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Towards preventative eco-industrial development: an industrial and urban symbiosis case in one typical industrial city in China

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ABSTRACT

Industry plays as a double-edged sword that can contribute to both gross domestic product (GDP) and pollution, thus the concept of eco-industrial development which emphasize the environmental cleanness in economy development has received more and more attentions recently. Different from the traditional development mode which merely relocating industries outside of the cities for pursuing sustainable development, eco-industrial development makes significant innovation by treating or utilizing wastes (i.e. solid wastes and waste energy) in a smart way for local industries to achieve a win–win situation. In order to investigate the eco-benefits of eco-industrial development in China, this study focused on an industrial and urban symbiosis case of Guiyang city in which process synergy, municipal solid wastes recycling and waste energy utilization were incorporated in this typical industrial city. This city is resource-dependent, has many heavy industries, and these severely hinder sustainable development in this city. In order to promote eco-industrial development, an integrated coal, electricity, aluminum, phosphor chemical, iron/steel industry and urban symbiosis network was firstly designed, with linkages between various industries through energy exchanges and process synergies. Subsequently, a quantitative assessment on the life cycle environmental benefits were further conducted. Then, we found that a dramatic resource saving and carbon dioxide emission reduction can be achieved. Finally, some policy implications to address the barriers of promoting industrial and urban symbiosis were proposed. This study is critical for future industrial and urban planning policy making and shed a light on innovative eco-industrial development in China.

1. Introduction

With rapid development, China has become a “world factory” and the largest energy consumption and carbon dioxide (CO_2) emissions country (Dong et al., 2014; Dong and Liang, 2014) (Fig. 1). To some extent, industry is a double-edged sword for China. On one hand, industry is the pillar for the national economy. On the other hand, industry contributes to about 80% of the energy consumption, and related CO_2 emissions (Chen et al., 2014; Tian et al., 2014b). Moreover, rapid industrialization resulted in a large amount of environmental emissions, such as solid wastes and wastewater discharge. Thus it is important to pursuit eco-industrial development so that a preventative and regenerative pathway towards sustainable development can be achieved.

The innovative concept of industrial and urban symbiosis (IS and UrS) (Fig. 2) provides a novel approach for China's industry to meet with both environmental challenges and resource depletion challenges. IS refers to a relationship that proximate industries exchange materials, energy and/or by-products in a mutually beneficial way and improve the resource utilization (materials, energy, water) through closing the loops (Chertow, 2000, 2007; Chertow and Lombardi, 2005; Eckelman and Chertow, 2009; Hashimoto et al., 2010; Jacobsen, 2006). As an extended concept

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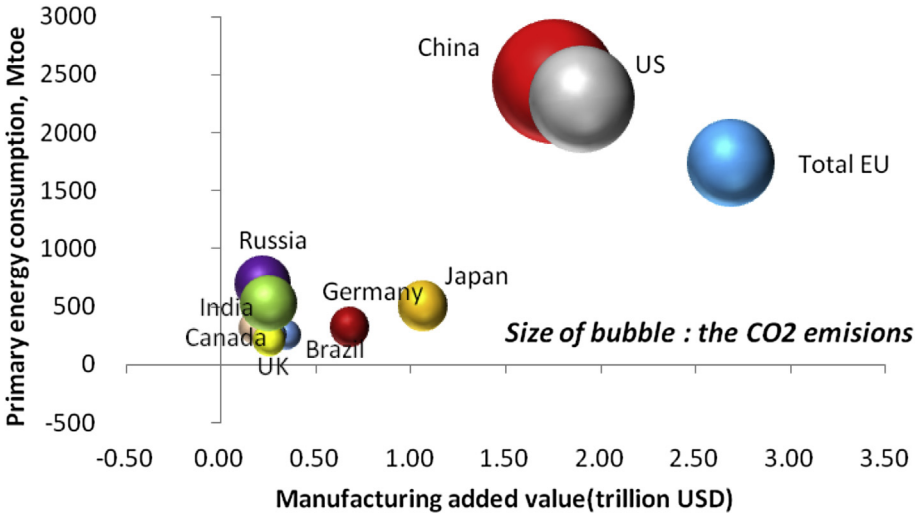

