Journal of Cleaner Production xxx (2014) 1–10

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Implementing a three-level approach in industrial symbiosis

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ARTICLE INFO

Article history:
Received 9 February 2012
Received in revised form
17 September 2014
Accepted 18 September 2014
Available online xxx

Keywords:
A three-level approach
Cleaner production
Industrial ecology
Industrial symbiosis
China

ABSTRACT

Industrial symbiosis (IS) involves two or more companies interlinked through the exchange of materials, heat, water and by-products. In fact, the evolution of industrial symbiosis could be part of a dynamic process leading to the development of a regional industrial ecosystem. Based on a regional context, this paper investigates a three-level approach, i.e., individual firm level, inter-firm level, and regional level, which incorporates cleaner production (CP) and IS to seek potential opportunities for improvement in an operating industrial zone. It was applied in the symbiosis in the Hai Hua Group (HHG) of China. The information was collected through survey questionnaires, open-ended interviews and cleaner production reports from companies. Implementing the three-level approach mainly shows that: (1) all the companies that implemented a cleaner production audit achieved economic and environmental benefits, (2) an existing symbiotic network was discovered, and (3) some potential symbiotic links were identified both at the inter-firm level and the regional level. Integrating cleaner production with industrial symbiosis, the relationship between the industrial symbiosis and its surrounding region, and the role of the government of implementing the three-level approach are discussed. In addition, some barriers were identified and possible resolutions are suggested. It can be concluded that the three-level approach is helpful to integrate CP and IS within a region and provides a useful guidance for discovering industrial symbiosis and promoting its development.

1. Introduction

Industrial Ecology (IE) is a promising theory which provides a creative path for humans to achieve a harmonious development between the industry and the environment. It has been accepted as a field of study and research. Industrial symbiosis (IS) is an important subject in industrial ecology (IE). According to Chertow (2007), industrial symbiosis can be "defined as engaging traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity" (Chertow, 2007; p12). Currently, many industrial symbioses are successfully operating around the world, such as the famous industrial symbiosis of Kalundborg, Denmark (Ehrenfeld and Gertler, 1997; Chertow, 2000; Jacobsen, 2006), the industrial symbiosis of Styria, Austria (Schwarz and Steininger, 1997), the forestry industrial symbiosis of Finland (Korhonen and Savolainen, 2001), and the Guitang industrial symbiosis of China (Zhu et al., 2007). Industrial symbiosis involves two or more companies interlinked through symbiotic relationships. Interlinked through cooperation with each other, companies can often achieve both environmental and economic benefits.

Arguably, the evolution of industrial symbiosis should be part of a dynamic process leading to the development of regional industrial ecosystems. In the often cited example of industrial symbiosis in Kalundborg, Denmark, the symbiotic relationships have been quite fruitful during its over forty years of evolutionary process. These are more than simply waste exchanges and show many features of an industrial ecosystem (Côté, 1998). During the development of industrial symbiosis involving multiple industries, new opportunities for improvement will likely emerge over time. Filling possible niches is significant for an industrial ecosystem (Côté and Smolenaars, 1997). The case of Kalundborg shows that there are potentials for further IS activity during the course of its evolution (Jacobsen, 2006). These potential opportunities should be explored and identified, which will be helpful for promoting the development of an industrial ecosystem. Although the evolution of

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http://dx.doi.org/10.1016/j.jclepro.2014.09.067

industrial symbiosis is often a spontaneous process (Lowe, 1997; Chertow, 2007), can more planning be done to promote the development of industrial symbiosis?

The research objective of this paper is to investigate a "three-level approach", which was applied in the symbiosis in the Hai Hua Group (HHG) of China. It is based on a regional context. It is also an attempt to combine cleaner production and industrial symbiosis in a mutually beneficial manner.

2. Theoretical foundation

According to the United Nations Environment Programme (UNEP, 2002: p5), "Cleaner Production is defined as the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment." CP is regarded as a win–win strategy because it can both improve industrial performance and protect the environment (UNEP, 1994). It aims to reduce the wastes at the source instead of at the end of the pipe and seek the potential opportunities for improvement within the firm. So, CP is considered as a useful method at the individual firm level (Boons and Baas, 1997; Baas and Boons, 2004). The implementation of cleaner production is mainly carried out within individual firms (Brattebø, 1996; Baas, 1998; Jackson, 2002). That is to say, the boundary of implementing cleaner production is usually the individual firm boundary. Some others suggest it can be applied at the life cycle or supply chain (Oldenburg and Geiser, 1997; Clift, 2001). However, it is difficult for an individual firm to reduce all the wastes within its boundary. Jackson (1993; p153) considers the "problem of clean production" as: "The goal of clean production is zero pollution. But all wastes are potential pollutants. And some waste is inevitable." Pauli (1997) points out that it is an ideal for an individual firm to achieve the CP goal of zero waste because the individual firm often can not find a cost-effective way to achieve it. Off-site recycling of materials, which may produce environmental benefits, is often excluded by CP (UNEP, 1994; Oldenburg and Geiser, 1997; Baas, 1998). It is also important to recognize that all wastes are resources (Côté, 2000a), and perhaps more appropriately referred to as by-products or non-product outputs (NPO) (Jasch, 2003). Schwarz and Steininger (1997) argue that waste recycling can be organized in two ways: (1) if there are available processes, reusing the waste within the company; (2) if no such processes exist, exchanging the waste between companies.

