Promoting low-carbon city through industrial symbiosis: case study and policy implication in China

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董亮*1) 2)、藤田 壮1) 2)、大西 悟2)、藤井 実2)、戸川 卓哉2)、董会娟2)

1) 名古屋大学、 2) 国立環境研究所

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Abstract

China launched low-carbon city strategy to respond global climate change. Industrial symbiosis (IS) could generate both economic and environmental benefits in clustered industries and communities. This research investigates the energy saving, CO_2 and air pollutants reduction effects of IS with a hybrid input-output model in a typical industrial city in China, then analyze the carbon mitigation of IS from a Scope 3 perspective. Results highlight that IS effectively contributes to a reduction of CO_2, SO_2 and NO_X reduction. The finding is critical for national low-carbon strategy.

Key words

Low-carbon city; Industrial Symbiosis; Scope 3; Iron/steel industry; China

1. Introduction

China launches ***low-carbon city*** strategy (Su,et al., 2012).

Applying ***industrial symbiosis (IS)*** could promote low-carbon city strategy. Shown as Figure 1, IS is a relationship at least two unrelated industries exchange materials, energy and/or by-products in a mutually beneficial way(Chertow, 2000, 2007). Through IS, could realize resource saving and emission reduction in sectors.

This study conducts a scenario analysis on:

- Evaluating how IS can facilitate energy saving, CO_2 and air pollutants reduction using I-O model.
- Investigate how IS can facilitate low-carbon city in terms of reducing Scope 3 emissions.

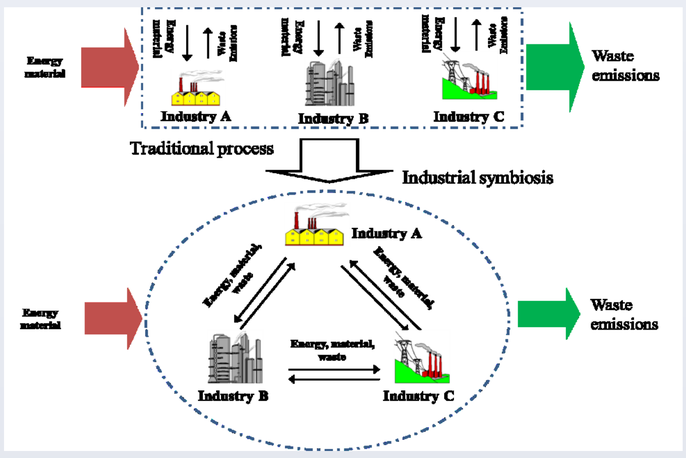


Figure 1 Schematic diagram of IS

2. Methodology and Case study

2.1 Methodology

2.1.1 HPIMO model

- Using ***hybrid physical input and monetary output model (HPIMO)*** to assess how industrial symbiosis could affect the energy consumption and waste reduction for each sector.

Table 1 Structure of established I-O model

Monetary Input		Intermediate Monetary Output Sector 1 …. n	Final demand	Total output	Pollutants emissions
Intermediate monetary input	1	*M*	Y_1	X_1	P_{11}
	…		…	…	.
	n		Y_n	X_n	P_{kn}
Added value	V				
Total monetary output	X				
Physical energy input		Physical input distribution			
Energy resource	1 … m	*E*			

2.1.2 Scope 3 emission

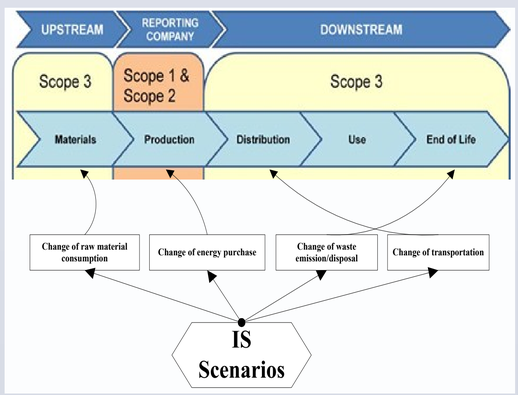


Figure 2 Scheme of Scope 3 calculation

- Calculating Scope 3 CO_2 emission change from the change of raw material consumption, energy purchase, waste emissions/disposal and transportation in up-stream or down stream under the scenarios.

