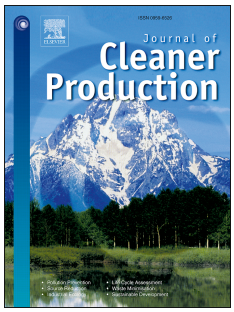
Accepted Manuscript



A methodological framework for Eco-Industrial Park design and optimization

E. Kuznetsova, E. Zio

PII: S0959-6526(16)30085-3

DOI: 10.1016/j.jclepro.2016.03.025

Reference: JCLP 6874

To appear in: *Journal of Cleaner Production*

Received Date: 15 September 2015

Revised Date: 17 February 2016

Accepted Date: 5 March 2016

Please cite this article as: Kuznetsova E, Zio E, A methodological framework for Eco-Industrial Park design and optimization, *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2016.03.025.

Manuscript contains **13763 words**

A methodological framework for Eco-Industrial Park design and optimization

E. Kuznetsova[1] **& E. Zio**[1,2]

[1] *Chair on Systems Science and the Energetic Challenge, Fondation EDF, CentraleSupélec, Université Paris-Saclay, Grande Voie des Vignes, 92290 Chatenay-Malabry, France*

[2] *Dipartimento di Energia, Politecnico di Milano, Milano, Italy*

Abstract

An Eco-Industrial Park (EIP) is composed of a number of Industrial Symbiosis (IS) instances, which allow energy/material exchanges among the different industrial enterprises (Individual Actors, IA) therein. By so doing, IA's economic and environmental performances can be improved. Despite recent methodological advancements, the existing approaches to EIP design optimization are still suffering from several major problems: (i) dominance of the global EIP optimum over the local IA optimum, (ii) limited number of optimization objectives falling into the categories of economic and environmental objectives and (iii) EIP optimization performed without considering possible operational uncertainties. In addition, the adoption of the bio-inspired concept of IS makes EIP evolve from classical engineered systems towards complex engineered systems, with associated static and dynamic complexity characteristics.

To highlight and understand the complexity features of EIP, in this paper we present them as intelligent networks for multiple energy and material exchanges, drawing a parallel with another typical complex system, that of the electric power network, in its modern Smart Grid (SG) concept, conceived to improve and optimize the distribution and use of electrical energy.

Then, the modelling and optimization framework proposed in this paper adopts a more systematic methodology for accounting of the EIP complexity characteristics and addressing the associated optimization challenges. The proposed approach allows ensuring a sustainable and robust EIP design, thanks to the due account given to the related uncertainties and risks, e.g., due to major changes in the regulatory context and IA operational strategies, failures of interconnections among IA, interruption or shutdown of IA operation.

Keywords: Circular Economy, Eco-industrial Park, Industrial Symbiosis, industrial interconnected system, complex system, modelling and optimization under uncertainty.

1. Introduction

Industry requires and consumes considerable amounts of energy and materials for transformation of raw materials into end products. It accounts for much of energy consumption (200 quadrillion British thermal units (Btu) or about 38% of the total energy consumption in 2010 (EIA 2013)). Due to the increase of production capacities in existing plants and the installation of new industrial units, this energy consumption continues to rise together with industrial emissions. These latter are typically quantified in terms of GHG emissions, and an increase of 30% has been observed between 2000 and 2010 (IPCC 2014). Utilization of natural resources, like water, is also significant in the industrial sector, with world consumption estimated to rise of 22% by 2025 (UN 2003).