



Regional industrial ecology: examples from regional economic systems of forest industry and energy supply in Finland

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Industrial ecology (IE) promotes the development of industrial systems based on recycling of matter and cascading of energy through cooperation. In this paper, the local/regional industrial ecosystem approach is reflected in two examples from Finland. The local forest industry system is based on renewable resources, waste materials and energy utilisation between forestry companies, a saw-mill, a pulp mill, a paper mill and a forest industry power plant. Waste energy from electricity production is used for production of heat and process steam. Regional city energy supply systems in Finland are also to a large extent arranged around power plants that utilise waste energy. The potential of combining the forest industry system with the energy supply systems of cities is considered and the conditions for success in the Finnish case are discussed.

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Introduction

This paper focuses on the emerging practice of industrial ecology (IE), a concept introduced in 1989 in a *Scientific American* article by Frosch and Gallopoulos (1989). IE is derived from industrial environmental management, and is based on a provocative ecosystem analogy of *roundput* or recycling systems. In ecosystems, waste equals food and energy is cascaded in the food chain, while the only input to the system is solar energy. Therefore, the purpose of IE is to consider the potential of facilitating the emergence of industrial systems, where the actors involved cooperate by using each other's waste material and waste (residual) energy flows.

The few case studies that exist have been in a regional context. A local/regional network of companies can in theory provide the IE concept with a fruitful testing ground. Also public organisations

and consumers could be studied as parts of such a network. The aim is to keep as much as possible of the product's life cycle within regional boundaries, to reduce the consumption of energy and improve the capacity of the actors to monitor and manage it. In this paper, experiences from Finland are illustrated with case studies from forest industry and the household energy supply of a Finnish city. The paper concludes with a scenario for future development of IE and considers some conditions of success in the Finnish example, or the extent to which these examples can be considered successful.

Regional industrial ecosystems

The most frequently cited working model of an industrial ecosystem is in Kalundborg, Denmark (Ehrenfeld and Gertler, 1997), where, according to many researchers, the industrial actors have created an economic-environment win-win situation (for discussion on win-win, see Porter and van der

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Linde, 1996; Walley and Whitehead, 1996) by utilising each other's waste material and energy flows. The vision of the local/regional industrial ecosystem analogy is presented in Figure 1. A group of industrial actors are located in close physical proximity to each other. Corresponding to a local ecosystem, the system's operation and sustainability is based on waste material and waste energy utilisation (recycling of matter, cascading of energy) between the actors. When successful, the environmental 'win' arises through reducing the system's material and energy input as well as the waste and emission output. In theory, recycling can reduce both. The economic 'win' arises from reduction of raw material and energy costs, or costs that result from the implementation of measures required by environmental legislation. The 'image costs' and waste management costs can also be reduced and the potential for green marketing can also be realised in this scenario.

The regional industrial ecosystem thesis is still in its initial stages and the definitions vary. According to Ayres and Ayres (1996), 'The industrial analog of an ecosystem is an industrial park (or some larger region) which captures and recycles all physical materials internally, consuming only energy from outside the system, and producing only non-material services for sale to consumers. This vision is highly idealised, of course.' A regional industrial ecosystem can be defined as an eco-industrial park. Cote (1998) describes an

eco-industrial park as a 'community of manufacturing and service companies seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. . . Through collaboration, this community of companies becomes an industrial ecosystem' (Research Triangle Institute and Indigo Development, 1996; Cote, 1998:9–11; Baas, 1998). The United States President's Council on Sustainable Development considered an eco-industrial park to be 'an industrial system of planned materials and energy exchanges that seeks to minimise energy and raw materials use, minimise waste, and build sustainable economic, ecological and social relationships.' (President's Council on Sustainable Development, 1996).

The local/regional context suits the ecosystem analogy. Here the actors involved may have the necessary motivation for cooperation. Mutual and common interests may emerge regarding the economic and environmental issues of the region. As noted above, in an ideal situation, regional industrial ecology can benefit the local economy. Reduction of transportation, the benefits of cooperation and the exchange of information, tacit knowledge and the opportunities for innovation in regional systems where firms are situated close to one another are issues that have been frequently discussed in the literature on regional economics. Cooperation may be easier in a regional or local

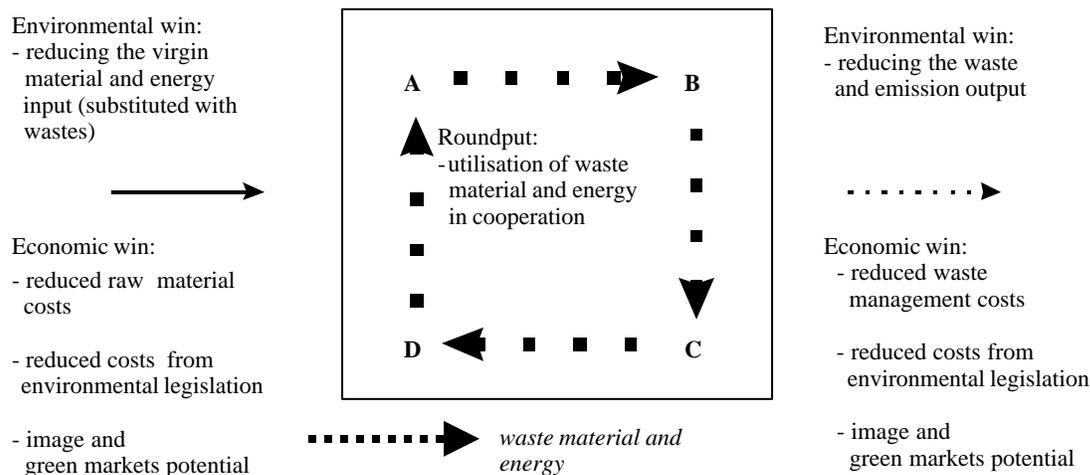


Figure 1. The basic local/regional industrial ecosystem analogy. Industrial systems are encouraged to move towards an interactive local system based on the system model of ecosystems, i.e. a *roundput* system. Through co-operative waste material and waste energy utilization between the local industrial actors A, B, C and D, the virgin material and energy input as well as the waste and emission output of the system are reduced (virgin resources are substituted with wastes derived from within the system). By reducing the waste management costs, raw material and energy costs, costs resulting from environmental legislation and by improving the environmental image as well as the green markets potential of the system, economic gains are possible. The benefits of successful regional IE may also include new economic opportunities that arise through increasing cooperation that this approach can create.

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