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Uncovering opportunity of low-carbon city promotion with industrial system innovation: Case study on industrial symbiosis projects in China

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HIGHLIGHTS

- Investigate two real industrial symbiosis projects in Jinan and Liuzhou of China.
- Quantify the material exchange and the CO_2 reduction potential of the IS network.
- CO_2 reduction potential is 3944.05 and 2347.88 ktCO_2/year in Jinan and Liuzhou.
- In current China, IS is main in term of material symbiosis.
- How to coordinate IS and low-carbon city is discussed.

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ABSTRACT

There is a dilemma for rapid industrializing China to balance economic growth and low carbonization. Industrial symbiosis (IS) provides a system innovation to utilize the industry to fight climate change and pursue sustainable urban development, while few attentions are paid in literatures. Under this circumstance, this study reviews the low-carbon city practice in China and conducts a case study to calculate the CO_2 emissions reduction potential under promoting IS projects in two cities of China, named Jinan and Liuzhou. With the real national project in Jinan as advanced example, new scenarios related to IS are designed for Liuzhou, including comprehensive energy network, waste plastics recycling, scrap tires recycling and flying ash recycling. The material/waste and energy exchange is quantified in the IS network, as well as the related environmental benefit. The material/energy exchange is over 10 million ton and 20 thousands tce in Jinan's case, and 2.5 million ton and 45 thousand tce in Liuzhou's case. Results highlight that IS could effectively reduce CO_2 emissions. The total reduction potential amounts to 3944.05 thousands tCO_2/year and 2347.88 thousands tCO_2/year in Jinan and Liuzhou. Finally, policy implications on the ever-improvement of industrial symbiosis and China's sustainable urban development are proposed and discussed.

1. Introduction

Rapid developing China is famous for its "world factory" and largest energy consumption and carbon dioxide (CO_2) emissions (Fig. 1). There is no doubt that 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. Thus it is important to find a smart way to coordinate the industry and its eco-efficiency, so that realize the low-carbon society strategy proposed by Chinese government.

In addition, combined with rapid industrialization and urbanization, how to coordinate the relationship of urban and industry becomes gigantic topic for China's sustainable urban development. Cities play an important role, both in the energy consumption/carbon emission and national environmental protection strategy. In current China, a number of cities like Tianjin, Shanghai, have heavy industries located (Zhang et al., 2013a). "To have the industry or make it out of the city" is under debate. Under this condition, find a smart

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way to build a harmonious relationship between urban and industry is necessary.

Industrial symbiosis (IS) provides a system innovation. IS is defined as a relationship that two or more unrelated industries exchange materials, energy and/or by-products in a mutually beneficial way (Chertow, 1998, 2000, 2007; Desrochers, 2004; Ehrenfeld and Gertler, 1997; Mirata and Emtairah, 2005; Pearce, 2008; Van Berkel et al., 2009; Zhu et al., 2007). Under the co-operation, a collective benefit could be achieved. With the philosophy of IS, the linkage between industries and between industry and urban communities could enhance their eco-efficiency. As a result, the "to be or not to be" question for industry could be improved.

Due to the above features, IS particularly brings brightness to China's low carbonization without impeding the industry development. Through the utilization of material/second energy and/or waste/by-products exchange among process and sectors, both the up-stream raw material and primary energy and the down-stream waste could be reduced. As a result, the related CO_2 emissions would be reduced.

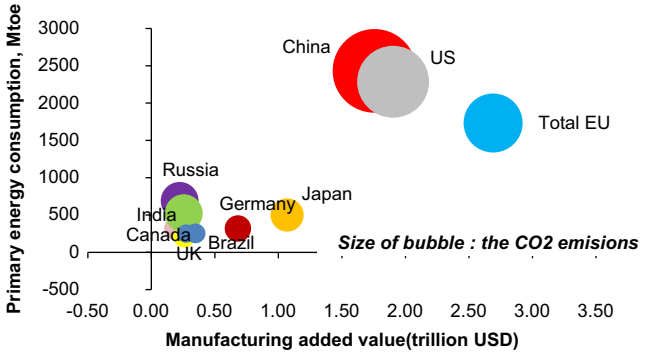

Fig. 1. Energy consumption, CO_2 emission and manufacturing added value in selected countries in 2010. *Note*: the price is current USD in 2010. *Data Source*: BP, 2011; World Bank, 2011.

