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Greenhouse gas emissions in China's eco-industrial parks: a case study of the Beijing Economic Technological Development Area

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ABSTRACT

To pursue the sustainable development of industry, China has been developing eco-industrial parks for more than a decade. However, the low-carbon performance of eco-industrial parks is unverified. In this study, a comprehensive greenhouse gas emissions inventory for industrial parks was established, including three sectors: energy consumption, industrial processes and product use, and waste. The Beijing Economic Technological Development Area (BDA), a typical national eco-industrial park of China, was chosen for a case study. The results show that the total greenhouse gas emissions of the eco-industrial park were 3.16 Mt CO_2e in 2010, and energy-related greenhouse gas emissions accounted for 97% of the total. The greenhouse gas emissions increased by 94% from 2005 to 2010. However, the greenhouse gas emissions intensity decreased by 20%, mainly due to optimization of the energy structure and improvements in energy efficiency. The share of non-industrial sectors in the total greenhouse gas emissions increased from 12% to 33%, and the construction industry became the second biggest emissions source, after manufacturing. Scenario analysis indicates that greenhouse gas emissions in the eco-industrial park could be lower than the 2010 levels as eco-industrial development proceeds, but more efforts are needed to improve energy and material efficiency. The case study has great implications for low-carbon development in other industrial parks. It is vital to build the low-carbon economy by implementing policies that will expand eco-industrial park practice and promote low-carbon development in more than 1500 industrial parks in China.

1. Introduction

China has been the world's largest CO_2 emitter since 2008, generating more than 7 billion tons of CO_2 and accounting for 24% of global emissions in 2010 (IEA, 2012). China has been actively working to reduce CO_2 emissions. Between 2006 and 2010, China achieved a 19.1% drop in energy intensity, with an estimated CO_2 emissions reduction of 1.5 billion tons (Xue et al., 2012). In 2009, the Chinese government announced an aggressive long-term target of cutting CO_2 intensity by 40–45% from 2005 levels by 2020. In 2011, China also committed to a short-term goal of reducing energy and CO_2 intensities by 16% and 17%, respectively, in the 12th Five-Year Plan period (2011–2015) (CCCP, 2012). That was the first time that China declared a mandatory target on reducing CO_2 intensity in its grand plan for socio-economic development. Among individual sectors of the Chinese economy, industry accounted for 75% of the total final energy consumption in 2010 (CNBS, 2011), and the proportion of CO_2 emissions from the industrial sector was 83% (Xie et al., 2010). Despite rapid improvement, the energy efficiency of the industrial sector is still far below that of other industrialized countries (Kahrl et al., 2011; Peters et al., 2007), which means that industry should still be the focus of China's energy-saving and carbon-reduction efforts (Dai et al., 2009).

In China, industrial parks have played a significant role in regional and national economic development. There are 1568 national and provincial industrial parks in China, producing more than 60% of the gross industrial output and 50% of the gross domestic product (GDP) (Bao, 2013). However, the concentrated industrial activities in these parks have created a series of environmental problems (Geng et al., 2010; Zhang et al., 2008). To help mitigate these environmental concerns, the eco-industrial park (EIP) strategy has been adopted by Chinese government to

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Abbreviation list

AFOLU	agriculture, forest and other land use
BDA	Beijing Economic Technological Development Area
BTEX	benzene, toluene, ethylbenzene, and xylene
CCHP	combined cooling heating and power
CNY	China Yuan
CO_2e	carbon dioxide equivalent
EIP	eco-industrial park
EF	emission factor
MEP	Ministry of Environmental Protection of China
GDP	gross domestic production
GHG	greenhouse gas
GWP	global warming potential
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
IVA	industrial value added
MSW	municipal solid waste
NMHC	non-methane hydrocarbons
$PM_{2.5}$	particulates less than 2.5 μm in diameter
SEPA	State Environmental Protection Administration
VOCs	volatile organic compounds
WWTP	wastewater treatment plant
HS	historical scenario
CIS	continued improvement scenario
SIS	stagnant improvement scenario
AIS	accelerated improvement scenario
AI-AEGS	AIS with an appropriate economic growth rate

support the sustainable development of industry through optimization of energy and resource use (Tian et al., 2013a, 2013b). Since the State Environmental Protection Administration (SEPA, renamed the Ministry of Environmental Protection (MEP) in 2007) formally initiated the national Demonstration EIP Program in 2001 (Shi et al., 2012a), 81 industrial parks have been chosen as national Trial EIPs, and 20 of them have been nominated as national Demonstration EIPs (MEP, 2013). Most of these EIPs are national industrial parks, representing the most advanced productivity in China. Through the eco-industrial development of these forerunners and practitioners, China aims to find a new path of industrialization.

