Industrial Ecology

Environmental and Economic Boon

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Illustration by Kirk Lyttle

Industrial pollution often affects low-income neighborhoods disproportionately. But a well-established development in Denmark points to a long-term solution that in time could benefit neighborhoods located near industry.

Kalundborg, Denmark, boasts an unusual industrial park that has grown up over 35 years. In an approach known as *industrial ecology*, its factories use the by-products of neighboring factories as raw materials. The first exchanges between Kalundborg plants were initiated to conserve water from scarce local sources. Some years later the local wallboard plant began to use by-product gas from the nearby oil refinery to heat its drying kilns. Bit by bit, more such exchanges were added.

Although environmental regulations created indirect incentives, no direct public subsidies or other interventions played any part. The industrial park grew quietly for decades, with the world at large hardly noticing. After about 20 years, the community woke up and began to promote the remarkable development, which epitomizes ideas about industrial ecology that were forming simultaneously elsewhere.

Production, Consumption, Pollution

Industrial ecology is not a familiar concept to Americans. The field emerged in the late 1980s, catalyzed by Robert Frosch and Nicholas Gallopoulos in a *Scientific American* article. The authors observed that energy and materials flows in industrial networks resembled flows in the food webs of natural ecosystems.[1] But natural ecosystems were doing better than human systems at recycling wastes and getting the most out of their primary energy source, the sun. Nature was providing a lesson.

Historically, industrial networks have operated primarily in "once-through" mode. That is, materials are extracted from the earth, converted into economically useful products, and then discarded back into landfills, air, and water: They go once through the process, and that's it. Superfund sites in New England and elsewhere are a direct consequence of once-through practices.

The unsustainable aspects of today's industry are closely related to massive levels of consumption in both affluent and developing nations, and scholars and critics have long called for drastic reductions. Contemporary heirs of the 19th century political economist Thomas Malthus (who worried about population growth outstripping growth in agricultural productivity) see a relationship between affluence and environmental sustainability.[2] They express that relationship in a formula, I = PAT. *I* is a measure of the stress on the global support system, and it equals *population* times *affluence* (gross domestic product per capita, roughly proportional to consumption) times *T*, which is a measure of the relative impact per GDP unit.

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Because population and affluence are bound to grow for some time, impact must decrease proportionally. Estimates of the amount of material reduction necessary to keep current environmental-stress levels from rising run from a factor of two to a factor of 50. In other words, given population increases and the concomitant stress on the environment, we have to decrease current consumption (and/or negative impact) by two to 50 times in order not to increase stress. We have to run two to 50 times faster just to stay in place.[3]

Industrial ecology offers hope for reversing current trends.

A New Dawn

Industrial ecology makes a twofold contribution to environmental sustainability. First, it improves understanding of material flows and how they impact the environmental system. Second, it offers ways to redesign products, services, and production methods. It can reduce stress at every industrial stage: resource extraction, production, use, and disposal.

Applying the industrial-ecology principle to product and production redesign reduces environmental impact and leads to more efficient use of materials and energy. Greater efficiency, in turn, helps both individual companies and whole economies grow.

To apply this simple but elegant principle regionally, look to nature. Natural ecosystem networks and their food webs have large numbers of symbiotic relationships. One species passes its wastes to another as its food. In Kalundborg, similar symbioses are occurring, with one company making good use of the wastes of another.

In fact, a visit to Kalundborg would reveal a large industrial complex with no significant waste lagoons or disposal sites. What might previously have been deposited in such catchments is instead passed along for reuse. For example, the calcium-based sulfur dioxide scrubber effluent from a large oil-fired power plant is piped to a wallboard plant, which now saves on imported hydrated calcium sulfate, the gypsum used in drywall. The biomass effluent from a large pharmaceutical plant is treated sufficiently to be piped or trucked to farmers in the immediate region and used as fertilizer. Waste heat from several plants' hot water and steam is combined and piped to the municipality for commercial and domestic heating.

Growing Urgency

Although Kalundborg grew in an unplanned fashion over decades, today there is a more focused urgency about implementing its symbiotic principles. Industrial ecologists are studying the best ways to develop similar complexes and are working more actively to get them going.

