Resources, Conservation and Recycling xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

China's coal consumption declining—Impermanent or permanent?

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ARTICLE INFO

Article history:
Received 30 April 2016
Received in revised form 16 July 2016
Accepted 28 July 2016
Available online xxx

Keywords:
Coal consumption
Embodied energy
Energy structure
LMDI
Input-output analysis

ABSTRACT

Coal dominates China's energy consumption, and academic published papers especially before 2010 usually undervalued China's coal consumption significantly. However, China's coal consumption has declined continuously in 2014 and 2015. This seems to indicate that China may have finally reached the peak of its coal consumption in 2013. There is minimal quantitative research on the analysis of this phenomenon. The logarithmic mean Divisia index (LMDI) method is used in this study to analyze the key factors that drive China's direct coal consumption variation. Approaching the issue from the perspective of indirect coal consumption, an Input-Output model is established to discuss China's embodied coal exports in this study, aiming to trace the ultimate demand for coal to understand why consumption might have peaked. The research results suggest that changes of industrial structure started to reduce China's coal consumption significantly since 2012, and the effects of energy intensity and energy mix have continued to play important roles in coal consumption reduction since 2007, especially the energy mix effect since 2012. On the other side of the equation, although the economic scale effect – the only factor apparently driving increases in China's coal consumption – is still large, the increasing trend has reversed, and its impact has stabilised. China's embodied coal exports, both absolute volume and the proportion of coal consumption, are falling even though the trade surplus has still been increasing in recent years, which is completely different with the trend before 2011. China's continuous efforts on export restructuring – shifting from labour & energy-intensive to capital & technology-intensive – will reduce embodied coal exports and coal consumption in the future.

1. Introduction

Coal dominates the present energy consumption of China, making-up 64.0% of total energy consumption in 2015, and it is the foundation of China's economic growth. However, the extraction and utilization of coal has also damaged China's ecological systems at the same time. Emissions and pollution caused by the coal-dominated energy structure have been a major source of atmospheric pollution (Bloch et al., 2015). Environmental pollution problems, especially severe haze in China has been the focus of much attention from government, society and academia in recent years (Li and Zhang, 2014). In fact, China has been consistently trying to constrain coal consumption, especially over the last decade during the 11th Five-year Plan (2006–2010) and 12th Five-year Plan (2011–2015). However, this hasn't always worked in practice, especially during the period 2006–2010. According to China's official 11th Five-year Plan (2006–2010), coal consumption was expected to be 2.56 Gt in 2010. However, the actual coal consumption was 3.12 Gt, or 22% higher than expected (National Bureau of Statistics of China, 2015a). Additionally, almost all of the published academic papers from Chinese scholars before 2010 undervalued China's coal consumption—with an average estimation of 2.32Gt described in a review by Wang (2014). As for coal demand in the future, Goldman Sachs (2013) indicates that China's coal demand will slow down sharply based on Alstom interview and structural trend analysis. Citi Research (2013) points out that China will have a possible flattening or peaking of coal use in the power sector before 2020 based on a detailed, top-down electricity supply-demand model for China, which factors in power demand, efficiencies, coal and non-coal power generation and capacity, among others. However, most studies still indicate growing demand. In the World Energy Outlook 2015, the IEA points out that China's coal demand is projected to grow slightly until 2030 under the New Policies Scenario, and go into a slow long-term decline after 2030 by using the World Energy Model (WEM). Coal use in China's power sector flattens only towards 2040, while industrial coal demand falls markedly after 2020, as the economy rebalances away from heavy industry (International Energy Agency, 2015). A panel of 29 Chinese

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http://dx.doi.org/10.1016/j.resconrec.2016.07.018
0921-3449/

Please cite this article in press as: Tang, X., et al., China's coal consumption declining—Impermanent or permanent? Resour Conserv Recy (2016), http://dx.doi.org/10.1016/j.resconrec.2016.07.018

provinces from 1995 to 2012 is utilised by Hao et al. (2015) to predict China's coal consumption through 2020, and the research results suggest that China's coal consumption is expected to continue growing at a decreasing rate until 2020 under the benchmark scenario.

According to the Statistical Communique of the People's Republic of China on National Economic and Social Development (National Bureau of Statistics of China, 2016), China's coal consumption declined by 2.9% for the first time in 2014, then 3.7% in 2015, while it increased by 3.7% in 2013. While this could be a temporary change, it may also indicate that China's coal consumption finally peaked in 2013.

China and the US released a climate change agreement in Beijing on November 11, 2014. According to the Joint Announcement, China intends to achieve the peaking of CO_2 emissions around 2030 and to make best efforts to peak early. The earlier peaking of coal consumption will be of significant importance for China to reduce CO_2 emissions. If China's coal consumption has already peaked, this offers hope that China will achieve the target of CO_2 emissions peaking even before 2030. Some analyses regarding the causes of China's declining coal consumption have already been undertaken – with various causes highlighted – for example, China's declining energy intensity especially in energy intensive sectors during 2005–2015 (Yang et al., 2015); slowing down of economic growth especially in heavy industries with high coal consumption intensity (Wang and Li, 2016); the Chinese government's strong efforts on reducing the share of coal consumption continuously and promoting the usage of renewable energy sources such as solar and wind (Yuan et al., 2013; Hao et al., 2015).

