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Industrial Ecology: From Theory To Practice

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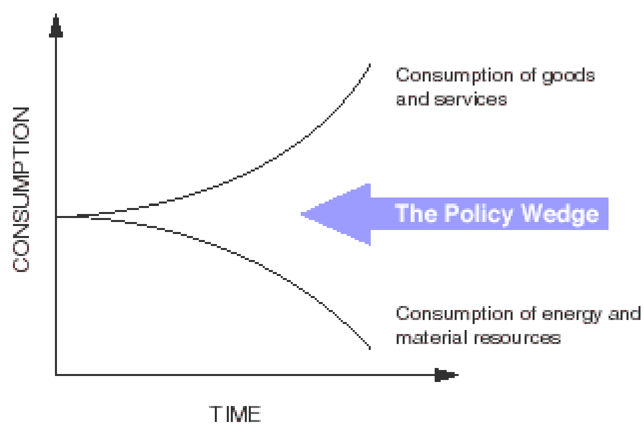
Introduction

A considerable amount of international debate about the meaning of sustainable development and how it can be applied continues as we approach the 10th anniversary of the Rio Summit. Much of this debate has begun to centre on minimum resource use, efficiency requirements, or sustainable production. With a rising global population and ever increasing levels of consumption among developed and developing countries, pressure on the earth's many ecosystems and the biosphere as a whole, promises to continue to mount well into the foreseeable future. Even many optimists - those who are convinced that technology will resolve most of our impending resource shortages - are beginning to recognize that there is a need for significant increases in the efficiency of resource use in developed countries in order to accommodate the rising consumption and production in developing countries.

Increasing levels of consumption at the limits of the biosphere's capacity to provide resources will require dramatic improvements in resource use efficiency. Substantial reductions in the amount of resource throughput per unit of output is referred to as *dematerialization*.

Figure 1: `Dematerializing' the Economy



At the limits to material throughput, sustainability requires that the growth in the consumption of goods and services be accompanied by a proportional decline in the energy and material intensity of that consumption.

(Source: William Rees, "Achieving Sustainability: Reform or Transformation" in *The Journal of Planning Literature*, 9. no. 4 (1995): 343-361; adapted from David Pearce, "Sustainable Consumption Through

Economic Instruments," *Norway Symposium on Sustainable Consumption*. Oslo: January 1994.)

Leading edge research is currently being undertaken to explore various strategies which will allow us to reduce the energy and material intensity of the global economy. Germany's *Wuppertal Institute*, for example, is currently studying the policy implications of reducing the material and energy throughput of developed economies. They estimate that the material intensity of developed economies should be reduced by a factor of 10. Their focus is mainly on the use of policy tools such as ecological tax reform.

The *World Business Council for Sustainable Development*- an organization representing over 50 large multinational corporations - held a workshop on the parameters of an 'eco-efficient' economy and concluded:

Industrialized world reductions in material throughput and energy use of over 90 percent will be required by 2040 to meet the needs of a growing world population fairly within the planet's ecological means (N. Robins, *Report on the BCSD: First Antwerp Eco-Efficiency Workshop*. London: International Institute for Environment and Development, 1993.)

In practical terms, what this means is that if, for example, you currently drive a car that achieves a fuel efficiency of 100 kilometers per litre, by the year 2040, your new, super light car will achieve 100 kilometers from one tenth of a litre. Reductions of material and energy throughput by factors of 9 and 10 over the next quarter century are not as farfetched as they may at first seem. Japan, for example, reduced the energy and material inputs for its manufacturing sector by 40 percent between 1973 and 1984, at a time of considerable economic expansion. In North America, there is considerable room for improvement. Manufacturing consultants, Orr and Boss, estimate that the tangible value of the 'wastes' generated by the U.S. manufacturing sector is $400 billion (US) annually.

This illustrates that tremendous opportunities exist for significant reductions in material and energy throughput in the more technological sophisticated developed economies. *Industrial Ecology* is an emerging approach to manufacturing which holds considerable potential to start dematerializing the global economy.

Industrial Ecology - A New Manufacturing Paradigm

One of the more radical approaches to achieving greater levels of material and energy resource use efficiency involves the concept of industrial ecology. 'Industrial ecology' refers to the exchange of materials between different industrial sectors where the 'waste' output of one industry becomes the 'feedstock' of another. For example, the excess steam from an electrical generating facility can be used as a heat source for a nearby chemical manufacturer. The fly ash from a coal fired generating station can be used as an input for the cement industry.

