

Acknowledgements

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Executive Summary

Sustainable development calls for production and consumption activities that satisfy criteria of economic efficiency, ecological integrity and social equity simultaneously. This report demonstrates that the promotion of eco-industrial parks or networks can help to implement Canada's commitment to sustainable development by integrating the three criteria into one industrial development strategy. Through a literature review and interviews this report identifies the current status of eco-industrial park/network development worldwide; reviews barriers, drivers, and relevant federal government policies and programs; and recommends opportunities for greater progress in the Canadian context.

Industrial ecology as a field of study and the eco-industrial park/network approach to implementation are relatively new. These concepts only came into prominence in 1989 but have already generated significant interest in several countries, most notably the United States.

The U.S. President's Council on Sustainable Development has defined an eco-industrial park (EIP) as:

"a community of businesses that cooperate with each other and with the local community to efficiently share resources (information, materials, energy, infrastructure and natural habitat), leading to economic gains, improvements in environmental quality and equitable enhancement of human

resources for business and the local community."

Over thirty EIPs/networks are at various stages of development worldwide (see Appendix 2). The emphasis in each ranges from resource recovery/reuse centres and green industry clusters, to energy cascading and region-wide by-product materials exchange. Some of these are manifested within defined industrial parks while others are networks of compatible industries distributed over a broader geographic area.

Several EIPs/networks are already well developed but most are still in the planning and feasibility stages. The U.S. has moved rapidly ahead of Canada in this field. At least fifteen major eco-industrial park projects are in the planning, feasibility or information gathering stages in the United States. Canada has some successes, most notably the Bruce Energy Centre near Tiverton, Ontario; Sarnia, Ontario; several sites located in east Montreal and a series of projects at Burnside, Nova Scotia. These sites form a solid basis upon which to build in Canada. Ten additional sites that have good potential to become EIPs have been identified.

The formation of EIPs results in numerous environmental and economic benefits and is being influenced by both drivers and barriers. The economic benefits from EIP/network development are the primary driver. These benefits are shared by participating businesses,

governments and communities.
Economic benefits include:

- Generation of local employment, particularly from innovative firms who are attracted to EIP/network developments and increases in the local supply of goods and services;
- Retention of existing business and redevelopment (for brown field developments in particular);
- Increased tax revenue (resulting from the first two benefits);
- Generation of cost savings for participants in the form of reduced waste management, reduced infrastructure costs, and improved process and product efficiency;
- Identification of opportunities for other cooperative ventures such as joint purchasing, combined waste recovery and treatment, employee training, environmental monitoring and disaster response;
- Provision of new marketing opportunities as in the case of the new European 'environmental label' for industrial parks that meet certain environmental criteria;
- Enhancement of opportunities for new investments; and,
- Generation of opportunities for new technology development that facilitate greater efficiency.

The tangible environmental benefits of EIPs/networks include:

- Reduction of greenhouse gas emissions and toxic air emissions;
- Promotion of 'green' technology development and diffusion;
- Improving energy, materials and water use efficiency and conservation;
- Improving land use planning and green space development within industrial and commercial sites;
- Promotion of pollution prevention on an industrial systems or community basis; and,
- Promotion of the redevelopment of brown field industrial sites.

A wide range of drivers currently support existing efforts to develop EIPs/networks and influence the direction of these developments. These include:

- The need for local employment through community economic development;
- The potential cost savings through material, water and energy exchanges;
- The existence of national and especially local champions;
- Pressures for increased efficiency of production (stemming in part from international competitive pressures);
- Increasing need to redevelop brown field sites and reduce urban sprawl;

- Increasing corporate environmental stewardship and the use of tools such as environmental management systems; and,
- The need to develop practical approaches to operationalize sustainable development.

A number of barriers to the implementation of EIPs/networks have been identified including:

- The lack of awareness among corporations and community economic development professionals;
- Liabilities associated with waste;
- Economic instruments such as taxes and subsidies;
- Bureaucratic inertia;
- A lack of long term financial support required to promote industry cooperation; and,
- A lack of support tools and general awareness.

A preliminary review of policies and programs at the federal and, to some degree, provincial government level indicates that a strategic and programmatic framework for advancing the development of EIPs/networks exists in Canada.

This research indicates that there are important opportunities for progress in Canada. If the federal government is interested in pursuing EIP/network development as an industrial capacity

building strategy for both brown field and green field sites the following measures are recommended.

- Develop a \$1.5 million program in support for five local EIP/network demonstration projects over a three to five year period that will clearly demonstrate the economic and environmental benefits and build a stronger constituency. It should leverage an equivalent amount of local and provincial resources. The program should be implemented on a competitive proposal basis on a similar model as that used for the development of the Canadian Environmental Technology Advancement Centres.
- Provide financial and strategic support for the development of a national conference on EIP/network development to broaden awareness and facilitate further action.
- Establish an ad hoc interdepartmental committee to coordinate program support for EIP/network development that exists, to some extent, indirectly, among several departments and regional economic development agencies.
- Provide assistance for the transfer of support tools developed in the United States and elsewhere for use in Canada.
- Support the development of an industrial ecology web site.
- Develop a resource guide on federal and provincial programs that may be used to support industrial ecology,

building on the programs already identified in this report.

- Through partnerships, promote the introduction of the concepts of industrial ecology into teaching programs in engineering, business, planning, design and environmental studies programs.
- Promote the introduction of the concepts of industrial ecology among local and regional industrial and economic development officials.

With a growing need to reduce material and energy throughput in the global economy by a factor of between 4 and 10 over the next generation in order to accommodate increasing consumption pressures, EIP/network development provides an important new approach to making greater progress.

Promoting EIP/network development can help achieve multiple economic, social and environmental goals. With appropriate federal government support, it promises to rapidly become a highly competitive industrial and commercial development strategy within Canada. Communities who adopt this new strategic approach to economic development promise to enjoy greater levels of job retention and creation well into the next century.

By collectively managing environmental and energy issues, eco-industrial park members can enhance their environmental and economic performance and, as a result, achieve a combined benefit that is greater than the benefits each company would realize from optimizing only its individual performance. The EIP concept serves as a model for sustainable community economic development.

*Eco-Efficiency Task Force Report,
U.S. President's Council on Sustainable Development, 1996*

1.0 Introduction

Most of the environmental problems currently facing Canadians result from the inefficient extraction, processing and use of resources. One of the factors contributing to this inefficiency is the uncoordinated manner in which industrial and commercial development has traditionally occurred. Businesses are highly interdependent organizations, relying on sophisticated networks of relationships in order to produce products and services. Recently, this interdependence has become more intense with the advent of flexible manufacturing networks, just-in-time delivery and the concentration of production among large corporations. All of this complexity is designed to maximize the efficiency of products and services. However, because wastes are not viewed as misplaced or misused resources, businesses haven't factored them into decision-making processes until only recently.

Facilities are planned and constructed with little or no regard to using byproduct reuse networks to help minimize the amount of wasted materials, energy, land and water. The lack of integration with the operations of other facilities results in a tremendous

amount of inefficiency which contributes to global warming, resource depletion and the production and dissipation of toxic and non-toxic substances. This inefficiency also has very important bottom-line implications for the international competitiveness of firms and nations. In the United States, inefficiency in the manufacturing sector translates into tangible losses of at least \$400 billion annually, mostly from the value of wasted materials (EDCO, 1996).

The growing need for job creation and improved competitiveness and environmental performance is currently driving a new, more integrated approach to industrial and commercial development based on the principles of industrial ecology. "Industrial ecology" is a term first given prominence by Frosch and Gallopoulos in 1989 and is described as the study of the physical, chemical and biological interactions and inter-relationships between industrial and ecological systems (see box below). It is rapidly emerging as an important strategic approach to economic development which emphasizes material cycling and networks of producers, consumers, and recyclers who encourage resource conservation and pollution prevention.

Industrial ecology theory is a dynamic systems-based framework that enables us to manage our activities on a more sustainable basis by:

- Enhancing the efficiency of resource use;
- Ensuring an acceptable quality of life for people;

- Minimizing the ecological impact of human activity to levels that natural ecosystems (local, regional, national and international) can sustain; and,
- Maintaining the economic viability of systems for industry, trade and commerce.

Overview of Industrial Ecology Theory

"Industrial ecology" is conceived as a system where the consumption of energy and materials is optimized and the by-products of one process serve as raw materials for another process. This theory was defined further by Harden Tibbs in 1991 to involve designing industrial infrastructures as a series of interlocking man-made ecosystems that interface the natural global ecosystem. Industrial ecology therefore aims to mimic the processes of a natural ecosystem. It emphasizes the development of eco-industrial parks in which there is material and energy cycling, and "webs" of firms that mimic the activities of producers, consumers, scavengers, and decomposers in a natural ecosystem. In an "industrial ecosystem", the waste of one firm essentially becomes an input into the production process of another firm. These byproduct exchanges result in cost savings and revenue for the firms, which are now able to not only cut down on waste disposal and material costs but also generate revenue by selling their by-products as a commodity.

Source: (*The New Urban Agenda*, Peck & Associates, www.acpco.com/panda)

The principles of industrial ecology as a strategic approach to industrial and commercial development are currently being implemented in both developed and developing countries. The term 'industrial ecosystem' is often used to refer to a network of firms engaged in a variety of interdependent material and energy exchanges. These interdependencies are also referred to as "industrial symbiosis." The larger the geographical scope of these networks, the more opportunities there are for byproduct material based exchanges. The smaller the scope, the more economical are energy-based linkages such as cogeneration or waste heat recovery.

The establishment of 'Eco-industrial Parks' (EIPs) is another, more geographically focused approach to implementing industrial ecology. An EIP can be relatively small, 10 acres or less, or encompass a much larger area zoned for industrial development. It can involve an existing industrial site (brown field), or a new development (green field). Each has its own set of advantages and disadvantages. Although several definitions of EIPs exist, we have adopted the following definition offered by the U.S. President's Council On Sustainable Development, an active proponent of this new approach to sustainable development.

A community of businesses that cooperate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat), leading to economic gains, gains in environmental quality, and equitable enhancement of human resources for the business and local community. (PCSD, 1997)

The implementation of industrial ecology theory through EIP developments is taking on many forms. Most of the EIPs identified in this report include plans for, or the existence of, one or more of the following features:

- One or more material by-product resource exchanges or a network of exchanges, such as a local or regional waste exchange;
- A recycling/reuse resource recovery business cluster;
- Cogeneration, energy from waste and/or other energy sharing infrastructure such as district heating and cooling and industrial heat recovery;
- EIP management organization and/or an information/resource centre;
- A collection of environmental technology and service companies;
- A collection of companies manufacturing 'green' products;
- An industrial park designed around a single environmental theme or objective such as a solar energy park, or a zero emissions park;
- Environmentally friendly infrastructure and construction;
- Environmentally sensitive planning and the preservation/regeneration of

- natural habitat within the park;
- Shared emergency response, information access, environmental monitoring and employee training;
- Shared inputs (purchasing) and infrastructure development costs through, for example, the use of a utility island; and,
- Integration of agricultural and industrial production.

These features are achieved because industrial and commercial development is more cooperative than has traditionally been the case, with firms establishing material and energy linkages and other cooperative ventures when it is proven that they are clearly economically viable. Current EIP development activities are centred on both green field and brown field industrial and commercial sites. Although a number of green field industrial development sites are currently being planned in Canada, our research focused on identifying developments that are currently being promoted as EIPs in Canada, the United States and overseas.

