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Bringing together Environmental Informatics and Industrial Ecology − The role of ICT in industrial symbiosis projects

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1. Introduction

Environmental Informatics and Industrial Ecology are two emerging fields of research striving for sustainability. The object of Environmental Informatics is to analyze information processing, support information management and develop information systems related to the environment in its broadest sense while using methods, techniques, and tools of computer science, thereby – it is hoped – contributing to environmental protection (Page et al. 1990a, 1990b; Page and Hilty 1995; Rautenstrauch and Patig 2001; Marx Gómez et al. 2009) and finally to a more sustainable future (Hilty and Gilgen 2001; Dompke et al. 2004; Hilty et al. 2005; Hilty 2008; Isenmann 2008a).

The object of Industrial Ecology is to study industrial systems and their fundamental linkage with natural ecosystems, with the aim to approach a more sustainable future (Isenmann and von Hauff 2007). According to White (1994) the focus of Industrial Ecology is „the study of the flows of materials and energy in industrial and consumer activities, of the effects of this flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use and transformation of resources“.

As Industrial Ecology takes a systemic approach and goes beyond the borders of single companies or other economic entities, a key issue right from the inception of the field is to build so-called industrial symbiosis projects. Industrial symbiosis stands for a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products. The keys are collaboration and synergistic possibilities offered by geographic proximity (Chertow 2000, 2007). Hence industrial symbiosis could be described as a certain type of eco-industrial development, open for economic entities from different sectors while using the entities' diversity within the industrial system in a productive manner.

2. Similarities in Environmental Informatics and Industrial Ecology

Almost three decades ago, Environmental Informatics (Pillmann et al. 2006) and Industrial Ecology (Erkmann 2007) were launched. In the early 1980s, the fields have started single attempts, and they have become a somewhat fuzzy movement, first: Environmental Informatics as a part in applied informatics (Page and Hilty 1995), while Industrial Ecology has its early focus in an engineering/technological- and resource/industry-focused bipolar view (Ayres and Ayres 1996).

Despite differences in history and early movements in detail, the number of similarities is obvious (Isenmann 2008b, 2008c): Both fields share the same goal, and both have reached a level of academic culture so that they are promising branches within "sustainability sciences". The two fields have their intellectual heritage today in professional international societies. Further, both provide numerous tools, studies, publications, resources and other characteristics that may make them a "discipline" – at least to a certain degree. Hence scientific profiles and constitutive characteristics may share common features. An indicator that there are actually overlapping areas is the current re-launch in 2007: The technical committee "Environmental Informatics" has formally broadened its scope, moving away from a solely environmental focus now also addressing sustainable development and risk management in its community headline. This development is mirrored in the new term of the expert group as "Environ-

mental Informatics – Informatics for Environmental Protection, Sustainable Development and Risk Management" (http://www.iai.fzk.de/Fachgruppe/GI/index.html).

3. The role of ICT in industrial symbiosis projects: Insights from eight different European countries

The goal of this expert workshop is to investigate and describe how Environmental Informatics could be brought together with Industrial Ecology, particularly to advance the use of environmental ICT applications and software tools for industrial symbiosis projects.

According to that goal, eight papers shed light on promising movements. They deliver forward-looking concepts, promising environmental ICT applications, latest software tools, and best practice examples in industrial symbiosis projects, while describing ways to fruitfully link Environmental Informatics and Industrial Ecology.

- As a starting point for discussion, Boons reflects on generic ways ICT applications intersect with the development of industrial symbiosis projects. Based on conceptual considerations, he presents four types of governance mechanisms for industrial symbiosis projects and their corresponding relationships to ICT. In order to exploit the potential of ICT, first the governance type that best suits an industrial system needs to be defined. Only then a certain ICT infrastructure should be established and specific ICT applications could provide their potential.
- Isenmann and Chernykh provide an overview on environmental ICT applications for eco-industrial development: First, they present a classification framework on how environmental ICT applications for eco industrial development could be clustered, from a technical (Environmental Informatics) and managerial (industrial symbiosis) perspective. Second, they analyze the current state of using ICT in industrial symbiosis projects, beginning to build an inventory of industrial symbiosis projects in Europe.
- Jacobsen discusses the importance of inter-organizational information availability in facilitating industrial symbiosis projects. Further to techno-economical and environmental factors often highlighted as central for implementations, he especially emphasises the role of ICT and accompanying social factors when organizing industrial symbiosis input-output matches. He illustrates conceptual considerations by personal experiences from the Kalundborg industrial symbiosis and other current projects involved.
- Recycling networks − a certain type of industrial symbiosis projects − are in the focus of Perl. She investigates the application of environmental management information systems (EMIS) and identifies barriers and obstacles why EMIS have merely been implemented to a certain degree, so far. Overcoming this status nascendi, she proposes recommendations for better inter-organisational exchange of environmental information. These recommendations are illustrated through experiences of the eco-industrial cluster Mödling, Austria, in a case study.
- Gibbs opens industrial symbiosis projects to a broader scope. He provides first-hand insights of UK's National Industrial Symbiosis Programme (NISP), the national level scheme to promote industrial symbiosis in the UK. In addition to training companies to 'think symbiotically' and providing technical assistance, he describes an ICT-mediated database that NISP utilizes to collect information on material and energy flows, finally approaching to a circular economy with reduced natural resources, waste transformation into firm inputs and energy cascades.
- Further to UK's NISP, Brullot adds the French perspective. She gives an overview of industrial ecology applications in France, including a list of past and present industrial symbiosis projects. Though she finds that the degree of implementing industrial symbiosis seems to be at an early stage yet, the potential for eco-industrial development is high. In order to exploit this potential the "Comethe" project was launched: In seven pilot areas more than 30 public actors and 1000 companies are involved. The software tool Presteo® facilitates the collection of input and output data and the identification of synergies through exchange.
- As an example of linking environmental informatics and industrial ecology through a sophisticated ICT application, Fernandez and Ruiz describe the development of a decision support system (DSS) based on a geographic information system (GIS) for spatial, territorial, and ur-

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ban planning purposes. This GIS-based DSS provides digital maps and indicates how different zones could be used for establishing industrial symbiosis projects. In order to increase the usability and decrease the complexity of the DSS, stakeholders have been involved, taking into account their simple evaluation routines.

- Last not least, and similar to the idea presented by Fernandez and Ruiz, Massard and Erkman draw the attention to a promising ICT application for industrial symbiosis projects, being used in the state and republic of Geneva, Switzerland. They illustrate the development of a web-based geographic information system (web-GIS). This web-GIS offers support for engineers and urban planners as it allows: the detection and visualization of potential exchanges, the evaluation of technical and geographical feasibility, the identification of new partners, and the discovery of further locations based on material flow considerations.

4. Conclusion and outlook

The insights presented in this expert workshop help to explore the role of ICT in industrial symbiosis projects, especially:

- how software tools in particular could be further developed from isolated environmental ICT applications and standalone environmental management information systems (EMIS) in single companies to an integral ICT infrastructure of industrial symbiosis projects enabling inter-organisational exchange of environmental information, and
- how to take into account and then implement the certain requirements and specific needs of actors involved in long-term eco-industrial developments.

On the one hand, the concepts, tools, and case studies included here are illustrating considerable efforts which actors on different levels have undertaken since Environmental Informatics and Industrial Ecology became prominent three decades ago. Closely linked to the increasing relevance of latest software tools in industrial symbiosis projects in particular, on the other hand, it becomes clear that a lot of work needs to be done to actually run ICT in a productive manner while exploiting its potential to its fully extent.

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