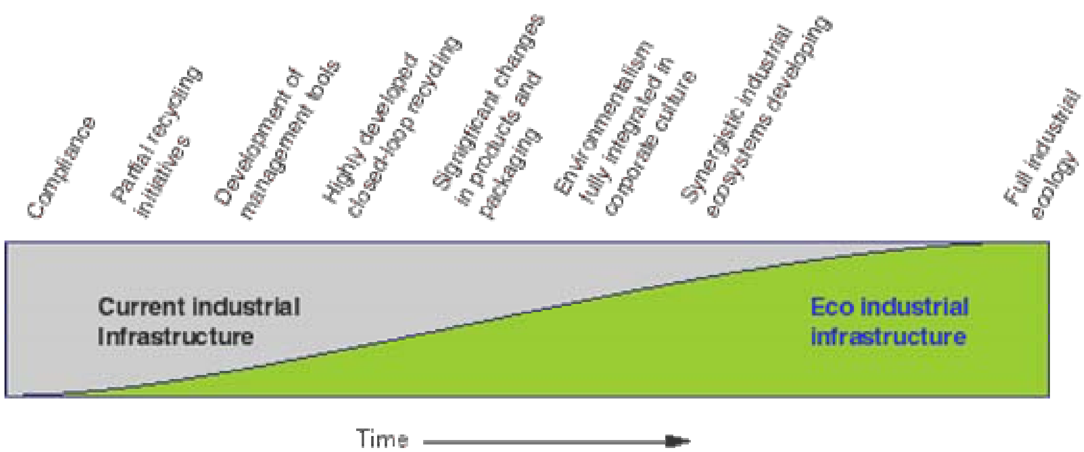
'Industrial ecosystems' refer to situations in which a number of different companies, usually in close proximity to each other, exchange a variety 'waste' outputs. Industrial ecology represents a relatively new and leading edge paradigm for business. It emphasizes the establishment of public policies, technologies and managerial systems which facilitate and promote production in a more co-operative manner.

Implementing industrial ecology involves such things as life cycle analysis, closed loop processing, reusing and recycling, design for environment and waste exchange. Technologies and processes that maximize economic and environmental efficiency are referred to as eco-efficiency.

Natural ecosystems do not generate waste since the wastes produced by one organism form the food source for another. Natural systems do not create an abundance of persistent toxic compounds that cannot be utilized by other organisms in the system. Hypothetically, in a completely efficient economy functioning in harmony with ecosystems, there would be no waste.

Figure 2 illustrates the changing nature of industrialization culminating in full industrial ecology, whereby "all process systems and equipment, and plant and factor design, will eventually be fully compatible with existing industrial ecosystems as a matter of course." (Arthur D. Little, "Industrial Ecology: An Environmental Agenda For Industry," *Industrial Ecology Workshop: Making Business More Competitive*. Toronto: Ministry of Environment and Energy, February 1994.)

Figure 2: The Emergence of an Eco-Industrial



Infrastructure

Source: Arthur D. Little

Environmental Technology Development

In order to move towards an 'eco-industrial infrastructure' significant technological advances will be required. Four generations of environmental technology have been identified by the International Institute for Sustainable Development - remediation, abatement, pollution prevention and sustainable technologies. The latter two types of technology, which are the least developed, have an important role to play in facilitating industrial ecology linkages and helping society move towards industrial systems that achieve the goal of '0 - waste' or 100 percent efficiency. The four types of environmental technologies are briefly described in Table 1.

	Point of Application	Characteristics	Examples
Remediation Technologies	• symptoms • damaged resources or environments	• after the fact • costly • range from low tech to high tech	• soil remediation • toxic site clean-ups • water treatment
Abatement Technologies	• pollutant capture or treatment at end-of-pipe	• captures or treats pollutants before release • consumes capital, energy and resources • generates waste stream • fairly costly	• flue gas desulfurization • sewage treatment plants • catalytic mufflers
Pollution Prevention Technologies	• industrial process design • product design or composition	• changes product or process or reduce or prevent pollution • more cost effective than abatement • reduced waste stream	• chlorine-free paper • cyanide-free electroplating • lead-free gasoline • industrial process design
Sustainable Technologies	• alternate product or service	• multiple benefits: environmental, economic, social, resource efficiency	• efficient lighting • recycled paper • renewable energy • bio-cosmetics and drugs

(Source: Thompson Gow and Associates, *1995 Environmental Scan*. Winnipeg: Canadian Council of Ministers on the Environment, 1995).

The majority of environmental technology firms in Canada manufacture technologies which fall into the remediation and abatement categories. Given the relative infancy of pollution prevention and sustainable technologies, there is tremendous growth potential in these areas. The anticipated annual growth rate of Canada's environmental industry is roughly 6 percent.

Industry Canada estimates that the growth in pollution prevention, also known as cleaner production technologies, will be roughly 30 percent per year. Pollution prevention and sustainable technologies, when combined with industrial ecology concepts, hold the promise of dramatically reducing the amount of 'waste' resulting from industrial production and consumption. Clearly we are capable of dramatic improvements in the efficiency of production, the question is, how do we get there as fast as possible. How do we move from theory to practice?