1.1 Purpose and Objectives

Eco-industrial parks/networks (hereafter referred to as EIPs) represent significant untapped opportunities for improved international competitiveness and environmental performance (industrial ecology, reducing greenhouse gas emissions, preventing toxic and non-toxic air and water pollution and improving resource use efficiency) among Canadian businesses. The purpose of this study is to identify the potential roles of the federal, provincial and municipal governments in providing

a policy, program and regulatory environment that is not only conducive to, but promotes, the development of EIPs in Canada.

The specific objectives of the research are:

- To identify the key public policy and program elements required to develop EIPs from existing brown field sites and green field sites.
- To identify what role the federal government, specifically Industry Canada, Natural Resources Canada, and Environment Canada, can play to facilitate/promote EIP development while building on current activities such as the ThermoShare Report, research on Sarnia, Ontario conducted by Michael Nisbet, research on the Port Industrial District by Peck et al. and on Burnside Industrial Park by Côté et al.
- To identify barriers that may be in place, focusing on existing strategies, policies and programs that may hamper or restrict such developments. What tools are at the disposal of the federal government to facilitate/promote EIPs?
- To identify how the promotion/facilitation of EIPs fits into existing program objectives, such as the Canadian Environment Industry Strategy, Energy Efficiency Programming, Climate Change, and efforts to enhance Canadian industrial competitiveness.
- To identify the potential role(s) of provincial and municipal

governments in promoting EIP development.

- To identify and describe the role(s) of other governments and quasi-governmental organizations in the development of existing EIPs, with a focus on the European and U.S. experiences. What tools, for example, are governments and other organizations currently using to facilitate/promote the development of these parks? To what extent may they be applicable to Canada?
- To examine the role(s) of the private sector and the extent of their involvement.
- To develop general and specific program and policy recommendations for Environment Canada, Industry Canada and Natural Resources Canada and other governments and organizations with an interest in promoting EIP development in Canada.

This report helps to define the role of Canadian governments in promoting the continuing development of EIPs in Canada and to improve the level of awareness of the many opportunities that can result from EIPs among key stakeholders.

1.2 Methodology

The methodology for this study involved two phases. Phase I was a literature search and review conducted from May-July, 1997. Phase I also included a key word search of the CANLOC database, owned by Business Development International, which contains federal,

provincial and municipal government business support policies and programs. Information obtained from this research presents a view of the status of government support as it pertains directly and indirectly to EIP development. An Interim Report was presented to Environment Canada and Industry Canada on June 19, 1997.

Phase II involved conducting telephone interviews with 15 individuals who are actively involved in promoting the development of EIPs in Canada, the United States and Europe. Several interviewees were sent draft questions for their input on the survey instrument. Interviewees were drawn largely from economic development agencies, industry and, to a lesser extent, government. The survey instrument and list of interviewees are included as Appendix 1. The interviews were extremely valuable in helping to develop this report given the recent emergence of this new field.

Phase I and II research were combined to produce a series of tables providing a detailed overview of the status of over thirty EIPs in Canada, the United States, Europe, the Middle East and Asia. These tables represent the first such inventory of EIPs ever compiled and clearly demonstrate a variety of different visions and approaches to implementation. These tables are included as Appendix 2.

Eco-industrial park development allows the weaknesses of one company to become the strengths of another in order to optimize efficiency. These synergies provide more economic and environmental benefit with less resource flows. It's really about doing more with less.

Gil Friend, Principal,
Gil Friend & Associates, U.S. Industrial Development Consultants.

2.0 Eco-Industrial Parks: An Overview of Benefits, Drivers and Barriers

In theory the convergence of industrial systems and the natural eco-systems they are embedded in will result in significantly more efficient production. Rapid population expansion and resource consumption continue to draw down planetary resources and increase ecosystem degradation. Estimates of the need for production efficiency increases over the next 25 years range from 75 to 90 percent (e.g.; factor 4 and factor 10). These two macro-level trends promise to help spur government and industry efforts to maximize the eco-efficiency of industrial production. A system of sustainable production and consumption, as envisioned by industrial ecology theorists, will require not only fundamental change to our mode of production, but far reaching changes in society's demand for goods and services and the manner in which we use them.

While the ultimate long term goal of the implementation of industrial ecology theory is to fully merge natural and human made systems, EIP development activities represent only a small, but important, first step in that direction. Many of the projects described in the tables of Appendix 2 remain in the planning and early implementation

stages, and only a handful of EIPs can be described as mature. Most of the projects currently underway in the United States involve the development of baseline information on the existing material and energy flows of facilities. These studies are being used to help assess the economic and technical feasibility of establishing waste and energy exchanges and to determine what types of facilities may be compatible with existing operations.

Potential economic advantages of industrial symbiosis include treatment and transportation, reduced costs of feedstocks and utilities, and increased local markets for products.

David Cobb, Bechtel Corporation

Membership in an EIP can potentially bring economic benefits to companies by improving their efficiency, reducing their infrastructure requirements, providing access to better information about their customers and suppliers and reducing the costs of regulatory compliance. However, the EIP may also require that each member form relationships with other EIP members that might bring greater risk than traditional customer/supplier relationships.

Eco-Industrial Parks: A Case Study and Analysis of Economic, Environmental, Technical, and Regulatory Issues. Prepared by U.S. EPA Office of Policy, Planning and Evaluation by the Centre For Economics Research and Indigo Development, 1996.

2.1 Economic Benefits

Economic benefits from EIP development are direct and indirect, broad based and project specific. These benefits can also be segmented according to who accrues the economic benefits, individual companies or communities. The main economic benefits of EIP development, segmented by benefactors, follows.

Company Economic Benefits

- Wide range of potential cost savings;
- Revenue generation;
- Promotional/marketing opportunities;
- Improved opportunities for new investment; and,
- Costs savings through regulatory flexibility.

Community Economic Benefits

- Increased local employment and tax revenue;
- Image improvements for the redevelopment of brown field sites;
- Promotion of innovation and

diffusion; and,

- Reduced infrastructure development costs.

Detailed data on the economic benefits of EIP development is, at this early stage, difficult to obtain. However, the existence of a number of functioning EIPs provides some quantitative evidence and a basis for identifying potential future benefits. An overview of the quantified evidence of the main economic benefits identified through this research follows.

Company Economic Benefits

- *Cost savings.* Direct project specific benefits stem largely from the increased efficiency for the participants, which may also include publicly owned facilities. For example, cost savings can result from reductions in government expenditures for infrastructure such as water treatment facilities and landfills. Public and private sector participants can reduce energy and waste disposal costs. The sharing of

materials, energy and water can yield significant cost savings, often with little or no capital investment. Businesses implement capital projects offering a competitive return on investment. In Kalundborg, Denmark for example, a \$60 million investment in EIP infrastructure generated a \$120 million in cost savings over five years (MOEE, 1994). Cost savings can also be realized through the shared capital and operating costs of utility islands which supply gas, water and other inputs to companies. By combining purchases of shared inputs, firms may also be able to negotiate better prices. Avoided disposal and treatment costs are another form of cost savings.

- *Revenue generation.* Companies are sometimes unaware that their byproducts have market value and can be sold rather than disposed of. The extent to which this may be possible should not be underestimated, since most manufacturing sectors have had little incentive to investigate byproduct exchanges or, to invest in technologies that will facilitate such exchanges. The sugar industry, recycled paper industry, brewing industry and forestry industry have been identified as having significant potential for improved byproduct linkages (Pauli, 1995). Furthermore, opportunities for such linkages will improve as the application of Environmental Management Systems (EMS) and Life Cycle Management (LCM) practices continues to become more widely accepted as an important business tool. EIP developments will benefit

from the new information that emerges from EMSs and LCMs. Several databases are currently under development that can take information on material and energy flows in specific sectors and identify energy and material exchange opportunities.

Revenue generation may also result from improved market share. In France, a system has been developed that provides firms with an 'eco-label' that identifies them as participants in a particular EIP. Discussions are underway to expand the use of the eco-label across the European Union. More detailed information on this is provided in section 3.2. The development of EIPs can also stimulate a reexamination of the internal operations of participating firms, particularly if process modifications are required in order for a byproduct exchange to take place. EIP development can therefore be a vehicle to help promote pollution prevention and eco-efficiency which, in turn, can lead to significant internationally- derived cost savings.

- *Improved opportunities for new investment.* The development of a flexible strategic plan for an EIP that includes baseline information on material and energy flows among existing firms can have a number of economic advantages for potential new investors. For example, candidate industrial facilities can use this information to determine the extent to which current suppliers may be redundant or, to reduce the risk of being reliant on a single supply of an important feed stock.

Information on material flows combined with the appropriate incentives can also help candidate industries modify a manufacturing process to replace a useless waste stream with one that is of interest to another industrial facility nearby, prior to the design and construction of a new plant. The cost savings from such linkages tend to be greater if they can be implemented at the planning stages, rather than after a facility is built since retrofitting costs can be avoided. Burnside, Nova Scotia has seen a veritable explosion of new companies taking advantage of availability of materials resulting from public pressure to recycle and bans on disposal of some materials in Nova Scotia landfills. At least 25 new companies have located or been created in the past three years. Being able to identify such opportunities for potential investors will give economic developers a competitive edge in the fierce competition for new investment.

- *Cost savings through regulatory flexibility.* In some jurisdictions, the United States in particular, EIPs may eventually lead to combined permitting systems, faster approvals and even pre-approvals on new industrial developments. This flexibility, based on proven corporate environmental performance, can lower the risk and costs of new industrial expansions and give facilities within EIPs a competitive edge. More information on regulations and policies of this nature is provided in section 3.0.

Community Economic Benefits

- *Increased local employment and tax revenue.* These are two direct, broadly-based benefits which are key objectives of the proponents of all U.S. EIP projects. EIP development is viewed as a strategy for business retention (since businesses that form linkages with neighbouring firms are less likely to relocate than those that do not) and expansion (due to new opportunities arising from material and energy linkages). In Canada, as much as 70 percent of new employment is generated by existing firms, as opposed to attracting new local companies (EDCO, 1996). EIPs in brown field sites with sufficient material and energy flows can be used to help attract new investment, particularly when they represent important inputs for candidate industrial firms. EIP development strategies can therefore help stimulate diversification and encourage the development of new industries. Local employment and tax revenue can also be improved through increasing the use of local suppliers for goods and services.
- *Image improvements for brown field sites.* Improvements in the image of a brown field site through EIP development can also help local governments keep existing tenants, encourage their expansion and promote new, environmentally appropriate developments. Several interviewees also made the point that firms which are likely to enter into an EIP will already be aware of modern business practices such as Total Quality Management and are

likely using environmental management systems, auditing and evaluation tools. These are the types of firms that communities want to attract because of their often superior environmental and economic performance. In order for the managers of an EIP to attract new investment, however, they must offer the potential for greater profitability than alternative sites. Early evidence suggests that this potential will grow as the level of cooperation, interdependence and opportunity in an EIP becomes more sophisticated.

- *Promotion of technological innovation and diffusion.* Technological innovation is required to help promote linkages between different industries. Categories of technologies that are needed to support EIP development include transportation technologies, information technologies, recovery, recycling, reuse and substitution technologies for many sectors, environmental monitoring technologies, energy and energy-efficient technologies, and water treatment and cascading technologies. The further development and diffusion of such technologies will help create knowledge-based jobs in Canada, promote the more rapid 'greening' of industry and provide a source of export potential in the \$600 billion dollar global environmental industry market. Moreover, greater cooperation between firms in overcoming inefficiency problems will provide a 'supplier' pathway for the diffusion of 'green' technology across sectors and help stimulate new

technological developments.

