

## *Part V: Exercises for Executive Education and Classroom Use*

### **Eco-Industrial Development Primer**

Robert J. Klee

M.E.S., Yale School of Forestry & Environmental Studies, 1999

#### **ABSTRACT**

What follows is a sample class exercise on Industrial Ecosystems created for the Yale School of Forestry & Environmental Studies *Corporate Environmental Leadership Seminar*. The Seminar is for senior environmental managers from the private and public sectors. This sample can be used as a template for teaching eco-industrial development concepts in industrial regions around the world (for example see *Hedges*, this volume).

#### **INTRODUCTION**

Industrial ecology, the marriage of ecology and technology, views industrial systems in concert with their surroundings, not in isolation from them. Industrial ecology studies the flow of energy and materials through various systems, thus bringing together environmental sciences, engineering, management and policy. The eco-industrial development concept – derived from the field of industrial ecology – is broadly based on the idea that one company’s wastes can become another company’s raw materials.

This primer serves as a background document to assist you in the Eco-Industrial Development Exercise.

#### **BACKGROUND ON ECO-INDUSTRIAL DEVELOPMENT**

A few key terms and principles should be defined at the outset to give a better understanding of eco-industrial development:

- **Industrial symbiosis** is one form of eco-industrial collaboration between traditionally separate industries in the industrial ecosystem. As in biological symbiotic relationships in nature, at least two willing participants exchange materials, energy, or information in a mutually beneficial manner. In industry these materials would most likely otherwise go to “waste.”
- **Waste exchange (or “green twinning”)** is the least complex form of industrial symbiosis. Generally, this occurs when two companies exchange materials based on mutual economic benefit. Waste exchange may be a one-time, informal arrangement or a long-term, formal contractual agreement. Two companies need not be closely located, and in some cases a third party may act as a broker or facilitator of the exchange.
- **Eco-industrial parks (EIPs)** are more complex forms of industrial symbiosis. An EIP is best defined as a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues. At the heart of the EIP concept is this exchange of

materials where one facility's waste (energy, water, materials, or "information") is another facility's input. By working together, the community of businesses seek a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only. Not to be overlooked are the social benefits that follow from EIP development, including fostering a sense of community among businesses and surrounding neighborhoods. Industries participating in an EIP can be located within the confines of a traditional industrial park, or can be connected "virtually" in a regional network. It is our belief that the benefits of an EIP can be expanded to encompass an entire regional economic community in which the potential for the identification of beneficial feedstock and waste trades is greatly increased.

- **Environmental benefits** are realized in eco-industrial development through:
  - reduced energy consumption and increased efficiency from energy cascading, co-generation, and utilization of waste heat from industrial processes
  - reduced water consumption and increased water use efficiency from closed-loop water use and gray water recycling
  - waste minimization from internal cycling of materials where residues from one process or industry are re-sold as feedstocks to other industries
  - reduced total environmental costs from virgin mineral extraction, including extraction, smelting, processing, forming, and transporting, when recycled materials from within the eco-industrial system are reused
  - brownfield redevelopment, whereby eco-industrial developments are located in existing industrial areas and help facilitate a co-location and linking of businesses instead of the current trend of greenfield expansion and dispersion of industrial sites
- **Economic benefits** flow from these environmental benefits, realized in costs avoided for waste disposal, reductions in raw material purchases, and from shared/centralized materials management services. As a brief hypothetical example of such accounting, imagine that an industrial firm produces 10 tons of organic waste per month that it pays \$500 to dump. A nearby nursery spends \$500 per month to purchase similar organic material. If these two firms were matched, they might agree to trade the waste, splitting the cost of transportation (perhaps \$100 each). Each month then the industrial firm saves \$400, the nursery saves \$400, 10 tons of residues are recycled, and as much as 10 tons of virgin materials are saved. Eco-industrial development provides a fresh, new

approach to economic development by seeking business not on the basis of a promotional campaign, but by pointing out true economic opportunities where feedstocks may exist at reduced costs, and where materials formerly discarded as wastes have value.

### INDUSTRIAL SYMBIOSIS AT KALUNDBORG, DENMARK

The archetype for eco-industrial development occurs in the small town of Kalundborg, Denmark. This well-documented example has developed over 30 years between large and small industrial firms in the social community of Kalundborg. Participants realized economic and environmental benefits through their agreements, without becoming cognizant of the fascinating network they had created until much later. Figure 1 below outlines the major flows of materials and energy that drive the industrial symbiosis at Kalundborg.