Fig. 1. Energy consumption, CO_2 emission and industrial manufacturing added value in selected countries in 2010.
Source: revised by the author based on (Dong et al., 2014); World Bank, 2011.

of IS, urban symbiosis refers to a specific opportunity arising from the geographic proximity of urban and industrial areas (Chen et al., 2011; Geng et al., 2010a; Van Berkel et al., 2009b). It could innovatively promote the local industries to utilize urban wastes in order to reduce the related environmental impacts. Under such a concept, urban waste management and industrial development could be connected harmoniously and the resource consumption and pollutants emissions could be reduced accordingly.

IS and UrS is particularly important for China's bulky industrial waste (Dong et al., 2013a; Li et al., 2010) and municipal solid waste (MSW) management considering its large generation, and provided extra solution apart from cleaner production and common MSW management (Burström and Korhonen, 2001; van Berkel et al., 1997). Compared with developed countries like Japan and EU, China's MSW management has been still at the early stage. Currently, more than 80% of the MSW is treated as landfill (Zhang et al., 2010a). There is rather few MSW is reused in industries. However, there is huge advantage for China to promote the utilization of MSW in industries with its large scale integrated industrial system, particular process industries like iron/steel and cement plants. Especially under the national promotion of circular economy strategy and eco-industrial park (EIP) project, there is high potential for China to promote IS and UrS (MOST, 2009).

However, to date, literature have mainly focused on Japanese cases due to its famous eco-town project. There are few studies on IS/UrS outside Japan. Under such a circumstance, this study aims to fill such a research gap by investigating the contribution of industrial and urban symbiosis implementation to regional eco-industrial development in China. The objectives of this study are: (1) introduce the idea of industrial and urban symbiosis for China's eco-industrial development, and develop hybrid LCA model (an integrated input–output and process LCA model); (2) conduct a case study for quantitative environmental evaluation on the application of industrial and urban symbiosis in one typical resource dependent and heavy industrial city, named Guiyang in southwest China. (3) provide policy implications on promoting industrial and urban symbiosis.

The whole paper is organized as below: after this introduction section, Section 2 makes a review on the development and evolution of industrial and urban symbiosis research; Section 3 describes our methodology and data; Section 4 depicts the industrial and urban symbiosis implementation in one typical industrial and resource dependent city in China and evaluates the environmental benefits, as well as policy implications; and finally, Section 5 summarizes our research findings.

2. Review on the development and evolution of industrial and urban symbiosis research

2.1. Theories and policies development

This section reviews the theories and the related policies development. As one type of system innovation, IS has been globally promoted. Fig. 3 summarizes the development of IS and the

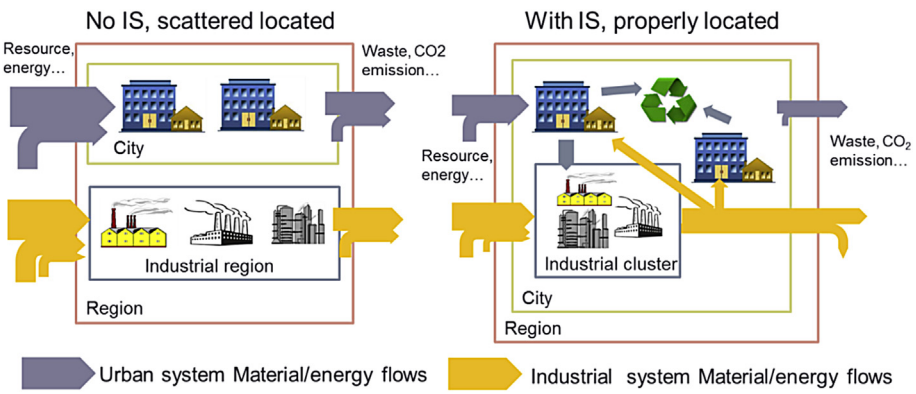

Fig. 2. Industrial and urban symbiosis.

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