- *Reduced infrastructure development costs.* EIPs can result in a more efficient use of municipally provided services such as water and waste water treatment and landfill capacity. Programs that can extend the life of this infrastructure can be more cost effective than new capital investments. Opportunities also exist to link publicly owned facilities into the EIP development.

The range of cost savings and potential for continuous improvement resulting from EIP projects promises to become a key factor in determining future industrial and commercial competitiveness. To a large extent, Japanese industry has led the way in terms of total quality, just-in-time delivery and energy efficiency through the late 1970's and into the 1990's. Some Japanese industrialists (and North American based companies as well) have begun to embrace the concept of zero emissions as a critical source of increased competitiveness. The EBARA Corporation, for example, is developing a fully integrated EIP which includes residential areas, commercial, industrial, agricultural and recreational activities with a goal of zero emissions. It is the first, fully integrated development of this kind in the world and is slated to open in the year 2000.

A number of performance based indicators have been proposed to measure the economic impact of EIP developments. These include company-based measures such as: change in annual profit, change in cost per unit of production, change in productivity, return on investment and pay back

period. Broader measures include: value added by manufacturer, total number of production workers, total production worker wages, average wage, tax revenues, and public expenditures for sewerage and sanitation, as a percentage of value added or tax revenues (Bechtel Corp., 1997).

The use of such measures by proponents of EIP developments will help them track the economic benefits of

their work and demonstrate the value of this new approach to industrial and commercial development. As EIP developments continue to mature and become more sophisticated, the economic and environmental benefits promise to expand as companies accept greater levels of investment, greater risk and more intensive cooperation with each other.

Our eco-industrial park is being driven by two main issues - one showing that businesses can operate harmoniously with the environment while making a healthy profit, (actually better than the traditional businesses) and two - Londonderry's Sustainable Londonderry program which will create a market niche for itself. On a national and international level, profits and environmental benefits are driving eco-industrial park developments.

Peter Lowitt, Director, Planning and Economic Development,
City of Londonderry, Hew Hampshire

2.2 Environmental Benefits

EIP development has significant untapped potential to complement and strengthen many government, non-governmental and industry-led initiatives aimed at improving the environmental performance of industrial sectors and individual facilities by expanding opportunities for pollution prevention and resource conservation. Several interviewees commented that although the economic benefits attainable through EIP development are of paramount importance, the environmental benefits attainable also help to generate support from many important stakeholders. Demonstrated environmental benefits include the following.

- Reduced greenhouse gas emissions;
- Reduced toxic air emissions;
- Promotion of pollution prevention and the three R's;
- Improved resource conservation;
- Promotion of 'green' technology development;
- Promotion of 'green' technology diffusion;
- Integration of agricultural and industrial production;
- Reduction of local environmental impacts;
- Regeneration of green space;
- Increase in the use of abandoned or decaying brown field sites; and,
- Shared waste treatment costs resulting in improved waste treatment.

Although EIP development is still in its infancy, a number of practical examples demonstrate the enormous potential of this approach to implementing sustainable development. The primary types of environmental benefit with examples from existing and planned EIPs are provided below.

- *Reduced greenhouse gas emissions.* This is achieved through the expanded use of cogeneration and district energy systems and the use of wasted low grade energy sources for heating and cooling and in a broad range of industrial applications. At Kalundborg, Denmark for example, the site of one of the most advanced EIPs in the world, linkages between a coal fired electrical generating station and 11 other facilities generate annual savings of 30,000 tonnes of coal, 19,000 tonnes of oil and decrease CO₂ emissions by 130,000 tonnes (Peck and Callaghan, 1997).

At the Bruce Energy Centre near Tiverton, Ontario, nuclear power (and some wind generated power) generate the byproduct steam. In a system conceived by the Integrated Energy Development Corporation, this steam is used by Bruce Tropical Foods, (a commercial greenhouse), Bruce Agra Foods, (processes vegetables) Bruce Agra Dehy (dehydrates crops for animal feed), BI-AX International (produces a special polypropylene), and Commercial Alcohols (creates low-carbon intensive commercial fuels like ethanol).

The use of the byproduct steam by six companies at the Bruce Energy Centre as opposed to heavy oil, represents an annual avoidance of 43,000 tonnes of CO₂, 0.5 tonnes of CH₄ and 8.4 tonnes of CO (Sarnia, 1997).

Case Study: The Bruce Energy Centre, Ontario

The Bruce Energy Centre is developing an eco-industrial park focused mainly around energy exchanges. In this park, six companies are organized around Ontario Hydro's Bruce Nuclear Power Development (BNPD) to take advantage of its waste heat and steam generation capacity (steam serves as a potential source of heat energy for a broad range of industrial and agricultural processes such as dehydration, concentration, distillation, hydrolysis and space heating). The main industries currently located in the park include:

Bruce Tropical Produce, which grows 2.3 million pounds of tomatoes each year in a hydroponic greenhouse, an amount equivalent to a 100 acre field. Steam from the BNPD is used to heat the greenhouse. The steam is transported in hot water coils and the condensed cool water is then returned to the BNPD for reuse.

Bruce Agra Foods which processes fruits and vegetables into concentrates, sauces and purees. The food processing facilitator uses steam energy from the BNPD to concentrate 84,000 gallons of raw products per day.

Bruce Agra Dehy dehydrates locally grown crops to produce nutrient rich feeds for livestock and horses. The facility uses steam to run its dehydrators. This firm produces 90,000 tonnes of feed cubes per annum.

Commercial Alcohols is the largest manufacturer and distributor of alcohol in Canada, and currently produces 23 million litres of industrial and fuel alcohol from 58,000 tonnes of locally grown corn. Steam from the BNPD is used in the distillation and ethanol processing of the alcohol.

BI-AX International is a specialized company that manufactures a special polypropylene film for domestic and international markets. The polypropylene is heated in steam-driven ovens.

St. Lawrence Technologies, is a research and development facility which specializes in finding ways to convert renewable resources to develop a wide range of products.

The positioning of and interaction occurring between these industries enable the participants in the park to exchange recovered material so that byproducts of one firm serve as a raw material in another. Any residues generated at the Bruce Agra Foods facility, for example, are used either for animal feed or as an input for ethanol by Commercial Alcohols. Another established waste linkage in the park involves the use of carbon dioxide from the fermentation plant by Bruce Tropical Produce in their agricultural process. The figure on page 14 illustrates the types of linkages that exist among the firms in The Bruce Energy Centre. This project has been championed by Integrated Energy Development Corporation, a local industrial firm. It has resulted in substantial savings for the firms involved, an increase in local jobs and environmental benefits.

Source: (Venta and Nisbet, 1997a)

Figure 1: Bruce Energy Centre

Source: (Venta and Nisbet, 1997a)

- *Reduced in toxic air emissions.* Increased efficiencies available through cogeneration and other shared energy systems can also contribute significantly to reductions in other toxic air emissions such as SO₂, VOCs, and Nitrous Oxides. For example, a \$55 million cogeneration facility located in Sarnia, Ontario involving Novacor Chemicals, Bayer Rubber, Dow Chemicals and Ontario Hydro saves an estimated 926 tonnes of CO₂, 4.5 tonnes of SO₂ and 1.5 tonnes of NO_x each day (based on 1/3 gas, 2/3 oil fuel ratio). Annual emissions avoided by Bruce Energy Centre companies are 487 tonnes of SO₂, 93 tonnes of NO_x and 1.7 tonnes of VOCs (Venta and Nisbet, 1997)
- *Promotion of pollution prevention and the three R's.* Most of the costs of inefficient manufacturing stem from the loss of useable material during the production process. EIP development can build on the successes of early pollution prevention efforts, the recycling industry and local and regional waste exchanges by promoting these linkages among existing firms, and during the early stages of facility development or expansion.

Within EIPs, byproduct materials (formerly wastes) are exchanged directly through pipes or by truck, rail etc.. They may be modified by the sender, receiver, or, in some cases, remain useable simply as a straight byproduct. They may also be exchanged indirectly through an intermediary such as a recycling firm or a reuse centre, which may or may not modify the material. Solvents, oil,

paper, wood, ferrous and non-ferrous metals, building materials, a variety of chemicals, manure, sludge, packaging and plastics are all examples of materials currently being exchanged economically in EIPs. In 1994 for example, the Styrian industrial network project in Austria resulted in the recovery, reuse, and recycling of:

- 225,000 tonnes blast-furnace sand;
- 180,000 tonnes slag from steel production;
- 33,600 tonnes gypsum;
- 130,00 tonnes iron scrap;
- 194,000 tonnes flue ash;
- 149,000 tonnes industrial coal ash;
- 110,000 tonnes waste paper;
- 5,000 tonnes calcium mud;
- 16,800 tonnes bark;
- 30 tonnes plastic materials; and,
- 22,000 tonnes fine materials (Recycling, 1997).

Baseline information on material flows can help to identify opportunities for smaller firms to pool their wastes, thereby achieving the required economies of scale for successful reuse and recycling applications. For example, this information helped establish a used oil collection and processing refinery at the Burnside, Nova Scotia EIP to recover waste oil within and outside the park and make it available as heating and diesel fuels. A paint reuse project is also currently under consideration.

- *Improved resource conservation.* EIPs promote and facilitate the efficient use of natural resources. When firms combine their production processes by sharing energy and materials, they are able to reduce their impact on natural resources more so than if they acted alone. The future development of clusters of firms that can engage in direct and indirect energy and byproduct exchanges is an important component of several existing EIP developments. At the Jubail Industrial Complex in the Eastern Province of Saudi Arabia, approximately 100 primary, secondary and support industries are clustered around the primary feed stocks of crude oil and methane. Secondary industries use the byproducts of the primary producers and all of the facilities are supported by smaller industries. The Kashima EIP in Japan, north of Tokyo, has a cluster of industries that exchange energy and materials including a large steel plant, a petroleum refinery and a power generating station. At a green field site in Bandung, Indonesia, an EIP development is planned for 20 textile firms. The goal of the proponents is to eliminate all of the emissions from participating factories and to recover all the dyes (a source of local environmental problems) used in the manufacturing process. At Burnside, Nova Scotia, several companies have entered into the business of supplying used building materials, a significant source of waste deposited in landfills.
- *Promotion of 'green' technology development.* Some EIPs under development in the United States involve the promotion of renewable energy, notably biomass and solar. In Eastville, Virginia, for example, a green field EIP is being implemented with a goal of having zero emissions from the facilities located in the park. This, combined with similar zero emission parks, will give significant corporate profile to their members and may therefore help to promote the development of 'closed loop' technologies and increase the number of corporations dedicated to this goal. In Oakland, California, an EIP development is centred on the establishment of a resource recovery facility that will encompass reuse, recycling, re-manufacturing and composting. In order to maximize the value of industrial ecology, new technologies will need to be developed in order to facilitate waste and energy linkages between industries.
- *Promotion of 'green' technology diffusion.* In many cases, technological developments that facilitate the exchange of materials and energy exist, but the willingness and or ability of firms to invest in them is insufficient for their widespread diffusion. Government regulations and economic instruments provide important incentives for technological innovation and diffusion in the marketplace. They can also, in the case of industrial ecology, prove to be a barrier. Barriers and drivers are discussed at greater length in sections 2.3 and 2.4. The Cape Charles' Sustainable Technologies

Park is a prime example of promoting green technologies in the United States. The Baltimore EIP also looked seriously at the potential of a Canadian technology for material and energy recovery for its park.