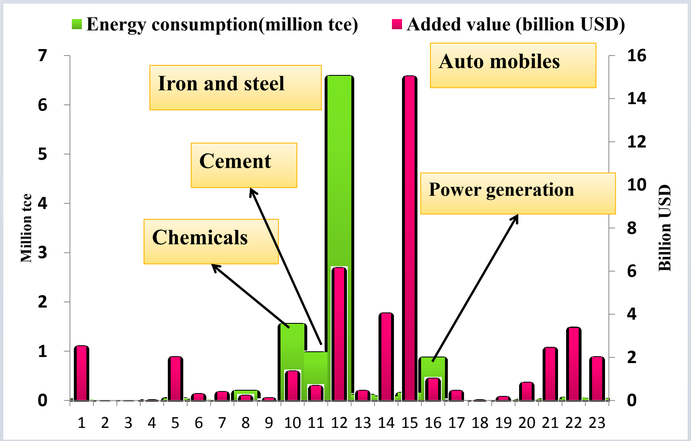


Figure 3 Energy consumption and economic output for each industry in Liuzhou, China

2.2 Case area and scenario setting

Select one typical industrial city in southern China, named Liuzhou. Based on a analysis on the industry and current IS in Liuzhou (Figure 3 and 4), design BAU/4 IS scenarios:

- S0-Business as usual in 2015
- S1-Waste plastics recycling in 2015;
- S2-Scrap tires recycling in 2015;
- S3-Flying ash recycling in 2015;
- S4-Biomass utilization in 2015.

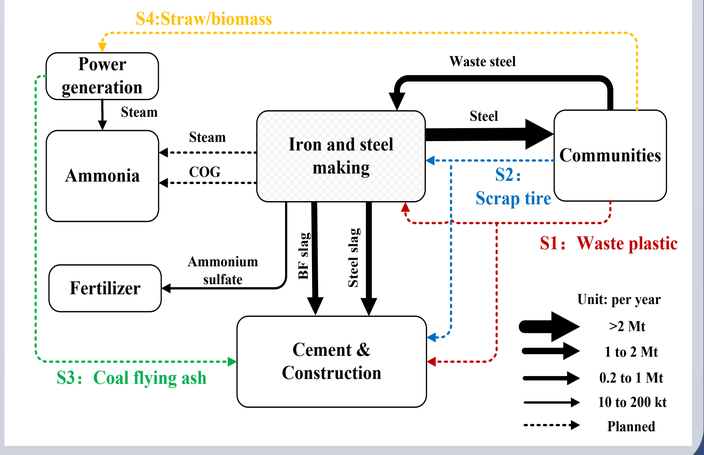
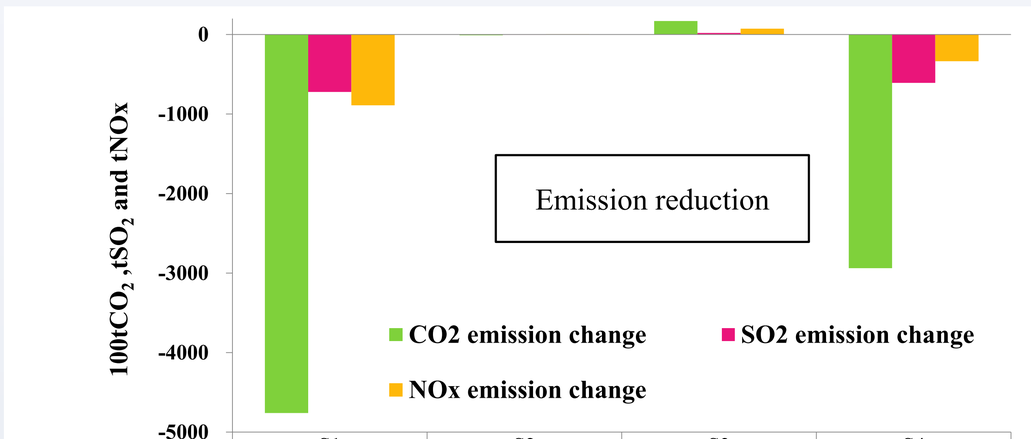


Figure 4 Current (solid line) and planned (dotted line) IS network and quantified material flow in Liuzhou, China