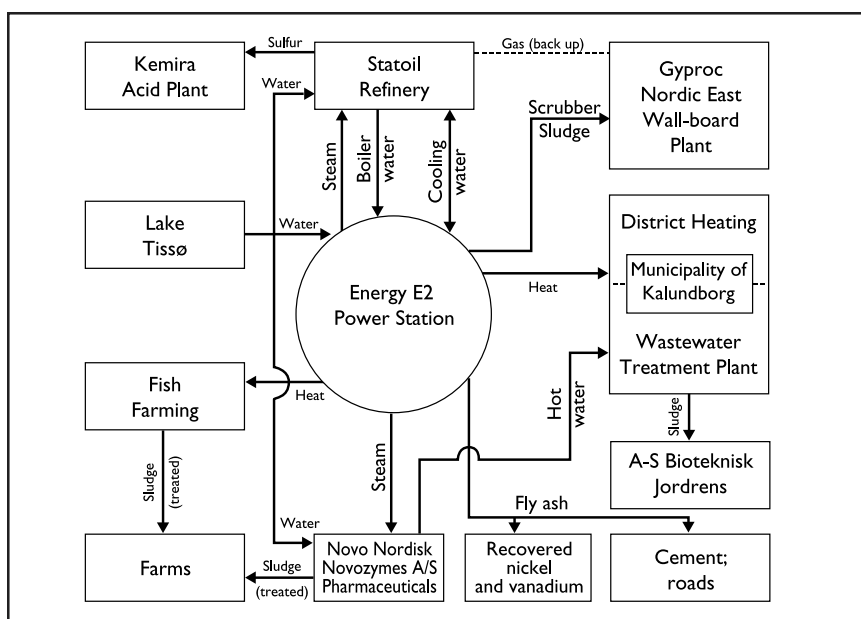


Figure 1 Industrial symbiosis at Kalundborg, Denmark

Kalundborg's industrial network behaves very much like an ecological food web, where industrial organisms consume each other's waste materials and energy, forming bonds of interdependence. The Kalundborg eco-industrial system includes six core partners: the 1,500 megawatt Energy E2 Power Station, the Statoil Refinery, the Gyproc plasterboard manufacturer, the Novo Nordisk/Novozymes pharmaceutical company, Bioteknisk Jordrens and the City of Kalundborg. The power station provides waste steam heat to the 20,000 residents of Kalundborg (for home heating) and to Novo and the Statoil oil refinery for their industrial processes. The major facilities use freshwater from Lake Tissø for cooling and have established wastewater networks, as well.

A small portion of the surplus-heated water was transferred to nearby aquaculture fishponds. A cement company utilizes the desulfurized fly ash from the power plant. The power plant reacts the SO<sub>2</sub> in the stack gas with calcium carbonate to produce calcium sulfate (gypsum) which is in turn sold to Gyproc. Historically, the refinery has provided excess gas (that otherwise would be flared off) to Gyproc as a low-cost alternative fuel source; however, this exchange has recently stopped. The refinery's desulfurization operation produces a product used in liquid fertilizer. Sludge from the fermenting and other biological processes at Novo and from the fish farms are used as soil enhancers in nearby farms. Local farmers use surplus yeast from the insulin production as pig food. The "community" nature of the eco-industrial park system is a key element in its growth and longevity.

## ADDITIONAL READING AND USEFUL WEB SITES FOR FUTURE REFERENCE

### Research Papers

- Allen, D., and N. Behmanish. 1994. Wastes as raw materials. *The Greening of Industrial Ecosystems*. Washington, D.C.: National Academy Press, pp. 69-89.
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- Gertler, N., and J.R. Ehrenfeld. 1996. A down-to-earth approach to clean production. *Technology Review*, 99(2): 48-54.
- Hawken, P. 1993. Creation of Waste. Chapter 3 in *The Ecology of Commerce*, New York: Harper Business, pp. 37-56.
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- Porter, M.E., and C. van der Linde. 1995. Green and competitive: Ending the stalemate. *Harvard Business Review*, 73(5): 120-134.

### Web Sites

- Cornell Work and Environment Initiative Eco-Industrial Development Page  
<http://www.cfe.cornell.edu/wei/EIDP/eid.html>
- Indigo Development EcoPark Page  
<http://www.indigodev.com/Ecoparks.html>
- Research Triangle Institute - Eco-Industrial Park Page  
<http://www.rti.org/units/ssid/cer/parks.cfm>