- *Integration of agricultural and industrial production.* In Burlington, Virginia, an EIP is currently in the planning stages on a brown field site with an objective of establishing an agriculture-based park. The focus of this redevelopment is on using biomass-based energy and living machines to capture the available thermal energy for the production of fish, vegetables and for water purification. Increasing the amount of locally produced food reduces toxic air pollution and greenhouse gas emissions related to the transportation of such goods prior to reaching the end consumer.
- *Reduction of local environmental impacts.* A key component in the successful development of EIPs is the participation of the local community, particularly when recruiting new development. In the United States, several EIP developments are ‘grassroots’ in nature with community groups in the lead, or as full and active participants. These groups demonstrate a shift in attitude from “industry = the problem” and an approach to new development characterized by Not in My Backyard (NIMBY) to “industry = opportunities for improved employment, human health and local environmental quality.” The Green Institute EIP in Minneapolis, Minnesota is one

example. The Green Institute is working toward the creation of 200 jobs by establishing a business development strategy on the 3.5 acre site for ‘green businesses’. The project is community driven and involves a commitment to incorporate environmental education into all aspects of the project.

- *Regeneration of green space.* EIP development also involves the preservation and regeneration of natural habitat through planning and design changes. In the context of an EIP, green space can help to reduce noise pollution, act as a buffer between different land uses, remediate contaminated soils, reduce the ‘heat island effect’, improve the efficiency of heating and cooling buildings, improve air and water quality through wetlands, improve aesthetics, and provide habitat for transient and permanent animal species. Green field developments provide the best opportunity for cost effectively realizing most of these types of environmental benefits. In Toronto, the Waterfront Regeneration Trust has been working to establish a green space strategy for the Portland Industrial District. Green space improvements can help improve the aesthetics of brown field sites thereby encouraging redevelopment.
- *Increase the use of abandoned or decaying brown field sites.* Brown field industrial sites are a challenge for most large cities in North America. They represent significant redevelopment opportunities but are often plagued with problems ranging from contaminated soil and ground

water, to a poor image for prospective investors and the continuing loss of existing tenants. The loss of employment generated by these areas has a wide range of negative social, economic and environmental impacts on urban centres. Brown field sites also represent significant wasted land resources that are well serviced by existing infrastructure. One of the drivers of EIPs in the United States is government and non-government efforts aimed at redeveloping these areas in order to economically reinvigorate cities.

- *Shared waste treatment costs.* Although not strictly industrial ecology, the pooling of wastes is also used for primary and secondary treatment purposes at many industrial estates. In developing countries, the cost sharing of waste treatment can be a key determinant in whether or not waste is treated at all.

These represent some of the primary environmental benefits attainable through EIP development. The exact benefits which result will depend on the types of firms involved, the goals of the organizers and managers of the EIP and the available support. The application of industrial ecology concepts to industrial and commercial development through EIP development can, and has, yielded multiple environmental benefits. This integrative approach to the amelioration of environmental problems is in contrast to the traditional single media approach which has, and largely continues to, characterize most government environmental protection efforts.

2.3 Drivers of Eco-Industrial Park Development

Industrial ecology is, in theory, a very attractive concept because of the potential to turn environmental problems into economic benefits. Factors which are driving EIP development are both economic and environmental in nature. Which factors are paramount depends largely on the organizations and individuals championing a particular EIP development. However, economic drivers appear to be paramount. The main drivers of EIP development, in relative order of importance, have been identified as:

- Potential cost savings;
- Existence of champions;
- Increased importance of cost and waste management;
- Brown field site redevelopment and inner-city redevelopment;
- Redevelopment of manufacturing facilities;
- Pressure for improved local employment;
- Creation of a market niche;
- Flexibility introduced by regulatory reform;
- Increased corporate environmental stewardship; and,
- Public concern over the environment.

Several general trends about the different drivers of EIP were identified in the research conducted. These drivers, listed according to the organizations they tend to influence most, are as follows.

Drivers Affecting Industry

- *Potential cost savings.* In cases where major EIP projects have been implemented the firms involved have achieved clear economic benefits. The potential for cost savings through material, water and energy byproduct exchanges and other shared resources is great, but, facility managers and owners do not, for the most part, often consider these more cooperative opportunities that lie beyond the scope of their own operations. Research conducted in the Portland Industrial District of Toronto, Ontario found that most firms were unaware of the operations of their neighbouring businesses (Callaghan and Ierfino, 1996). In cases where more advanced EIPs exist, the cost savings that have already been achieved are now helping to drive new project developments. Some of the linkages between firms in Sarnia, Ontario emerged partly as a result of head office pressure for more performance improvements during tough economic times.
- *Increasing importance and cost of waste management.* Waste management has become an increasingly important environmental, economic and political issue in many jurisdictions. The cost of handling and treating wastes has risen dramatically in many places while bans are being issued on the disposal of a range of materials into landfills. Governments and companies alike are being pushed into product life-cycle analysis, design for environment and product stewardship including

extended producer responsibility. The reuse, recovery and recycling of materials, involving companies functioning as 'scavengers' in an ecological sense, is still a growing sub-sector of environmental industry. These companies will play an increasingly important role in the creation and maintenance of industrial ecosystems. Multi-material resource recovery or recycling centres are being established across Canada, as are used building material centres and construction and demolition debris facilities.

- *Increasing corporate environmental stewardship.* The realization of cost savings through programs such as pollution prevention and environmental management systems, combined with improved monitoring and reporting and the use of voluntary agreements, is helping to spread environmental stewardship among industry. Concern over protecting international markets from punitive environmentally-based trade sanctions and the emergence of the first standards in the ISO 14,000 series are also promoting environmental stewardship activities. The gradual shift toward design for environment, increased use of EMSs, extended producer responsibility and product stewardship promise to help both drive and facilitate EIP development.

Drivers Affecting Government

- *Regulatory reform is introducing much needed flexibility.* In addition, governments are finding it increasingly difficult to maintain large bureaucracies and systems in light of

budgetary problems and pressure for reform from the private sector. Regulatory reform or reinvention, especially in the United States but also in Canada, is encouraging governments to look at new ways of dealing with environmental issues. One of the means of doing so is through the increased use of voluntary measures; another is through harmonization of policies in different jurisdictions. Yet another is to implement programs on a spatial, or sectoral and integrated basis. This latter approach has yet to be implemented in any significant manner in Canada or the United States. The United States and some European countries are beginning to experiment with new, more integrated approaches described more fully in section 3.1 of this report.

Drivers Affecting Local Economic Development Agencies

- *Pressure for improved local employment.* One of the primary drivers of both brown field redevelopment and the redevelopment of manufacturing facilities is the need to stimulate new employment opportunities in what are often economically depressed areas.
- *Need for brown field site redevelopment and inner-city redevelopment.* In the United States, a key driver is the pressure to make productive use of brown field sites often in the inner cities. Section 3.1 contains additional information on a federal government initiative designed to address this challenge.

- *Redevelopment of manufacturing facilities.* In the United States, manufacturing facilities linked to the defense industry and military bases are being closed. A number of the eco-industrial projects such as those in Cape Charles, Virginia; Baltimore, Maryland; Chattanooga, Tennessee; Trenton, New Jersey; Minneapolis, Minnesota and Plattsburgh, New York have resulted from this.
- *Creating a market niche.* Economic development organizations are playing important and often leading roles in many U.S. EIP developments. This is part of an effort to create a market niche in what is an increasingly competitive economic development climate. EIP strategies often involve providing additional services to existing tenants which help economic developers in their efforts to retain businesses.

Drivers Affecting Industry, Government, and Local Economic Development Agencies

- *Existence of champions.* As with any new or emerging development, the existence of one or more champions in government and the private sector is an important ingredient for success. In the United States, the President's Council on Sustainable Development (PCSD) has played a championing role at the senior level. At the local level, many of the EIPs are being championed by local economic development associations and corporations. In Japan, one of the key government champions has been the Ministry of International Trade and Industry. Its interest goes

back to the early 1970s but in recent years they have been supporting efforts to achieve zero emissions, eco-factories and eco-industrial parks. The Zero Emissions Research Initiative of the United Nations University, based at their Tokyo campus, is funded largely by the Japanese government. The vision and work of Sam McGregor, President of Integrated Energy Management has led to the development of the Bruce Energy Centre. A growing number of consultants and academics are also championing industrial ecology. Local champions are key to success, with most of the U.S. EIPs being driven by local economic development organizations and associations.

- *Public concern over the environment.* The priority attributed to the environment fluctuates in the polls but it is clear that environmental protection remains an important matter for Canadians. The recent report of the NAFTA Commission on Environmental Cooperation highlights the need for more action in Canada. The continuing loss of forests, wetlands and agricultural lands on the urban fringe to residential, commercial and industrial development is also of growing concern to the public. This was cited as a driver that will grow in importance and help to encourage the redevelopment of brown field sites and the intensification of industrial and commercial activities.

Some of the drivers described above are specific to a country, community or specific location. Many of the key

ingredients of successful EIP development have been identified and are discussed in section 4.0 of the report. As EIP developments continue to demonstrate that substantial environmental and economic benefits can be achieved through a wide range of cooperative ventures, international competitiveness and the resulting drive for improved efficiency promise to fuel this new approach to industrial development. In the short term, the challenge is to continue to find cost-effective and practical ways to move from theory to practice.

The message from Chattanooga's experience is simple: that changing 'business as usual' requires buy-in and participation from all sectors of the community. Therefore, community involvement is vital to any progress in adopting sustainable attitudes. It requires that companies 'think outside the box'. It means that a narrow focus won't work, that while all companies cannot participate in the sustainable business arena at the same level at this time, it is imperative these development projects make available a range of options that enable all companies to participate.

*Eco-Industrial Park Initiative Status Report to the Eco-Industrial Park Team.
Chattanooga/Hamilton County Tennessee, 1995.*

2.4 Barriers to Eco-Industrial Park Development

For the most part, EIP development is still in its infancy, even in the United States where it has gained considerable momentum. A number of barriers have already been identified in various reports and studies from the United States as well as through the interview process. The barriers identified through primary and secondary research include:

- Regulatory;
- Monopolies over electricity generation;
- Taxes and subsidies;
- Environmental liability;
- Conceptual-corporate cultural;
- Bureaucratic inertia (identified as a barrier in a number of U.S. projects);
- Lack of support tools;
- Predominance of a short term view;
- Lack of adequate opportunities for establishing by-product linkages;
- Lack of organization among those interested in EIP development; and,
- Lack of education and awareness.

The main barriers are described in detail below.

- *Regulatory.* Within complex regulatory environments, it is not surprising that many of the barriers are regulatory in nature, or at least stem from regulations. The largest barrier to byproduct exchanges seems to relate to the definition of waste, particularly hazardous waste, and the liability which accrues. The barrier is not as difficult to overcome in Canada as it is in the United States but, once a material has certain characteristics, it automatically becomes a 'waste' and is subject to a number of restrictions and administrative procedures. In the United States, regulations regarding the disposal of hazardous waste under the *Resource Conservation and Recovery Act* make it difficult to reuse or recycle hazardous waste between (rather than within) companies. The liability issue is also a more serious concern in the U.S. under certain laws.

