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Integrated inventory-based carbon accounting for energy-induced emissions in Chongming eco-island of Shanghai, China

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HIGHLIGHTS

- The use of natural gas in the large-sized industrial and commercial sectors is shown.
- This study estimates the market potential and characterizes the energy consumption.
- It makes a selection of technological alternatives for the use of natural gas.
- The residual oil and diesel consumption decline over time by the natural gas use.
- In 2017, the cogeneration could provide 7.7% of total electricity demand in Peru.

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ABSTRACT

The majority of the total carbon emissions in China are energy induced. A clear understanding of energy-induced carbon emissions is therefore necessary for local communities to develop a better carbon emissions management system. We develop an integrated inventory method for energy-induced carbon emissions accounting in local Chinese communities. The method combines scope and sectoral analyses on the basis of local statistical features. As an outcome four core findings are presented: (1) From 2000 to 2009, the energy-induced carbon emissions of Chongming rapidly increased from 1.75 to 4.90 million tons, with the annual growth rate of 12.12%. (2) Emissions from manufacturing, construction, and household sectors accounted for 84.44%; manufacturing is the biggest emitting sector. (3) Carbon emissions from imported electricity reached a historic high of 22.51% in 2009, indicating the necessity of taking the imported carbon emissions into consideration. (4) In 2008, the per capita carbon emissions of Chongming were lower than that of the United States and Shanghai, but higher than that of the global average. Three strategic approaches are proposed: to optimize industrial structure and improve efficiency, reinforce carbon management for the household sector, and enhance carbon statistics.

1. Introduction

In recent years, climate change has become a global issue. In its fourth report, the Intergovernmental Panel on Climate Change (IPCC) stated that most of the observed increase in global average temperatures since the mid-20th century is very likely (likelihood range: >90%) due to the observed increase in anthropogenic GHG concentrations (IPCC, 2007). Furthermore, energy-induced carbon emissions have been the main source of anthropogenic GHG emissions because of the increase in fossil fuel consumption after the industrial revolution. As a result, reducing GHG emissions from energy generation without inhibiting economic development has become a global challenge. To achieve this target, the success of GHG emission management is necessary, while it lies in making sufficient information available to policy makers. Although a relatively new field in China, GHG emissions accounting has evolved rapidly over the last 10 years as pioneer practitioners worldwide standardised the methods and protocols for calculating carbon emissions. The Local Governments for Sustainability (ICLEI) is a leader in developing accounting methodologies and setting standards for the carbon emission inventories of local communities. The simple pragmatic approach outlined in the 'International Local Government GHG Emissions Analysis Protocol (IEAP)' (ICLEI, 2009) by the ICLEI has been popularised in recent years, with more than 1000 local governments worldwide participating in the ICLEI initiatives. Many international local governments

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have published their GHG inventories (The City and County of Denver, 2007); City of Vancouver, 2009; The City of New York, 2010)). The GHG emissions accounting method of ICLEI improves carbon accounting implementation. In China, however, the sectoral division of activities (by which carbon emissions can be traced) differs from the subdivisions proposed by ICLEI (residential, commercial, industrial, and transportation initiatives.). Thus, the ICLEI approaches cannot be directly applied to the specific circumstances of local Chinese governments.

In the present paper, we proposed the integrated inventory method by integrating the sectoral division employed in China into the scope analysis, which can help the local communities of China establish their own inventories and effectively develop carbon emission reduction strategies for decision making. Furthermore, our findings can serve as a database and reference for empirical research on local carbon emissions management in response to climate change.

In addition, as the representative GHG of Shanghai, CO_2 accounts for up to 97.2% of total greenhouse gas emissions from energy consumption (Wang et al., 1996). For this reason, the current work focuses only on CO_2 emissions, expressed in unit of ton directly (ton).

2. Research object

As a highly developed city, Shanghai is one of the largest emitters of GHG in China. Located in the northeastern part of Shanghai, Chongming is the only national ecological demonstration zone located within Shanghai with abundant natural resources. In 2005, the Shanghai Municipal Government formulated the 'Master Plan for the Development of Chongming Three Islands (2005–2020)', in which Chongming was described as 'an important strategic area for sustainable development in Shanghai'. In 2010, Chongming was chosen as one of three low-carbon demonstration areas in Shanghai (Ministry of Commerce of the People's Republic of China Special Commissioner's Office in Shanghai, 2010).

