energy consumption control, coal consumption control has become the focus of policy makers and academics (Wolde-Rufael, 2010; Li and Leung, 2012; Yang, 2010; Li et al., 2008; Apergis and Payne, 2010a, 2010b). A large number of scholars have studied the relationship among coal consumption, carbon emissions and economic growth, predicting the peak of coal consumption, and medium/long-term coal demand in China (Bloch et al., 2012; Yu et al., 2015, 2016; Hu et al., 2014; Xu et al., 2016; Li et al., 2015). Wolde-Rufael (2010) conducted the Granger causality test of the relationship between coal consumption and real GDP in six countries; By conducting the Granger causality test, panel cointegration analysis or VEC model, Yang (2010), Li et al. (2008), Apergis and Payne (2010a, 2010b) studied the relationship between coal consumption and economic growth in Taiwan, OECD and non-OECD countries, and drew the conclusion that the Granger causality between coal consumption and economic growth in different countries was inconsistent; Bloch et al. (2012) conducted the Granger causality test of the relationship between economic growth, coal consumption and carbon emissions from both supply and demand sides, and found that there exists a two-way causal relationship between coal consumption and carbon emissions; Yu et al. (2015) found a inverted u-shaped environmental kuznets curve existing between coal consumption per capita and GDP per capita in China, and predicted the coal consumption of 29 provinces in 2020, by selecting four explanatory variables of per capita GDP, the ratio of secondary industry added value to GDP, urbanization rate and trade openness; By using the SDM model, Yu et al. (2016) verified the correlation of coal consumption among provinces, and found that the per capita GDP was high than that of no considering the space correlation of coal consumption, when coal consumption per capita reached the peak; Li et al. (2015) compared the coal demand prediction of five models with actual coal demand, and found that the PSO - DEM prediction effect is the best.

China's coal-dominated energy consumption structure has led to serious environmental pollution problems, where direct burning of coal is a major cause of haze in Beijing, Tianjin and other regions (Zhang et al., 2016; Zhang et al., 2017; Zhi et al., 2017; Liu et al., 2016). Zhang et al. (2017) constructed the WRF-CMAQ model to simulate the haze in the Beijing-Tianjin-Hebei region in December 2015, and found that the contribution of scattered coal combustion to PM2.5 was up to 46% by using the Brute Force method; By conducting a field survey of scattered coal consumption in rural areas of Baoding and Beijing, Zhi et al. (2017) found the scattered coal consumption in rural households was seriously underestimated, which results in higher levels of PM and SO2 than industrial and urban households; By constructing the competition and cooperation framework of local government, Liu et al. (2016) discussed the air pollution prevention and cooperation strategy in Beijing-Tianjin-Hebei region, and considered that the existing administrative decentralization and fiscal decentralization hindered the cooperative prevention of air pollution. Many scholars have studied health-related benefits of air quality improvement from coal control, and the effect of clean coal technology to reduce the emission of pollutants (Dong et al., 2016; Yang et al., 2016; Chen and Xu, 2010; You and Xu., 2010; Yang and Teng, 2016; Yu et al., 2011). Chen and Xu (2010) introduced clean coal technologies, including high efficiency combustion and advanced power generation technologies, coal transformation technologies, IGCC and CSS; Xu et al. (2000) presents the coal combustion scenario and its relatedin China; Yu et al. (2011) built a technology-based bottom-up model to estimate the performance of China's coal-fired electricity industry on resource consumption and environmental emissions.

Some scholars studied the ways of completing the control plan for