The definition of a source is also a potential barrier when linked to issues of liability. If a group of

companies or an industrial park agency cannot be considered a source under existing legislation, then the exchange or use of some waste materials may be essentially impossible. Onerous transportation regulations regarding the movement of hazardous wastes between industrial facilities and sites also represent a barrier.

At the local level, there may be regulatory barriers with respect to land use and the disposal of wastes. For example, if regulations banning the disposal of certain materials in landfills do not exist, or are not enforced, this may represent a barrier.

- *Monopolies over electricity generation.* In some jurisdictions, such as Quebec and Ontario, government-owned monopolies have blocked energy related EIP development projects ranging from cogeneration to renewable and other small scale generating projects. The deregulation of the utility sector in Ontario may result in new energy based EIP projects moving forward into implementation.
- *Taxes and subsidies.* A variety of tax and subsidy reforms emerged from the interviews and in the literature. Among these include the unequal tax treatment of virgin versus reused/recycled materials in the United States and Canada, the need for a carbon tax to help drive energy efficiency, and various subsidies that continue to encourage urban sprawl and green field development over the redevelopment of existing industrial sites. The general lack of

government financial support for industrial ecology development projects was also cited as a barrier by several Canadian interviewees.

- *Environmental liability.* The liability issue also rears its head in relation to the use of contaminated land. A number of EIP projects in the United States are being designed to make use of brown field sites, often contaminated industrial or commercial land, to revitalize inner cities through redevelopment and job creation. Restrictions can be placed by legislation or funding institutions on the uses of that land. In the case of governments, the concerns are health and environmental risks while in the case of the lending institutions, their primary concern is financial risk.
- *Conceptual-corporate cultural.* There are conceptual barriers among business people. Private enterprises managers tend to view themselves as competitive when cooperation is often the best way to achieve corporate goals. Private companies enter into working arrangements continuously within networks of suppliers and customers. Without some form of cooperation among the businesses in this network, they would never survive. Only recently has this cooperation extended to environmental management through such programs as product stewardship and extended producer responsibility and tools such as life cycle analysis. In an industrial ecosystem, products *and* byproducts are designed with the environment and other members of the EIP in mind. Rick Luna of the Brownsville Economic Development Council,

summed up this problem by saying "we need to get plant managers to think outside their factory fence, in a non-traditional way."

- *Bureaucratic inertia (identified as a barrier in a number of U.S. projects).* The inability to cross boundaries within and between agencies is viewed as an impediment to integrated development approaches. New programs under the Regulatory Reinvention and Common Sense initiatives in the United States have begun to break down this barrier but this is expected to be a slow process. Successful demonstration projects will go a long way to assisting this process. The shared jurisdiction over environment in Canada has the potential to create significant bureaucratic barriers. Local or regional champions will be very important in breaking down those barriers. Experience in the United States has shown that such champions make an important difference in creating the necessary momentum.
- *Lack of support tools.* The development of the necessary information base on inputs, outputs, skills, opportunities, etc. is a time consuming and costly effort. Funding to produce a comprehensive information base has been difficult to obtain in most instances. The recent release of a report by the Bechtel Corporation for the Brownsville/Matamoros Regional Industrial Symbiosis Project of a computerized tool to develop scenarios of materials exchange as well as the U.S. EPA's *Eco-Industrial Park Decision Support System*

software should provide tools that can be used to reduce this barrier.

- *Predominance of a short term view.* Changing the way we do business is fundamental to implementing industrial ecology. EIP developments should be viewed as a capacity building process over the long term, not as something that will yield significant benefits over the short term. Donald Huisinck from the International Institute of Industrial Economics commented that a key limitation is time - "The government and industrial organizations expect instant success. They didn't or don't properly appreciate that such programs take time to evolve." Time is required to build understanding and trust among participants. Along with the development of an information base, it is important to establish partnerships locally, and then with state (provincial) and federal agencies with the objective of creating a common view. Projects which have not followed a structured process of creating this partnership seem to have lost some momentum.
- *Lack of adequate opportunities for establishing byproduct linkages.* Current industrial development patterns do not lend themselves well to the establishment of material and energy linkages. In part, this is because of the complexity of such linkages and the costs associated with overcoming them. In order for materials to be exchanged, for example, a number of conditions must be met including: appropriate matching of material in each other's processes; sufficient quantities must be available at an appropriate rate;

sufficient incentives must exist to drive the transaction on the part of all parties; and it must be economically superior to other alternatives.

- *Lack of organization among those interested in EIP development.* This appears to be more of a problem in Canada than the United States, where more activities related to EIP development have taken place. Given the complexities involved, it is very important to gather all of the key stakeholders in a given project together and to build support for the concept and its implementation.
- *Lack of education and awareness.* This is deemed as being particularly important among key stakeholders such as local governments, economic development agencies, banks and the commercial real estate development community. Private sector involvement and willingness to fund feasibility projects also stems from a lack of awareness of the potential economic and environmental opportunities. Some communities and local governments have responded unfavourably to new environmentally responsible industrial development proposals. The Not In My Backyard (NIMBY) syndrome reinforces the need for broad stakeholder involvement in the visioning, planning and implementation of EIPs.

A shift to EIPs represents challenges for business, government, researchers, developers, and communities, so it is not surprising that many barriers have emerged during initial attempts at implementation. Fortunately, progress in overcoming many of these barriers is being made.

Once the eco-industrial park concept takes off, business creativity will carry it forward. In the meantime, governments should promote the concept, provide funding for community planning exercises and broad scale feasibility studies and be prepared to adapt regulations where required.

Gil Friend, Principal,
Gil Friend & Associates, U.S. Industrial Development Consultants

3.0 The Roles of Government, Industry, Community and Academe

A review of the experience of the United States and Europe illustrates that a variety of stakeholders have important roles to play in promoting the development of eco-industrial parks and networks. A combination of “top-down” and “bottom-up” support and activity is required.

3.1 The U.S. Experience

The U.S. has been actively involved in the promotion of EIPs since 1994 when a major contract was let to Research Triangle Institute in South Carolina and Indigo Development in California to assess the potential application of industrial ecology to economic development. The Environmental Protection Agency (EPA) was the primary federal agency interested in the concept at the time. Their interest resulted from new White House initiatives to "reinvent regulation" and promote community economic development. In 1995, EPA took up the challenge, looking at ways to improve the efficiency of its regulatory programs and reduce the burden on all concerned. EPA efforts were directed at cutting red tape, partnerships, flexibility and facilitating compliance.

Some of the specific projects which resulted include one stop reporting, multimedia and geographic approaches, performance partnerships, consensus based rule making, project XL on alternative management strategies, effluent and emissions trading, brown field centres redevelopment, small business compliance centers and an environmental leadership program. Project XL is a pilot program oriented at regulatory flexibility as long as superior environmental performance is achieved. It has been identified as one which would support the establishment of EIPs. Project XL is results-oriented rather than rules-driven and applies to industries, industrial sectors and communities. EPA provides a flexible and innovative approach to regulatory requirements in return for a commitment to environmental excellence and leadership and results in greater than minimum standards. The key to Project XL is that it focuses on environmental goals rather than technologies or processes and allows communities or groups of industries to interact rather than focus on control of individual sources. In this sense it could be argued that it is ecosystem oriented.

In an interview with Ms. Suzanne Giannini-Spohn, U.S. EPA, Office of Policy, Planning and Evaluation she stated that the policies and programs

that are needed to promote EIP development are:

Those that promote resource efficiency, recycling, pollution prevention, environmental management systems. In my opinion, at the federal level we need a coordinated effort to promote resource efficiency and to remove disincentives to the use of recycled/reused materials.

The U.S. EPA has spent approximately \$1 million in support of a variety of EIP development initiatives. The use of these programs to support EIP development allows the EPA to address many of its strategies and goals simultaneously, rather than through a more traditional media-based approach.

In addition to this direct support for EIP development, the Clinton Administration launched efforts to enhance economic development in urban centres throughout the country. One of several major initiatives is called the Empowerment Zones and Enterprise Community Initiative. Under this job creation initiative, seventy-two urban centres and 33 rural communities have received in excess of \$1.5 billion in performance grants and \$2.5 billion in tax incentives to create sustainable employment and support programs.

A related initiative providing financial support for EIP development in the United States is the Brown Fields Economic Redevelopment Initiative, launched in July 1995. Under this initiative communities with abandoned and contaminated industrial and commercial land receive financial support for redevelopment strategies. A

broad range of stakeholders including developers, local authorities and community representatives work together to:

- Assess the level of contamination;
- Involve community residents in all aspects of cleanup and redevelopment efforts;
- Leverage public and private funds to attract new economic activity;
- Resolve liability concerns; and,
- Serve as models for other communities seeking redevelopment approaches.

This initiative has been used to begin the development of an EIP at Cape Charles, Virginia.

At approximately the same time as these initiatives were announced, the President's Council on Sustainable Development (PCSD) was becoming increasingly interested in eco-efficiency. By definition, an eco-efficient production system uses less material, water and energy inputs and reduces the cost of manufacturing. This led to the creation of a Task Force on Eco-Efficiency. They established a program to promote EIP development and selected four demonstration sites through a contest. These sites enabled the Task Force and other project participants to assess the barriers and benefits of this concept. The results of this work on EIPs are contained in a PCSD report entitled, *Eco-Efficiency Task Force Report*.

Two other key departments of the U.S. government were brought into the picture through the work of the PCSD. These are the U.S. Department of Commerce and the U.S. Department of Energy. The three departments and the

PCSD continue to promote and assess the concept of EIPs. Four conferences/workshops have now been held in the United States on the subject of EIPs and a fifth is planned. In addition to the original four demonstration sites adopted by the PCSD and supported by the three government agencies, many other communities have recognized the potential for EIPs to link together a number of government programs launched by the Clinton Administration under the Common Sense Initiative. In a number of cases, communities with the support of government agencies are linking the EPA Brown Fields Redevelopment, Empowerment Zone and Small Business Support programs.

Research conducted by the U.S. EPA on EIPs has resulted in the identification of a number of regulatory strategies for encouraging the development of industrial ecosystems and the implementation of pollution prevention in the context of EIPs. These strategies could be used by Canadian policy makers to identify opportunities for improving government support for EIP development. They include:

- Modifying existing regulations;
- Streamlining existing permitting and reporting processes;
- Moving from technology-based regulations (which can stifle innovation) to performance-based regulations;
- Promoting the use of facility- wide permitting;
- Promoting the use of multimedia permitting;
- Utilizing market-based approaches, such as emissions trading;
- Utilizing voluntary agreements such as covenants, an approach currently

being undertaken at the Stonyfield/Londonderry EIP;

- Implementing manufacture 'take back' regulations which will impact on the design, production, use, reuse and recycling of products;
- Promoting technology diffusion within and between industrial sectors;
- Providing opportunities for technology development and commercialization; and,
- Providing technology development grants specific to industrial ecology applications (Bechtel, 1997).

In Canada, most of the authority over environmental protection and industry is vested in provincial governments. A number of them, such as Ontario and Alberta, are currently engaged in reviews which incorporate some of the elements described above.