Chongming is made up of three islands, Chongming, Changxing, and Hengsha, which cover 1411 km^2 (Website of Chongming County Government, 2011a). It is regarded as the convergence point of the strategic development in the east coast regions and Yangtze River T-shape regions because of its location (Fig. 1).

The county has developed rapidly in the recent seven years with consecutive double-digit growth rates and a GDP of RMB 17.06 billion by 2009. However, it remains the least developed county in Shanghai currently.

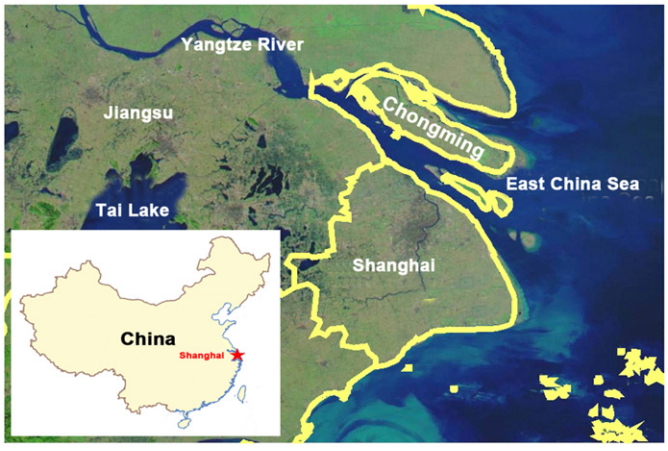

Fig. 1. Location of Chongming in Shanghai.

To ensure the construction of an eco-island and realize economic development, the local government has formulated a series of policies, a target of 20% reduction in energy intensity is clearly proposed in the 11th Five-Year Plan of Chongming, and some policies after it for supporting are as following: 'Advice on strengthening the implementation of energy saving in Website of Chongming County Government (2007), 'Working arrangements of energy saving by the Economic Commission of Chongming County (2009a); and 'Notice on the issuance of assessment methods for energy saving in villages, towns, industrial zones, and relevant units at Chongming County (2009b). Within the policy document 'Outlines of ecological island construction in Chongming, 2010–2020', which was developed in 2010, the Shanghai Municipal Development and Reform Commission pointed out that it is essential to adhere to a low-carbon development concept as the guiding ideology during construction of the Chongming ecological island. This plan depicts the low-carbon growth that characterized social and economic development in Chongming as a blueprint. The plan reveals a target of 0.6 t coal-eq/10^4 Yuan (RMB) decrease in the intensity of energy consumption by 2020 (Shanghai Municipal Development and Reform Commission, 2010). More recently, the 12th Five-year Plan of Chongming indicates that energy intensity should be reduced by approximately 18% (Website of Chongming County Government, 2011b).

Undoubtedly, this objective requires a complete inventory of local carbon emissions data as a fundamental support for the achievement of these targets. However, county-level statistical foundation in China is weak, and no relatively comprehensive accounting system as reference for the local government is in place. To the best of our knowledge, only a few studies have been devoted to the carbon emissions of Chongming. Li et al. (2009) conducted research on each district in Shanghai (including Chongming) using the sector estimation method in the city as basis. Their findings showed that the amount of emissions in Chongming was under 1million tC-eq, and that the per capita carbon emission was 1.17 t C-eq, which together represented the lowest carbon emission rates amongst all the districts in Shanghai. However, the coefficients used (coefficients of the energy consumption of the primary, secondary, and tertiary industries) for Chongming were the average values of Shanghai. Given that the economic status of Shanghai is higher than that of Chongming, Li's result should be further improved in accordance with local features.

The present study aims to provide local policy makers with original data to facilitate decision making on climate change priority sectors and assist the local government of Chongming in its efforts to reduce carbon emissions. Besides, it is of considerable demonstrative significance to other similar communities in China.

3. Methodology

3.1. Flowchart of integrated inventory method

The integrated inventory method for the carbon emissions estimation of local communities in China is shown in Fig. 2.

3.2. Emissions classification

With regard to the delineation of boundaries, we adopted the scope analyses proposed by certain institutes and researchers (World Resources Institute and Word Business Council for Sustainable Development, 2004; Tim and Anu, 2010; UNEP, 2010; ICLEI, 2009). Energy-induced carbon emissions within the