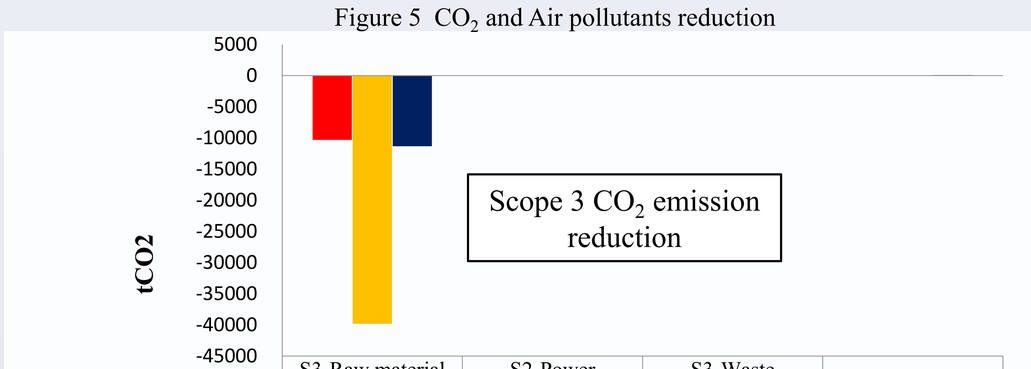
3. Results and Discussion

3.1 Analytical Results



	S1	S2	S3	S4
CO2 emission change	-4758.99	-9.46	170.25	-2937.47
SO2 emission change	-722.54	-4.06	19.19	-607.80
NOx emission change	-889.70	2.48	73.80	-336.03

Figure 5 CO_2 and Air pollutants reduction



	S3-Raw material consumption	S2-Power purchase	S3-Waste disposal	S3-Transportation
Waste plastics recycling	-10387.50	0.00	0.00	29.05
Scrap tires recycling	-39888.00	0.00	0.00	58.10
coal fly ash recycling	-11402.15	0.00	0.00	140.69

Figure 6 Scope 3 CO_2 reduction in scenarios

3.2 Discussion

The results show that IS could contribute to waste reduction and further generate co-benefits of energy saving, CO_2 mitigation and air pollutants reduction. Especially, Scope 3 emissions could be reduced by IS

Results also indicate that different IS efforts may bring different benefits. While waste plastics recycling and biomass utilization could generate more co-benefits, flying ash reuse could only reduce the total amount of solid wastes, but increase energy consumption and related air pollutants. Hence, smart design on IS patterns by considering the local realities is critical.

4. Conclusion and Policy implication

IS is one effective and efficient approach to reduce both virgin material consumption and waste emissions. Particularly, the extraction and refining processes for virgin materials are usually energy intensive, therefore, active promotion of IS could not only contribute to solid waste reduction, but also to the CO_2 reduction and SO_2, NO_X reduction. Finally, it contributes to low-carbon city construction in China.

IS is only in primary stage in China. To support IS, establishing stable and innovative urban waste recycling system is fundamental so that adequate wastes can be collected and delivered to the right users. Also, national financial support for the IS facilities/tech is important.

Finally, we want to emphasize:

- ***Iron/steel industry could act as a hub to facilitate the low carbon economy through IS***. The residual heat from the iron/steel making could be both utilized for industry and district. It is meaningful for China, considering its industrialization process.
- ***Improve local people's awareness and public participation***, activities related to the IS concept such as TV promotions, newsletters, achievement exhibitions and workshops would be helpful.

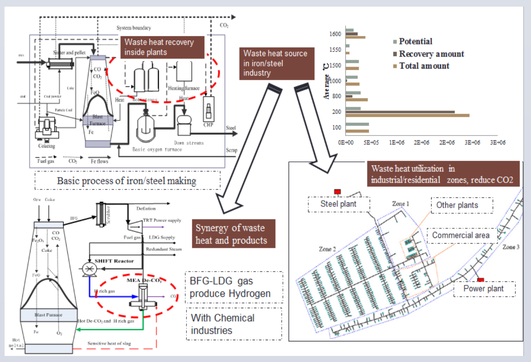


Figure 7 An image of iron/steel industry contribute to future low carbon society (Zhang, et al. 2013)

References

Chertow, M.R., 2000. Industrial symbiosis: literature and taxonomy. Annual Review of Energy and the Environment 25, 313-337

Chertow, M.R., 2007. "Uncovering" Industrial Symbiosis. Journal of Industrial Ecology 11, 11-30.

Hong Li, Dong Liang and Wang Di, "Economic and Environmental Gains of China's Fossil Energy Subsidies Reform: a Rebound Effect Case Study with EIMO Model, Energy Policy, 2013, 54: Pages 335-342.

H. Zhang, L. Dong, H. Li, B. Chen, Q. Tang and T. Fujita, Investigation of the residual heat recovery and carbon emission mitigation potential in a Chinese steelmaking plant: A hybrid material/energy flow analysis case study, 2013. Sustainable Energy Technologies and Assessments, 2:67-80.

Su, M.R., Chen, B., Xing, T., Chen, C., Yang, Z.F., 2012. Development of low-carbon city in China: Where will it go? Procedia Environmental Sciences 13, 1143-1148.

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* **Contact info**: dong.liang@nies.go.jp

- Author introduction: Mr Dong Liang (董亮) is Ph.D. student in Graduate school of Environmental Studies, Nagoya University, Japan; and research assistant in National Institute for Environmental Studies (NIES), Japan.