3.1.1 Eco-Industrial Park Workshops

Four workshops have been held in the United States on eco-industrial parks. These have been very successful at raising awareness and establishing a network among those who are actively promoting such developments. The first was held in San Diego, California in 1994 and co-sponsored by the U.S. EPA. This workshop was promoted to an international audience on designing, financing and building the industrial park of the future with a particular emphasis on the use of waste materials. This workshop attracted approximately 150 people from industry, consultants, business associations, local, state and federal government agencies, universities, and environmental interest groups.

A second workshop was held in Cape Charles, Virginia in October 1996 to coincide with the opening of the Port of Cape Charles Sustainable Technologies Industrial Park. The latter is one of the four demonstration projects adopted by the PCSD. This workshop was co-sponsored by the PCSD and Northhampton County and the Town of Cape Charles. In addition to updates on each of the 15 developing eco-industrial parks in the United States there was also a presentation on Burnside Industrial Park in Dartmouth, N.S.

The third workshop was held in Brownsville, Texas, another of the PCSD demonstration sites, in March 1997. Sponsorship of this workshop reflects a growing interest in eco-industrial parks in the United States. The sponsors were the Brownsville Economic Development Council, the Environmental Defense Fund, the City and Port of Brownsville, the Texas Manufacturing Assistance Center, the Gulf of Mexico Business Council for Sustainable Development and the Comite para el Desarrollo Economico de Matamoros.

A fourth workshop was held in Washington in June, 1977. At that meeting of the Cornell based Eco-Industrial Development Program, the representatives of federal agencies and national institutions including the PCSD, the U.S. EPA, Department of Energy, the Economic Development Administration, the Department of Housing and Urban Development, the Joint Center for Sustainable Communities of the National Association of Counties, the Laborers and Employers Cooperation and Education Trust and Institute for Local Self-

Reliance participated in the workshops.

These workshops have served a number of purposes. First they have created a network of interested stakeholders. As a new concept there was a danger that groups involved in planning the various projects would feel they were "out on a limb" without visible means of support. The workshops allowed EIP project representatives to communicate with one another. Second, the workshops permitted the PCSD, EPA, university researchers, and project leaders to discuss barriers and successes in overcoming them. For example sessions have been held on:

- Initiating an industrial ecosystem project;
- Recruiting private sector involvement;
- Governance structures;
- Financing projects; and,
- Setting performance standards.

Third, these workshops have encouraged other communities and groups to launch new EIP projects.

3.1.2 Eco-Industrial Park Projects in the United States

EIP projects in the United States demonstrate a variety of characteristics. In some cases actual, spatially defined industrial parks are involved while in others, that eco-industrial networks, linking discrete industrial facilities in and around a community are the focus of the project. Some parks involve green field sites while others involve brown fields (e.g.; Chattanooga and Plattsburgh). Some parks emphasize environmental technologies (e.g.; Cape Charles), while others highlight natural systems (e.g.;

Riverside and Raymond Green). Projects in the United States are described in more detail in Appendix 2.

The stakeholders or partners involved in these projects vary considerably across the United States. In most cases, EIP projects involve economic development agencies of local government such as the Brownsville Economic Development Corporation, the Baltimore Development Corporation, and the Burlington County Office of Economic Development. At the local or municipal level of government, the champion in the United States has generally been the local economic development agency or commission. In other instances, local community groups or institutions such as the Northhampton County Sustainable Development Task Force, or the Solid Waste Advisory Committee of Skagit County have taken the lead.

State agencies such as the New Jersey Department of Environmental Protection, or the Virginia Departments of Conservation and Recreation, and Housing and Community Development; national organizations such as The Nature Conservancy and the Environmental Defense Fund and federal agencies have also become involved. A wide range of companies including Bechtel Corporation, Brown and Root, Solar Building Systems Inc., Boeing Company and Seafirst Bank are also participating. In the majority of cases, efforts have been made to establish a strong local constituency with a wide range of interests.

All of the U.S.EIP projects are at different stages, but essentially still in early developmental stages. Some have done extensive planning such as the

sites in Chattanooga, Tennessee and the Fairfield area of Baltimore, Maryland, while others are slightly less advanced, such as Brownsville, Texas and Plattsburgh, New York. The Green Institute's project in Minneapolis, Minnesota may be the first one actually implemented. The reasons for this include strong leadership from the non-profit Green Institute, grassroots community support for the project (members of the community also volunteer to assist the Green Institute), the goals of urban redevelopment and job creation, and foundation funding support for the project. A more detailed description of this initiative is provided in the box below.

Case Study: EIP Under Development - The Green Institute, Minnesota

One reason for the recent proliferation of EIP projects in the United States has been the success of American industrial ecology champions in mobilizing support for EIP projects from a variety of sources. The Green Institute's EIP initiative in Minneapolis, Minnesota is an excellent example of such success. The Green Institute, a not-for-profit organization, is currently conducting a baseline study to further their intention to redevelop an industrial park in a disadvantaged area of downtown Minneapolis. It is hoped that this project will not only provide environmental benefits, but also stimulate the local economy and create jobs in the economically depressed area.

In order to advance this project the Green Institute has had to solicit and secure funding and in-kind support from a number of partners. The largest contributor to this initiative is the Northwest Foundation which contributed a grant worth \$216,000 (U.S.) which has made possible much of the preliminary work on this project. Aside from this financial support the Green Institute has also relied upon in-kind support from academic institutions. The University of Minnesota's Center for Survey Research has assisted in the data gathering phase of the project and Cornell University's Work and Environment Initiative has provided both strategic and technical assistance.

Government support to date for the Green Institute's EIP project has been in the form of strategic advice and networking support from the U.S. EPA. Additionally, participation by the President's Council on Sustainable Development has been instrumental in providing strategic support and also in raising the profile of the project. It is believed that federal government support will continue to grow and evolve during the course of the project.

The Green Institute is a grassroots organization and their biggest success to date has been obtaining the support of the local community for the project. Through their various communications and outreach efforts they continue to rally resident support for a project which promises to contribute to a better way of life for members of the community.

During the upcoming phases of the project the Green Institute hopes to secure more cooperation from local government and local economic development agencies, further funding from philanthropic foundations and potential funding from the U.S. government. Through its continuing efforts to bring a number of partners to the table it is likely that the Green Institute will realize its goal of an EIP in downtown Minneapolis. There is also a willingness on the part of federal agencies such as the EPA, the Department of Commerce and the Department of Energy to provide financial support for EIP development through a variety of programs and initiatives.

Another Green Institute initiative is the building of a new commercial industrial center, called the PEEC (Phillips Eco- Enterprise Center) which is to serve as a catalyst for new eco-industrial type activity. New businesses are to be nurtured in the incubator portion of the building. These businesses will use waste materials identified in the baseline study. Established businesses with an environmental slant will also be situated in this building. The building itself is to be a model for similar future developments and incorporates many environmental upgrades to the design including wind and solar power, passive solar heating, high efficiency lighting, gray water recycling, and composting toilets. It is hoped that most of this material will be donated. Most of the materials for this construction will come from the Reuse Center which is a construction/renovation materials recycling store run by The Green Institute.

Source: (Thad Mermer, pers. com., Dec. 1997)

Another important project being developed in the U.S. is the Brownsville, Texas/Matamoros, Mexico prototype eco-industrial park (see figure page 33).

This park was constructed to analyze economic, environmental, technical and regulatory issues for the Environmental Protection Agency. This work was

conducted by the Centre for Economics Research of Research Triangle Institute and Indigo Development (1996). This virtual eco-industrial park would be centered on the Port of Brownsville but link with industrial partners which are located remotely in the region. The principal members in the Port would include a refinery, a limestone company, an asphalt company and a tank farm. The remote partners would include a metal and plastics parts manufacturer, a textile plant, an auto parts manufacturer, a plastic recycler, a seafood processor, a chemical plant, a manufacturer of magnetic ballast and a gypsum wallboard company. The prototype developed through a series of 5 scenarios, involving pollution prevention, waste exchange, addition of new members and co-location and joint servicing. The following diagram represents the final scenario which could be economically sustainable with reasonable changes to the regulatory framework.

Source: (Bechtel Corp., 1997)

3.1.3 University and Research Institutes

Industrial ecology theory and EIP development are also being supported by research and development programs in universities including MIT, Harvard, Yale, Texas and Cornell. The latter's Eco-Industrial Development Program, launched by the Center for the Environment and the Work and Environment Initiative is playing a major role in supporting information gathering and planning at several sites. MIT has recently launched an academic journal, *The Journal of Industrial Ecology*, dedicated to industrial ecology.

Major American defence laboratories such as Oakridge National Laboratory and the Lawrence Livermore National Laboratory have been considering industrial ecology as a new area of emphasis. The Office of Energy and Environmental Systems at the Lawrence Livermore Laboratory has just commissioned a prominent group of scientists in the field to identify directions for further research in industrial ecology.

3.2 The European Experience

Experience in Europe is always linked to Kalundborg, Denmark. Kalundborg, described by the diagram on page 36 was not a planned EIP but rather an effort to create symbioses among the industries in and around the town in order to reduce costs associated with pollution control and to conserve fresh water. The success of the concept is demonstrated by the reductions in discharges of pollutants to air, water and soil and the resulting cost savings generated.

Other projects have started in the Styrian Region of Austria, at Rotterdam Harbour, Denmark, in Sweden and Ireland. The Austrian project looks at eco-industrial networking on a regional rather than park basis and is being led by university researchers in Graz, Austria.

The Rotterdam Harbour project, led by researchers at Erasmus University, involves 85 medium-to-large industries in Europort. It focuses on medium-to-large industries in the petroleum and petrochemical and related support industry sectors. The Dutch government is interested in promoting integrated chain management (industrial ecology; better supplier/customer relations) and cleaner production.

The Swedish project is in Linköping and is led by university researchers. It aims to create symbiotic relationships between the university, research institutions and companies in Linköping.

The Irish project is of a smaller nature, along the lines of the Green Institute's initiative in Minneapolis and involves the transformation a former industrial facility.

A particular initiative in France is deserving of special mention. A consulting company, Oree, has developed an eco-labelling scheme for industrial parks in France similar to the guidelines developed by the Burnside project for transforming industrial parks into ecosystems. Under the proposed scheme, firms would be able to use the 'PALME' eco-label to identify themselves as participants in an EIP (PALME stands for Program d'activités labellisées pour la maîtrise de

l'environnement). A local PALME team provides state-of-the-art technical and managerial assistance to participating firms including access to computer aided environmental management self-evaluation. Handbooks are provided which explain the procedures for environmental management systems, product life cycle analysis and energy conservation. This approach emphasizes the management of environmental issues on a park basis, as opposed to a facility basis.

Five pilot industrial zones involving largely foreign multinationals are developing criteria and procedures for establishing the PALME eco-label. The criteria for PALME EIPs is provided as Appendix 3. This French initiative is now expanding and the PALME eco-labelling scheme may be accepted by the European Community as sufficient to qualify for the voluntary Environmental Management and Audit Scheme accreditation program.

With the emphasis on cleaner production and cleaner products, Europe will likely remain fertile ground for the creation of EIPs and networks. Industrial ecology has been one of the themes at meetings of the European Roundtable on Cleaner Production since its inception in 1994.

Source: (Côté, 1997)

As part of our efforts to promote innovation, a new Liberal government will increase support for improving environmental efficiency and innovation in Canadian firms and products...