A number of literatures has proved that IS could significantly reduce the carbon emissions, whether at industrial park level (Hashimoto et al., 2010; Li et al., 2010; Park et al., 2008; Sokka et al., 2011; Van Berkel, 2010) or city level (Geng et al., 2010; Jacobsen, 2006). However, to our best knowledge, very few studies address this issue in China, largely due to the data availability. Considering China's industry scale and integration (high potential to promote IS) and surging CO_2 emissions (high potential for emission reduction), it is meaningful for policy making by filling this research gap.

Based on our previous study (Dong et al., 2013a), this study tries to fill such a gap by conducting a quantitative evaluation of CO_2 reduction potential through innovative IS system from two real projects in two cities of China, with updating data. We specifically choose the typical cases named Jinan city and Liuzhou city in China. The selected cases present different development stages of IS promotion. In Jinan city case, it presents an advanced case of China. It has established a low-carbon industrial system centered with its large iron/steel industry. The linkages between industrial sectors and between industry and community are formed. The selected case in Liuzhou city present developing stage of IS promotion. Currently here is only bulk solid waste exchange, which is the traditional IS activity. Based on the on-site survey, first hand data of energy consumption, material/waste exchange is gain and processed. IS network is evaluated by applying a material flow analysis and CO_2 reduction is accounted. Especially, based on the Jinan case (as advanced example in China), we design new IS for Liuzhou and conduct the evaluation. Further, comparison considering different IS development stage in China and policy thinking for the IS model transformation is discussed in-depth.

The paper is organized as following. After this introduction section, we review the low-carbon city practice in China and discuss the how an industrial system innovation could contribute

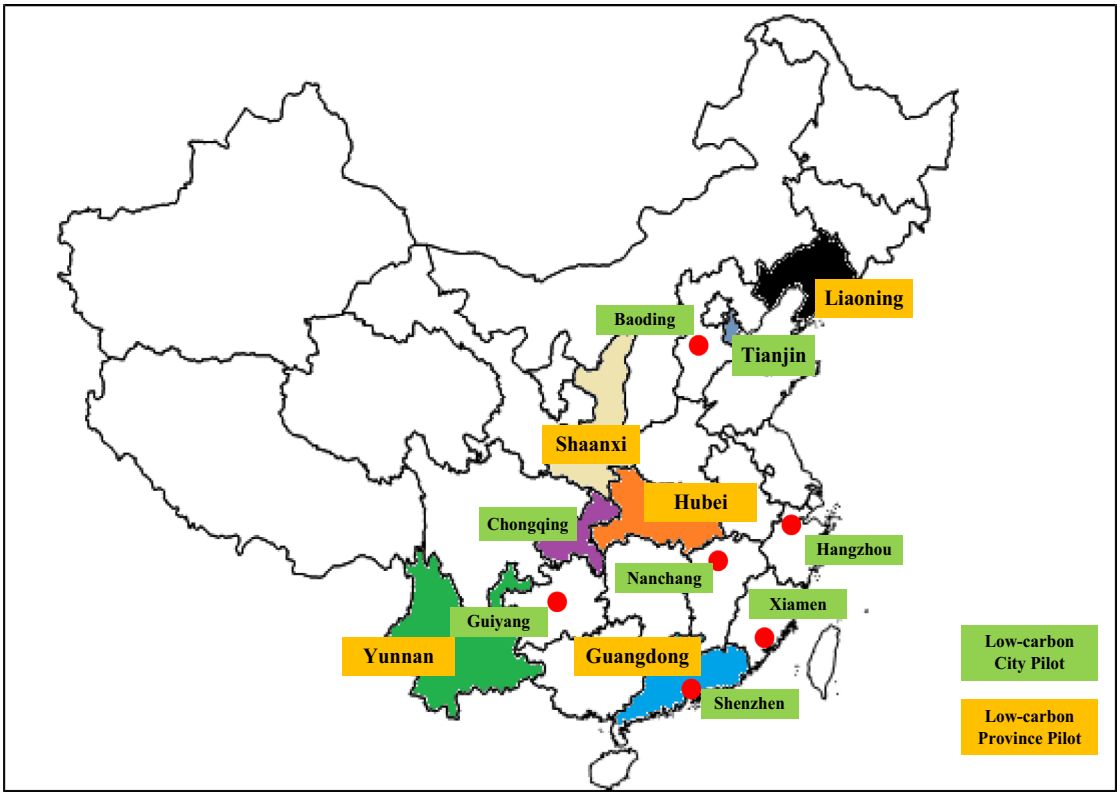

Fig. 2. National pilot program low-carbon provinces and cities in China.