Renewable and Sustainable Energy Reviews 47 (2015) 746–754

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Carbon emissions from energy intensive industry in China: Evidence from the iron & steel industry

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ARTICLE INFO

Article history:
Received 18 May 2014
Received in revised form
11 August 2014
Accepted 8 March 2015
Available online 30 March 2015

Keywords:
Total factor CO_2 emission performance
CO_2 emission mitigation potential
China's iron & steel industry

ABSTRACT

The iron & steel industry is one of the major industrial sectors of energy consumption and CO_2 emissions in China. In this paper, we estimate the total factor CO_2 emissions performance (TFCP) and the CO_2 emission mitigation potential (CMP) in China's iron & steel sector using the stochastic frontier analysis technique. During the period of 2000–2011, the average TFCP of China's iron & steel industry was 0.780, the cumulative CMP was 835.32 million tons in 12 years, and the average annual CMP was 69.61 million tons. Regional analysis showed that the TFCP is high in the northeastern and eastern regions but low in the central and western inland regions. Since the CMP is affected not only by TFCP, but also by the actual CO_2 emissions, both the eastern and western regions have the greatest potential for reducing CO_2 emissions. For the eastern region, the realization of the CMP relies on structural reform and government regulation; while for the western region, policies should focus on changing the production pattern and reducing efficiency loss. For all the regions in China, mitigating CO_2 emissions should place more emphasis on technical innovation and low-carbon investment.

Contents

1. Introduction

China's increasing CO_2 emissions has drawn much attention recently. In 2011, China's CO_2 emissions from fuel combustion were 7999.6 million tons and accounted for 25.4% of global emissions [1]. With China's rapid economic development, CO_2 emissions will increase inevitably in the future. At the same time, China is facing mounting pressure on CO_2 emissions reduction from developed countries in international negotiation on global climate change issue [2]. Therefore, controlling and reducing CO_2 emissions in energy-intensive sectors in China is a pressing issue. In order to reduce CO_2 emissions, China's government made a commitment to reduce CO_2 emissions

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http://dx.doi.org/10.1016/j.rser.2015.03.056
1364-0321/

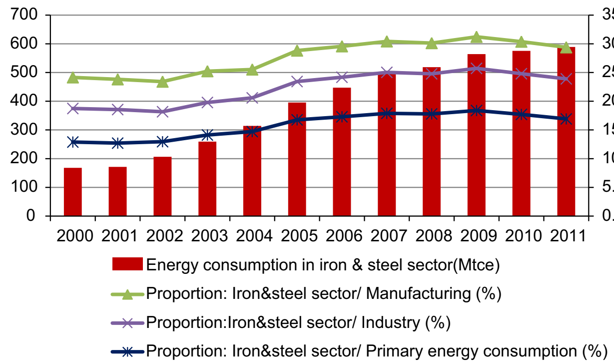

Fig. 1. Energy consumption and proportion of China's iron & steel sector.
Source: China Statistics Yearbook, 2001–2012.

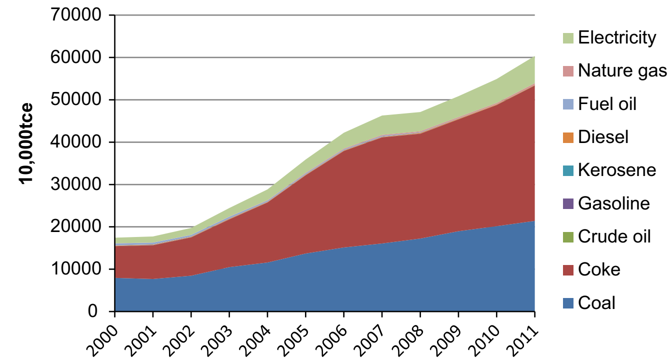

Fig. 2. Energy resources used in China's iron & steel industry.
Source: China Statistics Yearbook, 2001–2012.

considerably, and proposed the levels of emission for the coming years. On December 1st, 2011, the State Council proposed that the national CO_2 emissions per unit of GDP should fall by 17% in the "12th Five-Year" period [3]. The realization of this proposal will substantially boost China's contribution to the mitigation of CO_2 emissions at the global level. However, to achieve this goal, the concerted efforts of all energy-intensive sectors are required.