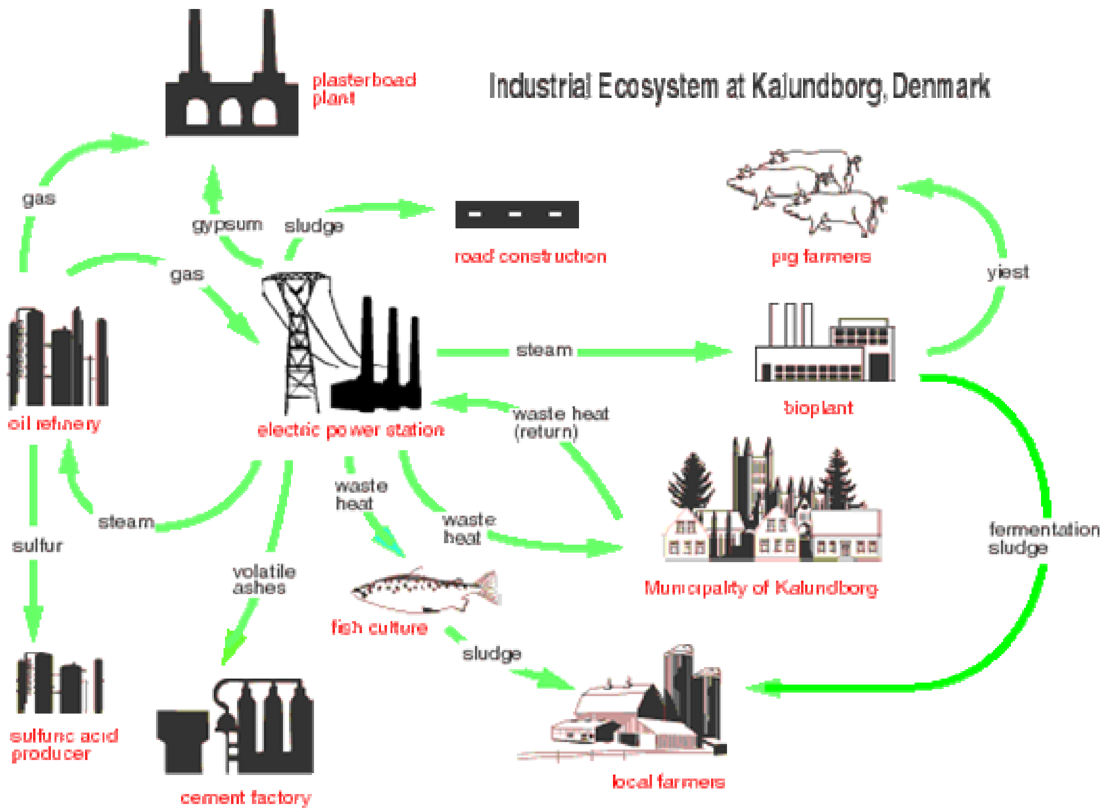
Industrial Ecology In Practice 1

Kalundborg, Denmark

The exchange of 'wastes' between independent firms in some sectors has been taking place for over a century, simply because it makes good business sense. The establishment of 'industrial ecosystems,' however, is a relatively new phenomenon, with the best known example being located in Kalundborg, Denmark. There, an industrial ecosystem has been established which involves an oil refinery, a gyproc factory, a pharmaceutical firm, a fish farm, a coal-fired electrical power station and the municipality of Kalundborg, among others.

At Kalundborg, steam and various raw materials such as sulfur, fly ash and sludge are exchanged in what is the world's most elaborate industrial ecosystem. Participating firms each benefit economically from reduce costs for waste disposal, improved efficiencies of resource use and improved environmental performance. For example, gas captured from the oil refinery which had previously been flared off is now sent to the electrical power station which expects to save the equivalent of 30,000 tonnes of coal a year. Figure 3 is a flow diagram which represents the industrial ecology system at Kalundborg.

Figure 3: Industrial Ecosystem at Kalundborg



Source: *Ecodecision*, Spring 1996: 20

As of the year 2000, Denmark, a clear international leader in promoting sustainable development, has established regulations that require that virtually ail discharges by industries be in the form of products that can serve other useful purposes.

Industrial Ecology In Practice 2

Burnside, Nova Scotia

One of the Canadian pioneers of industrial ecology is Professor Ray Côté of Dalhousie University. He has helped to establish industrial ecology linkages in a large industrial park located in Burnside, Nova Scotia. With Professor Côté's leadership, and support from the federal and provincial governments and other partners, the *Burnside Cleaner Production* Centre was established in the Burnside Industrial Park in Nova Scotia in 1995.

