Ecological Indicators 47 (2014) 112–122

Contents lists available at ScienceDirect

Ecological Indicators

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

China's CH_4 and CO_2 emissions: Bottom-up estimation and comparative analysis

Bo Zhang[a,b,*], G.Q. Chen[c,**]

[a] School of Management, China University of Mining & Technology (Beijing), Beijing 100083, PR China
[b] State Key Laboratory of Coal Resources and Safe Mining, China University of Mining & Technology (Beijing), Beijing 100083, PR China
[c] College of Engineering, Peking University, Beijing 100871, PR China

ARTICLE INFO

Article history:
Received 2 November 2013
Received in revised form 14 January 2014
Accepted 16 January 2014

Keywords:
CH_4 emissions
CO_2 emissions
Inventory assessment
Emission mitigation
China

ABSTRACT

For the greenhouse gas (GHG) emissions in China, little attention has been given to CH_4 emissions and related emission mitigation. This paper presents a detailed bottom-up estimation and comparison analysis of China's CH_4 and CO_2 emissions for the first time. China's CH_4 emissions are shown with comparable importance to the CO_2 emissions at the national and regional levels. The national total CH_4 emission in 2008 amounts to 39 Tg, equivalent to about 1/8, 1/3 and 3/5 of the total CO_2 emission by the 100-year global warming potential (GWP) factor, the 20-year GWP factor and the global thermodynamic potential factor, respectively. Increasing CH_4 emissions could compromise China's efforts to mitigate its GHG emissions. In contrast to energy-dominated emission pattern for CO_2, the major sources of China's CH_4 emissions are coal mining, enteric fermentation, rice cultivation and waste management. Meanwhile, there exists a large gap between the eastern coastal regions and the western and central inland regions in the emission magnitude and emission intensity for CH_4 and CO_2, with different mitigation flexibilities. Reducing CH_4 emissions should be integrated into the national and regional policies for GHG emission mitigation. In some central and western regions such as Shanxi, Henan, Sichuan, Guizhou, Qinghai and Tibet, the inclusion of CH_4 emission intensity reduction can be more cost-effective than only setting a target for CO_2 emission intensity to reduce the regional GHG emission intensity.

1. Introduction

As the second most important greenhouse gas (GHG) next to carbon dioxide, methane has a global warming potential (GWP) 72 or 25 times as great as that of carbon dioxide over a horizon of 20 or 100 years (IPCC, 2007), and contributes 18.1% to the overall global radiative forcing (WMO, 2010). Over the last two hundred and fifty years, the concentration of CH_4 in the atmosphere increased by 158% (IPCC, 2007). About 60% of global CH_4 emissions are related to human-related activities (WMO, 2010; Karakurt et al., 2012). As methane remains in the atmosphere for a much shorter period, stabilizing CH_4 emissions can make a dramatic impact on decreasing the buildup of GHGs in the atmosphere in the near-term (Bousquet et al., 2006). There is ample evidence that methane deserves special concern because of its effects on global climate change (Garg et al., 2001, 2004, 2011; EPA, 2012; Yusuf et al., 2012).

Till now, GHG emission inventories in China are primarily concerned with CO_2 emissions. Since China has been considered as the leading producer of CO_2 emissions in the world, many studies have contributed to the CO_2 emission estimation and related assessment for mitigation potentials (e.g., Peters et al., 2006, 2007; Feng et al., 2009, 2012, 2013; Zhang et al., 2009; Chen and Zhang, 2010; Liu et al., 2010; IEA, 2011; Meng et al., 2011; Guo et al., 2012; Hubacek et al., 2012). In contrast to the ever-increasing focus on China's CO_2 emissions, little attention has been given to its CH_4 emissions and related emission mitigation (Streets et al., 2001; Zhang and Chen, 2010a).

