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A decision support method for development of industrial synergies: case studies of Latvian brewery and wood-processing industries

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ABSTRACT

Industrial synergies – be they, the single by-product exchanges between two companies or the comprehensive industrial symbiosis networks involving numerous industrial synergies – have been recognized for their potential to improve industrial resource efficiency and provide simultaneous economic benefits. With increasing research on maximizing the implementation of industrial symbiosis initiatives per se, the notion of quality of these implemented exchanges has been disregarded. Nevertheless the quality and consideration of whole production life cycle impacts of industrial symbiosis initiatives are important to ensure harmonic and sustainable development. To develop and promote a strategy for advancement of new and qualitative industrial synergies the analysis and evaluation of existing examples of collaboration is necessary. To provide a means for evaluation and comparison of the quality of industrial synergies, a qualitative evaluation method is developed. An illustration of the evaluation method is presented through two case studies of industrial synergies identified in the brewery industry and the wood processing industry in Latvia.

The results of these case studies provide valuable information for decision makers in Latvia and industrial symbiosis practitioners worldwide. Case study results show that only few of the considered self-organized industrial synergies are beneficial regarding all three – environmental quality, economic quality and geographic proximity – evaluation categories. This leads to the conclusion that these three aspects create a three-layer filter for development of qualitative industrial synergies and the quality of each category should be considered before the planning stage of such collaborations.

1. Introduction

Climate change and sustainability concerns of current industrial development have increased the scientific focus on industrial resource consumption, resource efficiency and by-product management approaches. The notion of industrial ecology and its practical applications, i.e., industrial synergies,[1] industrial symbiosis and eco-industrial parks, are recognized for having a potential to increase resource efficiency in industry while also improving economic competitiveness (Zhu and Ruth, 2014).

Industrial symbiosis involves the development of mutually beneficial resource and energy exchanges between companies and utilizing "the synergistic possibilities offered by geographic proximity" (Chertow, 2000). The main principles of industrial symbiosis include ensuring economic and environmental advantages for the involved companies and society, and ensuring the least distance between companies that are implementing the by-product exchange. Implementation of qualitative industrial synergies increases industrial sustainability and reduces industrial impact on global climate change.

1.1. Consideration of the quality of industrial synergies

The worldwide research of industrial symbiosis initiatives has rapidly developed during past few decades (Yu et al., 2014). Currently the research focus has shifted from case studies of identified symbiosis to research on optimizing its provided advantages and finding the best strategies for implementation of new industrial symbiosis initiatives or eco-industrial parks.

With increasing research on maximizing the implementation of industrial symbiosis initiatives per se, the notion of quality of the implemented exchanges has been neglected. Nevertheless the

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[1] To distinguish the difference between a network of by-product exchanges and individual cases of cooperation within this study industrial by-product exchange between any two companies is regarded as "industrial synergy" in contrast to more evolved networks of industrial collaboration regarded as "industrial symbiosis".

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quality and consideration of whole production life cycle impacts of industrial symbiosis initiatives is important due to various aspects. As defined already by Chertow (2000) implementation of industrial symbiosis initiatives might even increase raw resource consumption in industry. "Since waste inputs to raw material offset some of the waste generated, [companies] need not systematically reduce waste generation" (Chertow, 2000). Ashton (2011) presents an example case study where the environmental disadvantages surpass the benefits of inter-firm collaborations. Geng et al. (2009) emphasize that high connectivity may not provide the best environmental outcomes. Jacobsen (2006) considers the quality of industrial synergies and emphasizes the importance of cascading and minimizing the material quality loss per application. Important aspect is that companies prioritize economic benefits over environmental ones therefore the implemented economically feasible industrial synergies may be environmentally inefficient.

To ensure harmonic and sustainable improvement within the whole production life cycle, the implementation of industrial by-product synergies should be integrated with raw material efficiency and cleaner production measures and should consider as well the quality of the exchange. However the current research lacks on purposeful methodology for analysis of quality of industrial synergies and comparison of the three main principles of industrial symbiosis – economic and environmental advantages and geographic proximity of the exchanges. To provide a means for evaluation and comparison of industrial synergy quality, a qualitative evaluation method is developed for rating the exchanges. The rating system includes evaluation if five levels of quality according to three aforementioned sustainability categories of industrial symbiosis (1) geographic proximity between the involved companies and (2) environmental and (3) economic advantages provided by the exchange. An illustration of the evaluation method is presented through two case studies of industrial synergies identified in brewery industry and wood processing industry in Latvia.

