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Effect of urban symbiosis development in China on GHG emissions reduction

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Abstract

This paper analyzes current urban symbiosis development and application in China, and then conducts a statistical analysis of the emissions reduction of CO_2 and CH_4 in relation to recovery of iron and steel scraps, waste paper, and waste plastics from 2011 to 2014 using the greenhouse gas (GHG) emission inventory calculation method provided by the IPCC. Results indicate that the cumulative recovery of renewable resources during China's main urban symbiosis development in 2011−2014 was 803.275 Mt, and the amount of iron and steel scraps, waste paper, and waste plastic recovery was the largest, respectively accounting for 62.2%, 18.0%, and 8.2% of total recovery in 2014. In addition, the cumulative emissions reduction of GHGs in relation to recovery of iron and steel scraps, waste paper, and waste plastics in 2011−2014 was 27.962 Mt CO_2-eq, 954.695 Mt CO_2-eq, and 22.502 Mt CO_2-eq, respectively, thereby totaling 1005.159 Mt CO_2-eq. Results show a remarkable GHG emissions reduction during 2011−2014.

Keywords: Urban symbiosis; Recovery of renewable resources; GHG emissions reduction

1. Introduction

Urban symbiosis aims to achieve development on an industrial scale while utilizing urban waste resources. These resources include recyclable resources (Zhou et al., 2014) such as iron and steel, non-ferrous metals, noble metals, plastics and rubber generated and contained in waste and discarded electromechanical equipment, family appliances, electronic products, wires and cables, automobiles, communication tools, metals, and plastic wrapping. The meaning of urban symbiosis has now expanded in line with technological and economic developments, and it should include both energy and materials recycling according to Peter et al. (2013). The concept of urban symbiosis development has gradually shifted to encompass the idea of environmental-friendly development that makes use of waste and transforms potentially harmful substances into something advantageous. This concept has not only become used as an effective approach for alleviating bottleneck restrictions on resources and reducing environmental pollution, but it is also important in developing a circular economy and realizing sustainable development.

Over 300 years of exploitation and utilization, 80% of global mining resources that could be utilized on an

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industrialized basis have been transferred from under ground to above ground. These resources are now accumulated around us in the form of garbage, and their total quantity has reached hundreds of billions of tons with the increasing rate of 10.0 billion tons per year. Many studies have been conducted on the tremendous above-ground resources that are currently abandoned and neglected by the society. And in this respect the idea of urban symbiosis proposed by Jane (1961) has comprehensively deepened.

Human beings are concerned about global climate change and have achieved greenhouse gas (GHG) emissions reduction to eliminate such change. The Chinese government are paying attention to addressing climate change, and the actions are continuously increasing. Research has been conducted globally addressing GHG emissions from fossil fuel combustion, industrial production processes, agriculture and forestry, human society, and vehicles (Richard and Naomi, 2016; Chen and Zhang, 2010). For example, it has been indicated that 8 Mt of metals were recovered in the U.S in 2010, which directly reduced GHG emissions by a total of 26 Mt. This amount is equivalent to the GHG quantity generated by over 5 million motor vehicles driven on highways in one year (Zhou and Zhang, 2013); the emissions reduction effect is therefore evident. In 1997, Berkel et al. (2009) began a comprehensive analysis of urban symbiosis development in Japan's Eco-Town program, and concluded that the program improved recycling legislation, government subsidies, and a recognition of environment issues. In addition, Dong et al. (2014) used a hybrid life cycle assessment (LCA) model to quantify the effect of carbon emissions reduction through a case study in Kawasaki Eco-town, Japan, and found that the carbon emission efficiency was improved by 13.77% with the implementation of industrial mining and urban symbiosis. Geng et al. (2010) used a scenario simulation model based on the LCA approach and determined that by recycling mixed paper, mixed plastics, and organic wastes, and utilizing recycled materials in industrial production, potential emissions reduction of 69,000 t CO_2-eq could be achieved and 8000 t incineration ashes could be landfilled by 2015. Furthermore, Hashimoto et al. (2010) evaluated the potential of reducing CO_2 emissions through industrial mining in cement companies, and found that one cement producer reduced CO_2 emissions by 43,000 t per year when using recycled materials rather than virgin materials. Urban symbiosis development can reduce GHG emissions due to reducing the landfill quantity of solid urban waste which is an important source of GHG, especially in China, since Zhang et al. (2011) indicated that landfill will continue as the main method used in treating waste in China in the near future.

The direct benefit of strengthening urban symbiosis development is to reduce the amount of garbage generated. In addition, this so-called “garbage” can be restored as constituent raw materials that can be re-used and reduce exploitation and processing of natural raw materials. In China, studies on urban symbiosis have focused on recycling and gaining knowledge from experience and practice gained overseas (Yu et al., 2015; Li et al., 2015). However, this paper focuses on the effect of urban symbiosis development on GHG emissions reduction. China's urban symbiosis development is mainly focused on the development of renewable resource industries. Therefore, three types of renewable resources (iron and steel scraps, waste paper, and waste plastics) are selected in this paper, which were determined to be the most recovered resources in China in 2011–2014. The study aims to estimate the emissions reduction in CH_4 and CO_2 in relation to recovery of these three types of resources. The effect of urban symbiosis development on GHG emissions reduction are also analyzed.

2. Material and methods

2.1. Data

Data of China's renewable resources recovered in 2011–2014 were collected for analysis of GHG emissions reduction (DCID, 2011, 2012, 2013, 2014), with a particular focus on amounts of recovered iron and steel scraps, waste paper, and waste plastics.

2.2. Methods

Methods for calculating GHG emissions provided by IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) are widely used (Chen and Zhang, 2010; Peters, 2008; Hertwich and Peters, 2009). The basic principles involved in calculating GHG emissions and associated methods for sectors given by IPCC can also be applied to area and enterprise levels. These methods are more appropriate than other methods such as LCA and economic benefit analysis, because detailed operational data are difficult to obtain from both government run and private factories. To correspond with the actual situation in China, the localized emission factors and parameters used in this article refer to the values recommended by China's National Greenhouse Gas Inventory 2008 (DCC, 2014). In addition, the results were compared with those of other studies to obtain a verified and superior assessment.

2.2.1. Calculation methods for waste paper

GHG emissions reduction from waste paper recovery is equal to the difference between GHGs emissions from the equivalent recovery of paper from wood and that generated by pulping paper using recovered waste paper, and plus the emissions saved in relation to the reduction in wood consumption and waste paper landfilling. The emissions from the equivalent recovery of paper from wood and waste paper pulping is calculated by referring to a LCA inventory analysis of a typical product used in China's paper-making industry (Chen et al., 2014). According to GHG emission from the production of 1 kg wood pulp and 1 kg recovered waste pulp, the GHG emissions in the paper-making stage are identical for both types of paper production. On the assumption that an equivalent amount of recycled waste paper is produced completely with wood pulp rather than waste paper pulp, and based on the global warming potential of CH_4 being 21 times