The primary role of the Cleaner Production Centre is to promote and facilitate the 'greening' of the over 1,200 businesses located in Burnside, eastern Canada's largest industrial park. The services the Centre provides include: promoting materials and energy conservation through audits; searching for technologies to improve resource use efficiency for business clients; facilitating packaging waste reduction through waste audits; and identifying and facilitating waste and energy linkages between firms. Industrial ecology relationships will be promoted by the Centre, in part, by the creation of a waste exchange.

The Burnside Cleaner Production Centre is an example of a very practical, 'on the ground' approach to promoting industrial ecology at an existing industrial park. Examples of actual and potential 'symbiotic' relationships in the park include:

- Recycling of corrugated cardboard which is collected by a company located in the park and sent outside for reprocessing into liner board.
- The reuse of a computer company's excess polystyrene by a packaging firm.
- A variety of recycling and reuse firms dealing with toner cartridges, ribbon re-inking, tire re-treading and furniture refurbishing.
- Potential for a silver recovery program for the printing industry (25 printing firms are located in the park) by combining resources to purchase a silver recovery systems.
- Potential for a paint exchange among the 21 firms that either use paint in their processes or distribute paint to customers. Roughly 5038 litters of paint are currently wasted each year with a total value of $52,000. Establishing a "paint swap" program could reduce this waste.
- Potential for a chemical exchange among the 19 firms that either manufacture, distribute or retail chemicals ('Industrial Park As Ecosystem Project,' March 1996. Burnished, NS: Cleaner Production Center)

Industrial Ecology In Practice 3

Portlands Industrial District-Toronto, Ontario

A team of fourth year Environmental Studies students from Innis College, University of Toronto, under the guidance of the course instructor, Ray Tomalty and myself, completed a research project on industrial ecology barriers and opportunities in Toronto's Portland's Industrial District. The research team found that a number of companies were already engaged in industrial ecology linkages and, more importantly, that there were solid opportunities, as in the case of Burnside, for additional waste linkages between firms. Some of the key findings from the report are as follows:

- Companies are reluctant to provide third parties with information about the nature of their inputs and outputs due to confidentiality issues. This makes it difficult to identify potential linkages without winning their confidence.
- There is a lack of knowledge among company owners and managers about the types of businesses located in other areas of the park and the potential linkages that may exist.
- There is a need for mechanisms to promote co-operation and information exchange about the economic benefits that may be derived from industrial ecology.
- Stressing the economic benefits achievable is far more important than appealing to a firm's sense of 'environmental responsibility' when promoting industrial ecology. Economic benefit will help to drive industrial ecology.

The report details a number of existing and potential linkages in the Portland's Industrial District, which derived from a survey of 75 firms and selected interviews. It demonstrates clearly that there are unrealized potential industrial ecology linkages that exist in the Portland's Industrial District, and suggests that such linkages may well exist in most industrial park locations.

Conclusion

The examples of Kalundborg, with its leading edge industrial ecosystem, Burnside and the Portlands Industrial District illustrate different stages in the practical development of industrial ecology linkages in existing industrial parks. An industrial ecosystem has yet to be built from scratch, although there is discussion in the Japan and U.S. about such an endeavour. Cornell University researchers, for example, have estimated that industrial ecosystems - as is the case in nature - generate zero waste, would achieve a relative advantage of at least 30 percent over competing firms with no such linkages.

Establishing such sites will of course, present an entirely new spectrum of challenges. In the shorter term, practical techniques, as are being applied in Burnside and were identified in the students' recommendations in the Portlands report - which gradually move firms towards more integrated relationships - represent important first steps on the road to more sustainable industrial production.

Industrial ecology and the development of technologies which eliminate waste and maximize efficiency will be critical to achieving the required reductions in material and energy throughput in order to maintain a basic quality of life into the twenty-first century. The extent to which these measures make economic as well as ecological sense - i.e. are 'eco-efficient' - will determine whether market forces play a role as an important driver of change.

The successful establishment of industrial ecology linkages requires continuing implementation of projects that identify industrial ecology opportunities. Work is needed to clearly identify the regulatory and other policy barriers in order that they be removed. Policy-based incentives - such as ecological tax reform and other practical techniques - need to be identified and implemented to help stimulate the market to drive industrial ecology. On the ground institutions, such as the Cleaner Production Centre, can help to facilitate such linkages in larger industrial parks. For sites with a smaller number of firms, as in the case of the Portlands, the preferred strategy may be to utilize existing institutions and networks, with a focus on promoting the economic benefits attainable through co-operation.

Governments, industry, academics - and other organizations which focus on establishing the right institutional, fiscal and policy environment for the practical implementation of pollution prevention technologies, sustainable technologies and industrial ecology - can help to ensure prosperity for their citizens and secure an important role for their countries in global efforts to achieve sustainable development.

More at --- http://newcity.ca/Pages/industrial_ecology.html