China's iron & steel sector is a resource and energy intensive industry, which has developed rapidly in recent years. China's crude steel output had reached 684 million tons in 2011, accounting for 45.04% of world's total steel production [4]. Along with the rapid growth of crude steel output, energy input also experienced sustainable increase. Fig. 1 shows the current situation of energy consumption in China's iron & steel sector. In 2000, energy consumption of iron & steel industry was 167.92 million tons of coal equivalents (Mtce). In 2011, energy consumption reached 588.97 Mtce, which was 3.52 times of that in 2000. Compared with other sectors, energy consumption in the iron & steel sector made up 29.39% of total consumption in the manufacturing industries. From 2000 to 2011, the ratio of energy consumption in the iron & steel sector to the whole industry rose from 18.73% to 24%, indicating an average annual growth rate of 11.6%. The proportion of energy consumption in this sector to total primary energy consumption rose from 12.89% to 16.92%, indicating an average annual growth rate of 11.94%. Energy consumption of the sector in 2011 was approximately 2 times the total primary energy consumption of the U.K. and 1.7 times the primary energy consumption of France[1][5].

Energy resources used in China's iron & steel industry can be divided into 9 kinds, including coal, coke, oil, electricity, etc., and the proportions of these resources are shown in Fig. 2. In the iron & steel industry, the consumption of coal and coke are the highest, accounting for 89.18% of total energy consumption on average, which was very stable during 2000–2011. This is followed by electricity, accounting for about 9.22% of total energy consumption. The ratio of electricity in total energy showed some increase from 7.59% in 2000 to 10.95% in 2011, which reflects the energy substitution trend in the industry. However, this cannot change the dominant status of coal-related energy in China's iron & steel industry. The average proportion of oil-related resources is even smaller (less than 3%). As coal combustion produce the most CO_2 emissions in the iron & steel industry, increase in energy demand has exerted enormous pressure on energy resources and resulted in severe problem of CO_2 emissions. According to Shangguan et al. [6], the direct CO_2 emissions in China's iron & steel industry was 920 million tons in 2007. CO_2 emissions in the industry account for 15% of total emission in China [7]. CO_2 emissions from the industry have resulted in serious environmental problems in China. Although energy efficiency has gradually improved, the exits of rebound effect may make energy consumption increase [8]. Therefore, the iron & steel industry has huge potential for energy conservation and carbon emissions reduction. On October 24th, 2011, the Ministry of Industry and Information Technology of China issued "the '12th Five-Year' development plan of iron & steel industry" [9]. This plan proposes the target that both energy consumption per unit of industrial value-added and CO_2 emissions should reduce by 18% during the "12th Five-Year" period.

2. Literatures review

In existing researches, we found that studies on CO2 emissions are usually based on analyzing carbon intensity index (which is CO2 emissions per unit of Gross Domestic Product (GDP), or CO2 emissions per unit of industrial output in a specific industry) as done by Lin and Liu [10], and Lin and Mohamed [11]. Since Ang and Lee [12] proposed the Logarithmic Mean Weight Division Index Method (LMDI), it was widely used in analyzing carbon intensity. Different from the previous simple arithmetic average weight method, LMDI uses a logarithmic average formula. The advantage of this method is that it does not produce a residual, and allows data values to be zero. Using the LMDI method, Ang and Lee [12], Ang et al. [13], Greening et al. [14–16] and Greening [17] decomposed CO_2 emissions in different sectors of 10 OECD countries, including manufacturing, transport, housing and private transport sectors, etc. Shrestha and Timilsina [18] studied the carbon intensity changes of the power industry in 12 Asian countries, and found that fuel intensity was the most important factor driving carbon emissions in China's power industry during 1980–1990. Similarly, Hatzigeorgiou et al. [19] analyzed energy-related carbon emissions in Greece from 1990 to 2002. In China, Wang et al. [20], Wu et al. [21], Xu et al. [22] and Liu et al. [23] analyzed the influencing factors of energy-related emissions in different periods in China. Wang et al. [24] focused on the influencing factors of CO2 emission in Beijing city. From these studies, we find that although the decomposition approach is convenient for studying changes in CO2 emission, it is not appropriate for estimating the carbon-reduction potential. Furthermore, carbon intensity index is based on the concept of a single factor efficiency [25], which only measures a proportional relationship between CO2 emissions and output.

Since the frontier analysis method was proposed, it has been widely used in the study of total factor efficiency of energy consumption and carbon emission. There are two main categories of frontier analysis. The first is Data Envelopment Analysis (DEA), and the second is parameterized Stochastic Frontier Analysis (SFA).

[1] BP, statistical review of word energy full report 2013. The primary energy consumption in the France and U.K. 2011 was 244.17Mtoe and 200.05Mtoe. 1toe=1.4tce, so the primary energy consumption in the France and U.K. 2011 was approximately 341.84Mtce and 280.07Mtce.