Compared with CP with its internal focus, IS stresses the symbiotic relationships between companies (Jackson, 2002), such as material exchange, or energy cascading through cooperation between two or more firms. Thus, the symbiotic links between firms can be perceived as providing supplementary approach for the individual firm-level CP solutions (Ashford and Côté, 1997). Baas (1998) argues that a project related to industrial ecology needs to begin with implementing cleaner production at the individual firm level. Cleaner production is also called "pollution prevention" in North America (Ashford and Côté, 1997; Kazmierczyk, 2002). Oldenburg and Geiser (1997) consider that pollution prevention should be encouraged as one practical tool within the industrial ecology concept. Ashford and Côté (1997) argue that cleaner production plus material/waste exchange can be regarded as of special importance in implementing sustainable development in developing countries.

When implementing CP, companies should attempt to identify wastes of various kinds and reduce or eliminate them to improve productivity. However, once a waste is identified, there are two options: 1) Can changes be made to a process to reduce or eliminate the waste because the waste represents a loss of money and resources? 2) Can those wastes be utilized by a neighboring company in a manner that benefits both companies? As mentioned earlier, an underlying question is: what is a waste? For example, in the case of a coal-fired electricity generating station, electricity is the valued product and heat is viewed in some jurisdictions as waste. But heat as hot water or steam has value and could be considered a secondary product for use in symbiotic arrangements with neighboring industries or district heating systems.

Setting system boundaries is the common phenomenon during the development of industrial symbiosis and industrial ecosystems. System boundaries should be viewed as dynamic issues (Baas and Boons, 2004). Boons and Baas (1997) argue that crossing a company boundary is a common fact for IE initiatives. Schwarz and Steininger (1997) pointed out that seeking potential waste reuse opportunities often has to cross the boundaries of individual companies. Seager and Theis (2002) consider that the expansion of boundaries may lead to supraoptimal solutions. Sterr and Ott (2004) suggest that the situation of crossing the boundaries of the industrial zone may also need to be considered, which usually means a regional context should be considered. Roberts (2004) argues that the boundaries related to industrial ecology can be defined at three levels which are the micro-level (companies), the meso-level (eco-industrial parks), and the macro-level (regional and wider networks of manufacturing activity centers). Thus it is likely that crossing the boundaries of individual firms, groups or industrial parks during the evolution process of industrial symbiosis, is likely to result in symbiotic activities expanding to the whole region, as has been occurring in the National Industrial Symbiosis Programme (NISP) in the United Kingdom (Mirata, 2004). In the UK, the regions are more or less arbitrary. However, in the case of China, regional industrial ecosystems are often strongly shaped by administrative boundaries, i.e., zones and provinces.

Based on the above analysis, a "three-level approach", i.e., individual firm level, inter-firm level, and regional level, is introduced and applied in an operating industrial symbiosis. It also incorporates CP and IS to seek potential opportunities for improvement in the symbiosis in the Hai Hua Group (HHG).

3. Methods

The data and information used in this paper are from a case study, namely the Hai Hua Ecological Industry Pilot Zone (HHEIPZ) project. A case study method was determined as appropriate to investigate the concept. The industrial symbiosis of this paper is mainly composed of the companies from the Hai Hua Group. The region where the symbiosis is located was first named as Hai Hua Economic Development Area. Then its name changed to Weifang Coastal Development Zone (WCDZ) and now is named as Weifang Binhai Economic-Technological Development Area (BEDA). Because of the successful practice on industrial symbiotic initiative of companies in the HHG, in 2005, the region where the symbiosis is located was designated as a national eco-industrial demonstration area and is often called as Hai Hua Ecological Industry Pilot Zone (HHEIPZ). Because of the name changed, the Hai Hua Ecological Industry Pilot Zone is currently known as Weifang Binhai Economic-Technological Development Area (BEDA). This region lies in the northern coastal area of Weifang City, Shandong Province of China. Its location in Shandong Province is shown in Fig. 1. The HHG is the largest marine chemical production and export base in China. Its establishment was based on the salt–soda combination between the Yangkou salt field and Weifang soda plant on 1995. Therefore it is a key starting point for its development (Liu et al., 2012).

All the companies which participate in the symbiosis are attached to the HHG. The HHG contains 20 companies. All these companies have not implemented CP. The seven pilot companies