An EIP is defined as “a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only” (Lowe et al., 1995). In theory, EIPs can be ultra-low emission or no emission facilities because their goal is to shift the industrial processes from a linear system to a closed loop system (Chertow, 2000). Some studies show that it is practical to reduce GHG emissions in industrial parks through EIP development (Hashimoto et al., 2010; Sokka et al., 2011), and EIP may even achieve “carbon neutral” status (Block et al., 2011; Maes et al., 2011). In China, the government has also used EIPs to promote low-carbon development in industrial parks. At the end of 2009, MEP issued a statement to encourage low-carbon development among the national EIPs, which required that “the planning, construction, and assessment of national EIPs should adopt the concepts of circular economy, low-carbon economy, and industrial symbiosis, thus reducing energy consumption, environmental pollution, and GHG emission within EIPs” (MEP, 2009). However, the assessment of low-carbon performance for Chinese EIPs is still insufficient in literature (Tian et al., 2013a), because of absence of detailed assessment method for the low-carbon performance of EIPs in China and lack of basic data for most Chinese industrial parks (Tian et al., 2012). Both Chinese government and academic researchers paid close attention to the role of EIPs in low-carbon development. It is necessary to study GHG emissions in EIPs so that the successful experience and failure lessons of the EIPs can be shared by other industrial parks.

The aim of this paper is to analyze the change of GHG emissions in industrial parks during the eco-industrial development. Our case study considers the Beijing Economic Technological Development Area (BDA), one of the National Demonstration EIPs in China, with the consecutive years of data in a long-term study. A comprehensive GHG inventory at the industrial park level was developed to access the low-carbon performance of BDA. The dynamic GHG emissions and intensity are analyzed from 2005 to 2010. The future trends of GHG emissions and intensity are also estimated under four possible scenarios. The results could provide a more comprehensive understanding of GHG emissions at the industrial park scale and should help enable ongoing work in industrial metabolism. The remainder of the paper is organized as follows. Section 2 gives a brief introduction of BDA, presents the methodology for establishing the GHG inventory at the industrial park level, and provides data sources. Section 3 reports the GHG emission and intensity of BDA, discusses the results, analyzes the scenarios in the next decade, and provides recommended strategies. Finally, Section 4 concludes.

2. Materials and methodology

2.1. Brief introduction of BDA

BDA is located in E-Town (Yizhuang region, southeast of Beijing) and covers 46.8 km^2. BDA was founded in 1992. After more than two decades of development, BDA has formed four pillar industries: information and communication technology, bioengineering and medicine, automobile manufacturing, and equipment manufacturing. BDA is both a National Economic Technological Development Zone and a national Hi-Tech Industrial Development Zone. Thus far, more than 4600 domestic and foreign enterprises have registered in BDA, with a total cumulative investment of 32 billion USD since 1992. In 2012, BDA had a GDP of 82 billion CNY (13 billion USD, 1 USD = 6.2855 CNY in 2012) and accounted for 20% of gross industrial output in Beijing. BDA initiated the EIP project in 2005 and was accredited as a national Demonstration EIP in 2011.

2.2. Accounting boundary and scope

Chinese EIP program is an integration of circular economy, cleaner production, energy conservation and emission reduction, industrial symbiosis, pollution prevention, waste recycling and so on (Shi et al., 2012a, b; Tian et al., 2013b). It is impractical to calculate the GHG emissions reduction one by one for each specific project in EIPs. And the assessment of overall performance of industrial parks during the eco-industrial development has more practical significances. So in this study, we develop a comprehensive GHG inventory at the industrial park level. The boundary and the scope of the GHG inventory are described as the following.

Determining the boundary of a GHG inventory helps to prevent accounting errors. In China, every industrial park has a statutory organizational boundary, and most enterprises are located and operated within the boundary. Some enterprises are located in the