According to the late Edward Cohen-Rosenthal, of the Work and Environment Initiative at Cornell, eco-industrial development (EID) should be viewed not only as promoting sustainability but also as a potential source of good jobs.[4] As he anticipated, attitudes toward waste handling,

traditionally an undesirable trade with low wages and uncertain security, have been changing. More people are realizing that recycled wastes have value to industry and agriculture and that keeping wastes out of the environment has a value to communities.

Eco-industrial development could lead to regional economic development. Existing enterprises could save money, as wastes are expensive to haul. New sectors with new jobs could be created. For example, eco-industrial development would be a good use for former Superfund sites and brownfields, which tend to be located in older industrial zones amid low-income neighborhoods that might welcome a more sustainable use. This is not a question of poor neighborhoods getting manufacturing plants no one else wants but of providing completely clean industries with good jobs.

Unfortunately, eco-industrial development is moving slowly in North America. The President's Council for Sustainable Development under President Clinton put together an initiative to develop eco-parks, but it essentially went nowhere.[5] Today, interest has increased in Canada, where EID is a central theme of Burnside, a large industrial complex (1,300 companies) in New Brunswick.[6] Additionally, several small networks centered on the pharmaceutical industry are coming to life in Puerto Rico.[7]

Public Role

High discovery costs—finding partners that have wastes suitable for exchange—are stumbling blocks in the eco-industrial development process. Additionally, constraints and liabilities imposed by hazardous-waste regulations, even if not technically problematic, tend to scare companies away. Moreover, all the success stories have taken a long time to flower, suggesting that patience is essential, and patience is not a typical characteristic of industrial developers.

The impediments point to a possible role for public agencies. For example, government could consider supporting information exchange to lower the discovery costs, it could offer innovative regulatory waivers, or it could create sources of low-cost capital earmarked for EID. The British government set the example recently with a £13 million grant for the development of the National Industrial Symbiosis Program.[8]

Eco-industrial development's potential should spur the private and public sectors to find ways to create partnerships among industries. However, as the Conservation Law Foundation has found, leaving the job primarily to developers' initiatives does not work well, because neighbors often resist plans that have been formulated without their input.[9] It is critical for communities that have suffered from past industrial problems like pollution to get involved early in the process.

Deeply rooted social and political concerns sometimes bring promising brownfield-development processes grinding to a halt. Suspicion about any industrial development, even projects with sustainability objectives, runs deep. Community members need to educate themselves about eco-industrial development and the significant economic and environmental benefits.

Understanding industrial ecology's potential can begin with the recognition that a system in which nothing is wasted already exists, and that system is nature.

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Endnotes

1 R. Frosch and N. Gallopoulos, "Strategies for Manufacturing," *Scientific American* 261 (1989): 142-55.

2 P.R Ehrlich, and J.P. Holdren, "Impact of Population Growth," *Science* 171 (1971): 1212-1217.

3 E. Von Weizsäcker, A.B. Lovins, et al., *Factor Four: Doubling Wealth: Halving Resource Use* (London: Earthscan Publications, Ltd., 1997).

4 E. Cohen-Rosenthal, "What Is Eco-industrial Development?" in *Eco-industrial Strategies: Unleashing Synergy between Economic Development and the Environment*, eds. E. Cohen-Rosenthal and J. Musnikov (Sheffield, United Kingdom: Greenleaf Publishing, 2003).

5 http://pubs.acs.org/subscribe/journals/esthag-w/2005/jul/business/kb_ecology.html.

6 http://www.uneptie.org/pc/ind-estates/casestudies/Burnside.htm.

7 M.R. Chertow and D.R. Lombardi, "Quantifying Economic and Environmental Benefits of Co-Located Firms," *Environmental Science & Technology* 39, no. 17 (2005): 6535-6541.

8 See http://www.alfed.org/publishor/system/component_view.asp?LogDocId=40644&PhyDocId=33243.

9 James Hamilton, personal communication, June 13, 2006.

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