Methane emissions in China are also remarkably important (Zhang et al., 2014). The first official GHG emission inventory of China for the year of 1994 from the Initial National Communication on Climate Change of China pointed out that CH_4 represented 19.4% of the total nationwide GHG emissions in terms of CO_2, CH_4 and N_2O (INCCCC, 2004). Chen and Zhang (2010) reported that methane accounted for 11.2% of the total GHG emissions (covering CO_2, CH_4 and N_2O) of 26 industrial sectors by Chinese economy in 2007. Recently, the Second National Communication on Climate Change of China (SNCCCC, 2013) provided the latest official National GHG

* Corresponding author at: School of Management, China University of Mining & Technology (Beijing), Beijing 100083, PR China. Tel.: +86 10 62767167; fax: +86 10 62754280.
** Corresponding author. Tel.: +86 10 62767167; fax: +86 10 62754280.
E-mail addresses: zhangbo@cumtb.edu.cn, zhb@pku.edu.cn (B. Zhang), gqchen@pku.edu.cn (G.Q. Chen).

1470-160X/$ – see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ecolind.2014.01.022

Fig. 1. Regional distribution of Mainland China.

Inventory of China and reported that CH_4 contributed 12.5% to the total national GHG emissions covering six GHGs in 2005. Therefore, to address greenhouse gas emissions in China, more efforts have to be made to understand CH_4 emissions.

As regional inventory is the prerequisite for national inventory compilation, bottom-up estimation methods have been extensively used to quantify the CO_2 emissions in China (e.g., Geng et al., 2011; Guan et al., 2012; Liu et al., 2012; Zhao et al., 2012; Feng et al., 2013). Nevertheless, there has been little research on the evaluation of regional CH_4 emissions, though some studies are concerned with CH_4 emissions from one or several representative emission sources at the provincial level (e.g., Huang et al., 2006; Fu and Yu, 2010; Cheng et al., 2011; Lin et al., 2011; Yue et al., 2012). The real status of CH_4 in regional GHG inventory still remains to be elucidated systematically, and the contribution of CH_4 to GHG emission mitigation in China has rarely been considered.

To fill this gap, a bottom-up estimation and comparative analysis of China's CH_4 and CO_2 emissions in 2008 is carried out in this paper. Provincial-level data are employed to address the CH_4 and CO_2 emissions by region based on the latest data availability and related literatures, with the emphasis on emission comparison at the national and sub-national levels. Furthermore, the mitigation potential and path of China's CH_4 emissions are investigated and evaluated, especially for the policy implications. The results will help to understand the importance of China's CH_4 emissions, and to support policy making for comprehensive GHG emission reduction by inclusion of the non-CO_2 gases.

The remainder of this paper is organized as follows. Section 2 describes the bottom-up estimation methods for CH_4 and CO_2 emissions, and the regional information. The estimation results and a detailed comparison of China's CH_4 and CO_2 emissions are presented in Section 3. Uncertainty analysis and comparison with existing reports are also performed in this section. Corresponding policy implications for GHG emission mitigation in China are addressed in Section 4. Concluding remarks will be drawn in the ending section.

2. Methodology and data sources

2.1. Estimation for CH_4 emissions

In this study, the major emission sources of CH_4 in Mainland China are considered, including agricultural activities (i.e., enteric fermentation, manure management, rice cultivation, and field burning of crop residues), energy activities (i.e., coal mining, oil system leakage, natural gas system leakage, fossil fuel combustion and bio-fuel combustion), and waste management (i.e., municipal solid waste (MSW) landfill, industrial wastewater management, and domestic sewage management). All the CH_4 emissions at the regional level are estimated, and then the total nationwide CH_4 emissions are calculated by aggregating emissions from all the 31 regions at the provincial level (provinces, municipalities and autonomous regions) shown in Fig. 1.

According to the guidelines for national greenhouse gas inventories (IPCC, 2006), it is necessary to adopt country or region-specific available and reliable data on emission factor for compiling the inventories of GHG emissions. Based on a comprehensive review of previous studies relevant to the CH_4 emission factors for different sources, emission factors specifically suitable to the Chinese condition are obtained. Estimates on regional CH_4 emissions are largely based on country or region-specific emission factors, and when the local data are unavailable, the default emission factors recommend by IPCC (2006) are used. For certain emissions whose direct evaluation is difficult, some concrete assumptions are made on the basis of recent studies for CH_4 emissions, as a preliminary approximation. Detail descriptions of inventory