Securing Our Future Together: Preparing Canada For the 21st Century.
The Liberal Plan - 1997

3.3 The Canadian Experience

There is a growing level of interest in the development of EIPs in Canada. For the most part, interest originated in academic institutions such as Dalhousie University in Nova Scotia and later, at the University of Toronto. The intriguing possibilities EIPs present have also caught the attention and imagination of a handful of champions in the public and private sectors. Although in its infancy in Canada, the establishment of several successful pilot projects and research efforts have yielded promising results and helped to set the stage for more widespread EIP development.

In February 1994 a workshop in Toronto entitled "Industrial Ecology: Making Business More Competitive", was sponsored by a group of ten governments, businesses and business associations. This workshop was successful in introducing the concept of industrial ecology to over 150 business and government leaders, but following the workshop there remained no organized or formalized infrastructure for EIP promotion and development. Momentum for EIP development was not generated by government or private sector coalitions, but was generated instead by isolated projects led by a handful of individuals.

One of these was Professor Ray Côté of Dalhousie University who mobilized support from a variety of sources to begin to re-engineer the Burnside Industrial Park in Dartmouth, Nova Scotia. (See box below) Through working with local industry to establish a variety of waste linkages (described in the report *Designing and Operating Industrial Parks as Ecosystems*) Côté and his team were able to demonstrate the viability of EIP development in Canada. Further evidence of industrial ecology's tangible benefits is present in the Bruce Energy Centre near Tiverton, Ontario which utilizes the cascading of excess steam from the Bruce Nuclear Generating Station to power a number of industrial applications. Most recently, research on firms located in the Portland Industrial District in Toronto, Ontario has generated more evidence of the potential economic benefits provided by EIP development.

Recently, progress in Canada continues due in large measure to the efforts of three federal agencies: Environment Canada, Industry Canada, and Natural Resources Canada. Research projects examining potential brown field EIP development in both Sarnia, Ontario and East Montreal, Quebec (see figure describing potential improved energy linkages on page 40) have yielded promising results and the prospect of future EIP implementation in these

areas. Another initiative undertaken by these agencies was to commission a study by ThermoShare Inc. which identified 40 industrial parks across Canada which hold promise for the implementation of energy-based industrial ecology projects.

ThermoShare was also instrumental in working with these agencies to organize a one-day workshop on EIP development held in November 1996 in Ottawa. This workshop provided a setting for some progressive discussion on the topic and valuable networking among the participating government, consulting, economic development, and industry representatives.

Aside from the aforementioned government-driven initiatives, provincial and local support for EIP initiatives has not materialized in the same way as it has in the United States. In part, this may stem from the fact that awareness of EIP developments and the potential benefits to industry are not well understood outside of the handful of Canadian champions. Communications work, however, by these champions, such as a technical workshop at the 1997 Air & Waste Management Association Conference in Toronto and articles published in *Alternatives Journal*, *EcoCycle*, and *Hazardous Materials Management* help to raise the level of awareness among Canadians.

In order to continue this communication and awareness raising, a conference on EIPs in Canada will likely be held in the early spring of 1998 in Toronto. Other recommended measures to help promote EIP development in Canada are provided in section 6.0.

Case Study: Burnside Industrial Park, Nova Scotia

Burnside Industrial Park in Dartmouth, Nova Scotia (now Halifax Regional Municipality) is considered a living experiment in transforming an existing industrial park into an industrial ecosystem. The park is the focus of a multi-disciplinary research and development program based at the School for Resource and Environmental Studies, Dalhousie University. The goal of this program is to test the application of various industrial ecology strategies and tools.

Burnside was established 25 years ago and has grown into one of Canada's largest industrial parks encompassing 1,200 hectares, with more than 1,200 businesses and approximately 18,000 people. Many of Canada's small and medium sized business sectors are represented in the park bringing in a large variety of materials and products and generating various wastes. The Park has been evolving and maturing in an ecosystemic sense. Site development standards for the construction and operation of facilities are extensive and increasingly environmentally sensitive. In recent years many companies have filled niches which foster the reuse, recovery, remanufacture, rental and recycling of materials. Environmentally friendly products are increasingly being sold and used which reduce the environmental impact of goods and services provided from the Park. Efforts have been underway to educate managers and employees by providing waste minimization fact sheets, a booklet on opportunities for reusing, remanufacturing, renting and recycling materials in the Park, and a monthly newspaper column, *The Burnside Ecosystem*. As a living experiment, the project continues to test new strategies and tools and attempt to enhance the evolution of Burnside at a more rapid rate than would occur "naturally".

The Burnside Cleaner Production Centre (BCPC) was established in March 1995 for a one year period to assess the need for a focal point to promote and provide information on strategies which would facilitate the creation of an industrial ecosystem in the Park. These strategies included waste reduction, pollution prevention, environmental auditing, and industrial symbiosis and waste exchange. This Park and most industrial parks in Canada are operated by municipal governments through their industrial or economic development offices. In some instances, they are the responsibility of industrial commissions or regional development authorities. As such, encouraging park-wide activities can be problematic unless businesses have formed an association.

A number of different services were investigated during the tenure of the Centre. The BCPC served as:

- An information centre on waste reduction and pollution prevention opportunities and regulations;
- A networking service especially for businesses which could use the waste materials of others;
- A waste reduction fair and producer of a booklet on the five Rs;
- A coordinating service for businesses which might cooperate in environmental management initiatives; and,
- An auditing service undertaking preliminary surveys of environmental problems and opportunities in individual companies.

A number of additional niches were identified. These included:

- A centre for packaging reuse;
- A used building materials facility (one has been established by a private company in the park);
- A centre for creative reuse for small quantities of diverse materials which might be used by schools and the arts and crafts community; and,
- A chemicals exchange for small quantity generators (a local exchange already exists for universities and hospitals in the metropolitan area).

Some of these services should be operated on a cost recovery basis. Providing such services might serve to attract responsible businesses to locate in an industrial park but the scale of the centre's operations will depend on the size and complexity of the industrial base in the park.

Source: (Venta, 1997b)

3.4 Support Tools

The experience to date has led to the development of a number of important support tools. The question of what support tools are needed to promote EIP development was asked at a meeting of eco-industrial park practitioners held at Cape Charles in October of 1996. The most frequently cited needs were:

- A mechanism for how to develop the industrial ecosystem linkages needed to make the park work (what types of industries need to co-locate for maximum efficiency?);
- Financial tools (how does one sell the idea to financing agencies, and especially to the private sector); and,
- Model codes and covenants for agreements among the members of the eco-industrial park (what does one do if a member violates provisions of a park environmental blanket permit, etc.).

In a number of EIP projects, there was earlier recognition that an information management system would be required to facilitate the interconnectedness which is at the heart of an ecosystem. The U.S. EPA has supported the development of the Eco-Industrial Park Decision Support System called the Designing Industrial Ecosystem Tool (DIET). This software program includes a linear programming optimization model designed to aid decision makers and planners in identifying combinations of industrial facilities that exhibit economic and environmental potential in a specific area. In Brownsville, Texas they are currently using the DIET

software to help develop an industrial ecosystem. DIET is also currently being tested in Plattsburgh and Boston.

Several firms recognize that there are opportunities to provide industry with a variety of products and services directly related to EIP development. For example, the Bechtel Corporation has been developing an information system with search and match capability and the ability of producing mass flow scenarios for a region as well as sector scenarios for selected industrial categories. Bechtel is interested in marketing a capability to assist in the planning and management of EIPs. A private property development and management company, Robson-Dunk Inc., has developed EMEX, an environmental management excellence system for EIPs and industrial complexes. The purpose of EMEX is to facilitate the accomplishment of eco-efficiency goals by voluntary, market driven, self-regulatory means. Robson-Dunk has operations in the United Kingdom and the United States.

Two major resources in support of EIP development have been produced as a result of work done by Indigo Development for the EPA. One was produced by Research Triangle Institute titled *Eco-Industrial Parks: A Case Study and Analysis of Economic, Environmental, Technical and Regulatory Issues*. A companion report, *A Fieldbook for the Development of Eco-Industrial Parks*, was prepared by Indigo Development.

3.5 Other Experience

Japan has been interested in industrial ecology concepts since the early seventies beginning with an emphasis on energy efficiency followed by material use efficiency. More recently, Japan adopted the 1991 Law Promoting the Utilization of Recycled Resources and the Ministry of International Trade and Industry has been investigating the concept of 'Ecofactories', with particular attention to the life-cycle of products and design, production, dismantling, reprocessing and systems technologies. In 1996, the EBARA Corporation proposed to construct an EIP in Fujisawa involving residential, industrial, agricultural and recreational facilities. This EIP is slated to open in the year 2000.

There has also been activity on industrial ecosystems in the former Soviet Union since the mid-eighties. The Mendeleev Institute of Chemical Technology in Moscow had what was the perhaps the first academic Department of Industrial Ecology in the world. Projects were carried out in a number of industries in Russia and other republics.

There is also growing interest in EIP development in countries such as Indonesia, the Philippines, Mexico, Thailand and India among others. In Indonesia, one of the key players is Sustainable Project Management, an institution launched by Hon. Hugh Faulkner, a Canadian associated with the International Chamber of Commerce and the World Business Council for Sustainable Development. In the Philippines, initiative is being taken by a private corporation with support from the

University of the Philippines, Los Banos and the Asian Institute of Management.

The Industry and Environment Office of the United Nations Environment Program (UNEP-IE) has also become interested in EIPs as a result of its work on environmental management of industrial estates. This work has been supported in part by Environment Canada. In its recently released guide to Environmental Management of Industrial Estates (UNEP, 1997), the UNEP-IE suggests that the development of industrial ecosystems would be the ultimate aim of an environmental management program for an industrial park.

3.6 Roles of the Private Sector

EIP development experience to date indicates that the private sector has a variety of critically important roles to play. That to date, most of the work being done does not involve traditional large industrial and commercial firms but rather, is being led by consulting/engineering firms. As EIP development continues to mature, traditional industries, particularly those who have developed a culture of innovation and continuous improvement, will likely be the first to embrace it.

Some of the key roles being played by the private sector include:

- Promotion of the EIP concept and provision of services and products in support of its implementation. This includes the provision of technical information required to assess the material and energy flows, the development of software tools to support this activity and

communications, planning, public consultation and design;

- Financing and conducting of feasibility studies on specific industrial ecology projects;
- Provision of advisory and active support to local, sub-national and national governments and economic development associations on EIP development; and,
- In the near term, the provision of capital and expertise required to evaluate and implement the required infrastructure developments.

These are still early days in the development of EIPs and the private sector in the United States is still feeling its way. Some companies have played significant roles. The Eco-Efficiency Task Force of the President's Council on Sustainable Development, which spearheaded eco-industrial park activity in the United States, had private sector membership: Georgia-Pacific Corporation, Ciba-Geigy Corp., Dow Chemical Company, General Motors Corp., S.C. Johnson & Son Co., and Amoco Corp.

Major consulting companies such as Bechtel Corporation of San Francisco have recognized the potential of EIPs and have become involved. One of the products under development by Bechtel is a computer based tool for evaluating technically feasible materials exchange scenarios (see section 3.4). Property management companies such as U.S. Facilities Management Inc. and Robson-Dunk Development Inc. also see the potential of EIPs in providing value-added services in their management portfolios.

Technology companies such as Lucent Technologies (formerly AT&T) are interested because of the potential for new technologies, designs and materials. It is also important to remember that the paper which launched industrial ecology as a serious concept and field of study was authored by two senior General Motors personnel, Robert Frosch and Nicholas Gallopoulos.