Despite this, quantitative research is still lacking in studies on this phenomenon. Will China's current coal consumption decline be impermanent or permanent? This study will discuss this issue from the perspectives of both direct and indirect coal consumption. The key work of this study isn't accurate coal consumption forecasting but comprehensive analysis. From the direct coal consumption perspective, this study will analyze the driving factors for coal consumption change in different periods. And from the indirect coal consumption perspective, coal embodied in international trade as an example will also be analysed, which can reflect China's coal consumption change indirectly. Based on the driving factors analysis of China's coal consumption from both direct and indirect perspectives, including the outlook of these driving factors, it will be easy to understand whether these driving factors are impermanent or permanent, and can clearly reflect the tendency of China's coal consumption.

2. Methodology and data

2.1. Methodology

LMDI (Logarithmic Mean Divisia Index) and Input-Output models are used in this study. LMDI is mainly used to decompose direct coal consumption and trace the main causes for its change. An Input-Output model is established to analyze the change of embodied coal exports from the perspective of indirect coal consumption.

2.1.1. LMDI method

Decomposition analysis has been widely used in the analysis of the main factors which lead to changes in energy consumption and pollution emissions. This method can separate each factor's contribution to the total index and trace causes for changes in the index. For this reason, it has become one of the commonly used approaches in the study of energy and environmental problems. LMDI method, based on Simple Average Division, is applied extensively because it has no residuals and is transparent in the interpretation of results (José et al., 2015; Zhang et al., 2016).

This study uses the LMDI method to decompose the changes of coal consumption in China. Four-factor decomposition has been proposed to quantify the main determinants of coal consumption changes and analyze contributions of various influencing factors to this variation. The decomposition factors are the: economic scale factor, industrial structure factor, energy intensity factor, energy mix factor, respectively. China's total coal consumption can be decomposed as follows:

$$C = \sum_{i=1}^{n} C_i = \sum_{i=1}^{n} G \times \frac{G_i}{G} \times \frac{E_i}{G_i} \times \frac{C_i}{E_i} \tag{1}$$

Where, C is the total coal consumption; C_i is the coal consumption of i industry; G is the gross domestic product (GDP); G_i is the GDP of i industry; E_i is the energy consumption of i industry.

Where, G_i/G designates the economic structure; E_i/G_i designates the energy intensity of i industry; $\frac{C_i}{E_i}$ designates the energy mix of i industry, which is the proportion of coal consumption to total energy consumption in i industry. G_i/G, E_i/G_i and C_i/E_i are represented by F_i, I_i and S_i, and Eq. (1) can be expressed as follows:

$$C = \sum_{i=1}^{n} C_i = \sum_{i=1}^{n} G \times F_i \times I_i \times S_i \tag{2}$$

Where, G, F_i, I_i and S_i designate economic scale factor, industrial structure factor, energy intensity factor and energy mix factor respectively. In this study, C^0 and C^t are assumed to be the coal consumption in base year and year t respectively. ΔC designates the variation from base year to year t, and can be expressed as follows:

$$\Delta C = C^t - C^0 = \Delta C_G + \Delta C_{F_i} + \Delta C_{I_i} + \Delta C_{S_i} \tag{3}$$

Where, ΔC_G, ΔC_{F_i}, ΔC_{I_i} and ΔC_{S_i} designates the changes of coal consumption caused by economic scale factor, industrial structure factor, energy intensity factor and energy mix factor, respectively. The contribution of each factor can be expressed as follows:

$$\Delta C_G = \sum_{i=1}^{n} \frac{C_i^t - C_i^0}{InC_i^t - InC_i^0} In \frac{G^t}{G^0} \tag{4}$$

$$\Delta C_G = \sum_{i=1}^{n} \frac{C_i^t - C_i^0}{InC_i^t - InC_i^0} In \frac{F_i^t}{F_i^0} \tag{5}$$

$$\Delta C_G = \sum_{i=1}^{n} \frac{C_i^t - C_i^0}{InC_i^t - InC_i^0} In \frac{I_i^t}{I_i^0} \tag{6}$$

$$\Delta C_G = \sum_{i=1}^{n} \frac{C_i^t - C_i^0}{InC_i^t - InC_i^0} In \frac{S_i^t}{S_i^0} \tag{7}$$

2.1.2. Input-Output model

An Input-Output model is utilised to calculate China's embodied coal exports and imports, based on a previous model Tang et al. (2012) developed to calculate Chinese embodied oil exports and imports. The equations to calculate China's embodied oil exports EEE_{oil} and embodied oil imports $EEI_{oil}$are established as follows:

$$EEE_{oil} = \frac{E_{oil}}{Y_{oil}} \sum_{j=1}^{n} EX_j \times b_{kj} \tag{8}$$