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Symbiosis between industrial systems, utilities and public service facilities for boosting energy and resource efficiency

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Abstract

Industrial symbiosis represents a great opportunity for boosting energy efficiency, shifting the focus from a single industry to cluster of firms. Collaboration and synergistic possibilities offered by geographic proximity lead to great competitive advantages involving waste and resources flows. Energy clustering can provide relevant benefits hardly achievable without cooperation, mutually improving the energy efficiency of industries and of other activities in the neighbourhoods, e.g. hospital, schools. In the present work, several synergies currently applied have been mapped in a district of Brescia, moreover the introduction of foreseeable new synergies have been identified and evaluated aiming at reducing the local energy utilization and environmental impact, considering industrial facilities, utilities and public service facilities as an holistic system.

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Keywords: industrial symbiosis; energy efficiency; synergies; sustainable production; resource flows

1. Introduction

Climate change and sustainability issues concerning the industrial development have recently increased the scientific focus on Industrial Ecology (i.e. industrial resource consumption, resource efficiency and by-product management approaches), looking at natural ecosystems as models for industrial activity. Specifically, Industrial

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Symbiosis (IS) refers to business-to-business relationships that mimic symbiotic interactions between organisms, where surplus resources generated by an industrial process are captured and redirected as 'new' input into other processes providing mutual benefits instead of being thrown away. Among the industrial ecology research area, IS represents a great opportunity to optimize the efficiency and the utilization of the resources and, at the same time, to improve environmental, economic and social performances leading to huge competitive advantages [1–3]. This is mainly due to the fact that the global benefits introduced with the industrial symbiosis network are greater than the sum of the single benefits that the actors could individually generate [4]. Moreover, a broader vision of industrial symbiosis considering an increasing collaboration between private companies and regional or national authorities, through public-private partnerships, allows to gain greater benefits also for public organizations: (1) improved performance of the public service facilities; (2) reduced and stabilized cost for providing services such as heat, cooling and electricity to public service facilities (e.g. hospitals, offices and schools) leading to greater cost-efficiency and (3) reduced environmental impact.

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 in order to exploit the synergistic potentials offered by geographic proximity [1, 5, 6]. As the nature makes a complete and continuous recycle of every material, IS also addresses high focus on closed-loop solutions and circular economies for which everything is recycled or re-used and nothing destroyed, i.e. no waste and pollution are produced. Actually, three types of symbiotic transactions can occur: (i) using waste as raw material input for other actors (by-product exchanges), (ii) sharing infrastructures, utilities or access to services (such as energy or waste treatment), and (iii) cooperating on issues of common interest such as emergency planning, training or sustainability planning [7]. Evolving from the traditional single firm perspective to the holistic system approach leads to catch energy efficiency opportunities at an aggregated level and to achieve optimizations otherwise not realisable. These greater benefits are possible thanks to the fact that the aggregation provides higher economies of scale, reduced installation costs, higher production efficiency of large scale installations, accessibility to more efficiency techniques, reduced raw material purchasing costs, revenues from by-product exchanges, reduced waste management costs, reduced maintenance costs, reduced taxes related to greenhouse gas emissions and access to subsidies. Industrial symbiosis represents a significant opportunity especially in boundaries characterized by industrial districts (ID), since clusters of firms present heterogeneous service requirements and geographical proximity, leading to a greater scope of interventions. In Italy, for example, there are several companies that have realized programs of synergies and internal collaboration: e.g. [8] presents the case of the ID of Manzano (Udine), known also as "the triangle of the chair", which constitutes one of the major reality of the regional economy.

The concept of industrial symbiosis has been firstly introduced by Chertow in 2000, [1]. Afterwards, the term has become widely used and has gradually developed into a research domain of the industrial ecology. Reference [9] presents a recent bibliometric and network analysis describing the evolution of industrial symbiosis research. It illustrates that in the first period (1997–2005), the research was mainly about the concept of IS, the assessment of eco-industrial park projects, and the establishment of networks for waste treatment and recycling; while, in the second period (2006–2012), different research approaches and theories enriched the field, evolving from practice-oriented research toward coherent theory building. However, most of the works are still focused on specific case application such as the analyses of the district of Kalundborg in Denmark [10] and the National Industrial Symbiosis Program (NISP) in the UK [11]. Other relevant case studies include: [7] which conceptualizes the relationship between agglomerated economies and industrial symbiosis, finding that many negative environmental externalities can be reduced while increasing production efficiency in four industrial regions of Puerto Rico; [12] proposes an optimization model and a case study to evaluate the economic benefits of industrial symbiosis in the forest industry; [13] aims to develop a conceptual framework to embrace integration and identifies opportunities for companies to jointly work, considering the case of a large UK distributor; [14] presents the results of a research project which studies the potential of synergies in the Taranto industrial district; [15] analyses the existing opportunities for small and medium sized enterprises grouped in industrial areas or parks for systemic eco-innovation in the region of Cantabria; [16] studies the physical flows of materials and energy in a local forest industry in Finland using a systems approach; [17] demonstrates the benefits introduced through "green practices" in the aluminium supply chain management, proposing a model that evaluates economic and environmental effects of substituting the traditional supply strategy through solid ingots with the supply in molten state. From the best knowledge of the authors, industrial symbiosis is becoming more