1.2. Foundation for the case studies

Increasing reuse and recycling of industrial by-products is an important issue in Latvia, as more than 85% of municipal wastes were landfilled in 2010 and severe reductions will be necessary to comply with the regulations of European Union (EU) (Pubule et al., 2014). Though resource efficiency and sustainable waste management is defined in Latvian legislation, industrial symbiosis has not been particularly promoted. Though distant location of companies poses an important drawback for development of close located industrial synergies, various efficiency measures and the practice of responsible housekeeping have been implemented by industrial companies and have resulted in development of several industrial synergies (as collaborations between two entities applying common by-product reuse techniques). Some of these synergies have already become a typical practice through the whole industrial sector, i.e., the use of wood processing residues for compressed solid biofuel production, use of organic by-products from food processing industry as cattle feed or for biogas production. But implementation of the common reuse pathways can have different quality due to specific conditions for each industrial synergy as the by-product transportation distance, economic benefits of exchange, needed treatment for the exchange flow, etc. Therefore the drawback of general implementation of common industrial synergies is that one solution cannot be the most beneficial solution for all applications. The evaluation and comparison of quality of each by-product reuse case will provide decision support for further creation of industrial synergies and for planning of the national policy for industrial symbiosis development in Latvia. Moreover the developed framework can be extended and applied for evaluation of whole industrial symbiosis networks in order to promote efficient and qualitative cycling of industrial resources.

1.3. Summary of the research

The aim of this research is to develop a framework for evaluation and analysis of the quality of industrial synergies, to apply through the use of case studies the framework for evaluation and comparison of industrial synergies identified in Latvian brewery and wood-processing industry and to provide decision support information for future development of industrial synergies in Latvia. The structure of this paper is following: first, the currently applied methods for analysis of industrial synergies are reviewed to determine how the quality of industrial synergies has previously been evaluated. Second, the development of framework for evaluation of industrial synergy quality is described. Then, the description of two case studies is provided and the results of industrial synergy quality evaluation are presented. Finally the conclusions are drawn and discussion about further application and development of this method as well as its limitations are expresses.

2. Industrial symbiosis research directions and currently applied analysis methods

The notion of industrial synergies (as it is applied within this study) is based on the overall framework of industrial symbiosis. In this chapter the development of industrial symbiosis research and the relevant analysis methods are examined that can also be applied for evaluation of the quality of industrial synergies.

2.1. Current industrial symbiosis research directions

The main objectives of industrial symbiosis research have significantly changed over time. Starting with descriptive research characterizing the identified collaborations (Ehrenfeld and Gertler, 1997), the further studies provided variety of quantitative assessments of industrial symbiosis networks (Chertow and Lombardi, 2005; Jacobsen, 2006), in-depth case studies (van Beers et al., 2007; Yang and Feng, 2008) and theory building case studies (Mirata and Emtairah, 2005) and policy configurations for improved environmental and economic benefits (Pearce, 2008). After an extensive study on industrial symbiosis research directions Yu et al. (2014) conclude that industrial symbiosis studies have currently evolved from a practice oriented research to research that involves coherent theory building for improved analysis and increased stimulation of industrial synergies. Currently common industrial symbiosis research approaches include life cycle analysis (LCA), material flow analysis (MFA), application of eco-efficiency indicators and new methods from other research fields, i.e. social network analysis, systems dynamic modelling, agent based modelling, linear and mathematical programming methods, geographic information systems, emergy analysis, etc.

The evaluation of industrial symbiosis is valuable for decision support and can provide essential information for stimulation of new collaborations. Jacobsen (2006) indicates that economic and environmental evaluation of industrial symbiosis exchanges supports decision making and provides reasoning for implementation of exchanges. Mirata (2004) emphasizes that long-term sustainability should be considered by industrial symbiosis coordinators and the potential future scenarios should be analysed to identify the desirable strategies. The current studies on industrial symbiosis focus to a greater extent on the quantification of various types of emissions, consumption of different resources or cost of operation of industrial symbiosis. The importance of quality and efficiency of resource exchanges is discussed by several authors (Ashton, 2011;