Brief for GSDR 2015

# Industrial symbiosis: powerful mechanisms for sustainable use of environmental resources

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Decoupling of resources use from economic growth is one of the central challenges of pathways towards a sustainable future. In this context, industrial symbiosis[1] holds huge potential. While increased resource efficiency is one of its central aspects, industrial symbiosis links to broader agendas in the fields of green economy, innovation, material and energy security, climate change, as well as local, regional and national welfare.

## Introduction

Industrial symbiosis encompasses initiatives in which two or more industrial entities develop mutually beneficial relationships. Most common is the case that one entity makes productive use of a material stream that is regarded as waste by another entity. Other examples of symbiotic cooperation include the shared utilisation of specific equipment or facilities and the pooling of resources. Environmental benefits result from reduced consumption of resources and reduced amounts of waste and emissions. The system of exchange typically converts negative environmental externalities, mainly in the form of waste, into positive environmental externalities such as decreased pollution and reduced need for raw material (Chertow & Ehrenfeld 2012). For the industrial entities, the benefit lies primarily in economic advantages.

Industrial symbiosis promotes economic growth, while at the same time it generates environmental benefits. Implementation of industrial symbiosis therefore holds huge potential to unlock powerful mechanisms that foster sustainable development.

## Scientific debate

Academic interest in industrial symbiosis was raised by examples of cooperating companies in practice in the second half of the twentieth century (the best-known example is Kalundborg in Denmark). A considerable number of case studies are now available in literature from different countries.

In the early years of the twenty-first century, industrial symbiosis became a widely accepted and strategically prioritised policy tool in the context of a green economy. There is wide consensus that industrial symbiosis holds huge potential to make a significant contribution to improved resource efficiency and increased innovation and that it is a key element in establishing circular economies. Industrial symbiosis was included as one element in the Roadmap for a Resource Efficient Europe[2], which is embedded in the

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Date of compilation: 19 January 2015

[1] The most commonly cited definition of industrial symbiosis was proposed by Chertow (2000) as follows: "The part of industrial ecology known as industrial symbiosis engages 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." There is some inconsistency how industrial symbiosis is described in literature, and interpretation can be subject of critical discussions (Lombardi & Laybourn 2012). The same is the case for industrial ecology. Industrial ecology is a relatively new discipline, focusing on optimisation of material and energy flows in industrial systems (generally understood as all systems influenced by anthropogenic activities), and postulating that valuable knowledge and advantage can be derived from analysing the cycles in natural ecosystems and by transferring key underlying principles to industrial systems.

[2] See http://ec.europa.eu/environment/resource_efficiency (accessed January 2015)

Resource Efficiency Flagship Initiative[3]. The OECD (Organisation for Economic Co-operation and Development) has identified industrial symbiosis as a systemic innovation element, vital for future green growth[4]. Some national waste management initiatives or official plans (e.g. Portugal) explicitly prioritise industrial symbiosis (Laybourn & Lombardi 2012). Programmes comprising elements linked to industrial symbiosis are in place in various countries (e.g. implementation of eco-industrial parks in China as element in the country's circular economy strategy) or under development.

During the last 15 years, industrial symbiosis research has advanced from descriptive case studies to systematic analysis based on various theoretical frameworks (Boons et al. 2014). Understanding the dynamics of industrial cooperation and industrial systems remains an area that requires further progress. Chertow & Ehrenfeld (2012) highlight that robust industrial systems show patterns of complex adaptive systems rather than centrally planned models with predetermined developments, which among others seems to explain why placing by-product reuse as a far higher business priority than it merits economically is in itself not a success criteria. Industrial symbiosis examples show various forms of self-organising properties.

While it is one challenge to better understand the processes in industrial systems and networks, it is a key challenge to identify the pathways to facilitate and coordinate implementation of new initiatives. This includes assessment of mechanisms to foster the processes that align intrinsic motivation of industry and delivery of public and environmental benefits.

It is further necessary to elaborate and standardise methods for quantification of the benefits of industrial symbiosis. This refers to various levels (individual industrial entity, local, regional, national, international level).

| **Food for thought on industrial symbiosis** |
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| • The private sector accounts for around two thirds of natural resources consumption.<br>• Industrial symbiosis converts negative environmental externalities into benefits.<br>• Industrial symbiosis promotes economic growth and at the same time reduces environmental burdens.<br>• While implementation generally is in a geographical distinct area, the benefits are not limited to this area but link to global issues.<br>• Industrial symbiosis is increasingly seen as integral part of economic and environmental policy, but its dynamics have not yet been fully understood.<br>• A better theoretical analysis and understanding of the network mechanisms would lead to facilitated coordination of initiatives and would help to ensure long-term successful operation. |
| *Source:* Author's compilation |

**Issues for further consideration**

Despite the vital role that cooperation between companies and industrial symbiosis have to play in a green economy, both the extent of practical implementation and the theoretical knowledge have remained underdeveloped. The following issues should be addressed with priority:

- Suitable forms to institutionalise industrial symbiosis initiatives and to facilitate implementation and coordination of projects
- Research to improve the theoretical basis and to advance models
- Improved economic and environmental analyses to reveal the implications at different levels (individual entities, local, regional scale, national scale) and to quantify benefits
- Mechanisms and opportunities to bring together practitioners, policy leaders and other stakeholders

**References**

[3] See http://ec.europa.eu/resource-efficient-europe/ (accessed January 2015)

[4] OECD 2010. Project on green growth and eco-innovation. OECD, Paris. Cited in Laybourne & Lombardi (2012)

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