Large firms with existing facilities that have demonstrated environmental management excellence are likely to continue to support EIP development activities as well as those with a secondary interest in seeing linkages develop such as resource recovery and recyclers and energy and technology and service suppliers. Smaller firms will realize more benefit when EIP networks become more sophisticated.

3.7 Conclusion

The development and implementation of EIPs clearly requires active participation and support from a number of stakeholders. Senior levels of government have important roles to play in demonstrating leadership by identifying eco-industrial development as a strategic approach to sustainable development, setting a supportive policy framework, providing core financial support, coordinating the programs and efforts of key agencies and raising the level of awareness. Local governments, local economic developers and related bodies have important roles to play given their jurisdiction over, and involvement in, local economic development planning and infrastructure services, maintenance and development support. Grassroots community

organizations, as the United States experience demonstrates, can also play a leading role in EIP development. Without sufficient community and local government support it is unlikely that EIP projects will realize their full potential.

At this stage in the development and application of industrial ecology theory, academic institutions are also playing important roles by providing research and development on the theory of industrial ecology. Additionally academic institutions are promoting awareness through the creation of new journals and specialized programs, and, as champions and key partners in EIP projects throughout the United States, in Europe, Canada and Asia.

Finally, service-based consulting companies in the private sector are currently playing important roles in championing industrial ecology and in the development of tools required to increase the rate at which EIP development occurs. Industrial ecology holds the promise of initiating significant changes to traditional manufacturing and thus, represents significant opportunities for the services sector. Private industry, including financiers, will ultimately have to evaluate and invest in industrial ecology projects that provide economic and environmental benefits.

In the near term, it appears as though firms that are already integrating sustainable development into their corporate culture and strategic planning will be the first to fully embrace and benefit from industrial ecology and eco-industrial parks. While these companies remain a small segment of the overall business community, a shift towards EIP

as a mainstream approach to industrial and commercial development will broaden overall business interest in eco-efficient products, processes, and services. Product and service firms in the environmental industry sectors will clearly benefit from the overall 'greening' of industry represented by the gradual shift towards EIPs we are now witnessing.

Crafting eco-industrial parks and industrial ecosystems can draw upon many design options, not just byproduct resource exchange strategies. Each project must be designed in terms of the site, the community and the region. There are no blueprints!

Ernest Lowe, Indigo Development.

4.0 Key Elements for a Successful EIP Development

Prior to reviewing strategies and programs among Canadian federal and provincial government departments related to EIP development, the critical elements for successful EIP projects were identified. While there are clear differences between green field and brown field developments, the experiences gained in the United States, Europe and Canada suggest that the following elements are central to achieving early success:

- Adequate financial support for EIP management with a strong public/private partnership;
- Regulations which stress flexibility, higher performance, community participation, environmental management systems;
- Financing and taxes which have flexibility, encourage reduction of waste and enhanced efficiency as well as the creation of investment funds;
- Programs which support community economic development initiatives linked to strong and forward looking local community business organizations;
- Involvement of labour through skills development programs;
- Transportation logistics including multi-modal, and inter-modal systems, public transportation, and

- shared facilities;
- Access to sufficient publicly/private owned land that can be used for future development purposes;
- The existence of private sector and government champions at the local, sub-national and national levels;
- Sharing of information about operations by companies and openness to depending on each other; and,
- The existence of medium to large enterprises to help 'anchor' the EIP, particularly where district energy systems can be established on sources of excess 'waste' steam or effluent.

The experience of U.S. proponents of EIP development suggests that the following generic steps are required to develop an EIP strategy. These are:

- Obtain sufficient funds for development activities;
- Involve the community and develop of a vision;
- Build consensus around the key features of the EIP;
- Understand the EIP and its relationship to the community, not simply as a 'piece of real estate';
- Develop an understanding of the existing material and energy flows and identifying opportunities for interdependencies;
- Promote communications and learning;

- Understand the economics involved and have appropriate economic incentives;
- Make sure information is accessible to industries and community;
- Reduce and address technical and financial risk;
- Expedite implementation with government regulatory support; and,
- Ensure confidentiality and building confidence.

These principles were used to help identify federal and to a lesser extent, provincial government strategies, policies and programs that might support such developments.

What is required to improve industrial ecology is good information about the material and energy flows in the region, knowledge about possible exchanges and a communication program which helps that managers of companies get to know each other better.

Erich Schwarz, Styrian Region Project, Austria

5.0 A Review of Selected Canadian Federal and Provincial Strategies and Programs

One of the objectives of this research is to identify existing and potential federal and provincial government strategies and programs that may support EIP development in Canada. To accomplish this, a series of keywords were entered into the Business Development Institute's CANLOC database. A total of 54 federal and provincial programs were extracted from the database and reviewed (see Appendix 4). In addition, strategy and policy documents from Environment Canada, Industry Canada, the Atlantic Canada Opportunities Agency (an example of a federal regional development agency), and the Nova Scotia Department of Economic Development and Tourism (an example of a provincial economic development agency) were also reviewed.

While this does not provide a comprehensive analysis of the strategies, policies and programs of Canada's federal and provincial governments, it is clear that a strong policy and program base already exists among key federal departments for supporting EIP development. A review of several major policy documents and their relationship to industrial ecology is presented below, followed by a description of a number of federal and

provincial programs that may be used to support EIP development activities.

5.1 Strategies and Policy Frameworks

Based on our analysis of the economic and environmental benefits attainable through EIP development, it is clear that a strong strategic and policy framework exists at the federal and provincial levels to support activities that promote EIPs.

5.1.1 Securing Our Future

The principles of environmental stewardship articulated in the government's "Securing Our Future Together" plan for Canada support EIP development. These include: the focus on improving science and technology, promoting innovation, resource use efficiency, research on toxic substances, action on climate change, and investments in infrastructure. A number of new programs described in this document may also support EIP development and several of these are described in more detail in section 5.2.

5.1.2 Environment Canada's Action and Business Plan, and Sustainable Development Strategy

A review of Environment Canada's 1997/98-2000 Action and Business Plan reveals that activities in support of EIP development would help to accomplish the goals and objectives of this department. Environment Canada also released its Sustainable Development Strategy in April 1997. That strategy, it can be argued, has adopted values, principles and approaches relating directly to EIP development. For example the strategy commits Environment Canada to "encouraging practices that replace renewable resources faster than they are used up, taking the needs of industry, society and the environment into account; and encouraging more efficient use of non-renewable resources like oil, natural gas and minerals." As a challenge the strategy identifies "dealing with the integration of environmental, economic and social issues." This challenge must also be addressed by Industry Canada and Natural Resources Canada, and in fact, the federal government as a whole. The strategy states that meeting this challenge will require cooperation among governments and new and innovative approaches. Extensive EIP development across Canada would satisfy this.

The strategy also states that the department will become a more effective advocate of sustainable development. Priority will be given to "changing the processes of governance and decision-making; and building partnerships across social, economic and environmental sectors." It is difficult to

achieve this except at a very superficial level, on a national or international basis. This change will be felt most concretely at the local level, where social, economic and environmental issues come face-to-face for the average citizen. Initiatives achieving this integration at the local level are those that are likely to make more of a difference. The strategy says that the Department will work to "stimulate innovations by streamlining the regulatory burden, encourage industry to adopt sustainable development approaches, in particular eco-efficiency; develop voluntary approaches; ... develop with other government departments and natural resource industries clear policy statements related to the greening of energy...." EIPs would be excellent demonstration projects in assisting Environment Canada and other departments in implementing the principles and approaches of their Sustainable Development Strategies.

5.1.3 Industry Canada's Draft Sustainable Development Strategy

Although in draft form, Industry Canada's SD Strategy establishes a policy framework that is also supportive of EIP development. The strategic objectives outlined are:

- To foster a marketplace climate that promotes sustainable development;
- To enhance the ability of Canadian firms to develop and use innovative new technologies and tools which contribute to sustainable development;
- To encourage trade and investment flows contributing to sustainable

- development; and,
- To improve the capacity of Industry Canada to manage and deliver departmental policies, programs and operations which contribute to sustainable development.

The key priorities established in the draft document which can be directly achieved through EIP development include: encouraging technology development and diffusion, working in partnership with industry to develop innovative tools and practices, and encouraging better linkages between the ground rules on how the market place works and sustainable development. The strategy also identifies EIPs as an emerging concept and states that “there are clear environmental benefits associated with an ecosystem approach to industrial production.”

5.1.4 A Renewed CEPA and Toxics Management

The draft revised *Canadian Environmental Protection Act* (CEPA) is intended to provide the legislative authority to implement the federal Toxic Substances Management Policy. The overall goal is to adopt a preventive and precautionary approach to deal with substances that enter the environment and harm humans and the rest of the environment. In addition to the virtual elimination of priority toxic substances, the policy also emphasizes the management of other toxic substances of concern throughout their life cycles. The life cycle approach requires a systems view -- one involving components of the production-consumption, or supplier-customer chain. An EIP encourages enhanced management of materials within the boundaries of a park and region through the development of a network. EIPs may be designed, in part, to ensure that there are better linkages between suppliers along the product life-cycle.

Industrial ecology can help to improve energy and material efficiencies but caution should be taken to ensure that such improvements do not institutionalize inefficiencies within the primary companies or block product or process innovations and optimizations.

Donald Huisingh, International Institute of Industrial Economics
University of Lund, Sweden

5.1.5 Shift Toward Pollution Prevention

One of the arguments associated with industrial ecology is that it is not consistent with pollution prevention or cleaner production and, in fact, some have argued industrial ecosystems

encourage the generation of wastes. There are a number of problems with this interpretation. Ecology and ecosystems necessarily involve interactions among species, within communities, and between biotic and abiotic elements of the system. In part this means exchanging materials which

are either products or byproducts of various processes. In immature ecosystems, some species and materials can build up to the point that significant changes or shifts, viewed as detrimental by some of us, occur. Mature ecosystems however are much more stable, involving a more balanced flow of materials between species as well as between species and the abiotic environment. In mature ecosystems, there is really no such thing as waste: material is reused, recovered and recycled continuously.

An assumption has been made by proponents of pollution prevention and cleaner production, as currently defined, that focusing on improvements in individual products or processes will result in improvements in the environment overall. Each product or process involves links to other materials and processes. Changing the flow of materials or energy in one could result in greater emissions to the environment elsewhere in the chain of production. What is needed to prevent this is a systems view.

The Canadian Council of Ministers of the Environment has defined pollution prevention as "the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and wastes at the source." The first part of this definition is consistent with the functioning of an ecosystem but a problem is the nature of the source. It has been interpreted as an individual industry or business. But if the objective is to prevent pollution, the source *could be* identified as a group of operations in a defined area such as a petrochemical complex, or a group of businesses in an industrial park. The

nature of the source should not be a factor as long as pollution is not occurring, that is, detrimental effects should not be seen in people, other species or ecosystems. If a group of industries or businesses in an industrial park enter into an agreement through contracts or covenants and act in concert, as a *source*, then governments should consider treating them as such. The onus is then on the industrial association, the park management agency, or the municipality to enforce those requirements.

Pollution prevention is intended to minimize or avoid the creation of pollutants; prevent the transfer of pollutants from one medium to another; minimize health risks; promote the development of source reduction technologies; use energy, materials and resources more efficiently; reduce the need for costly enforcement; recognize that waste is a cost that can be reduced; and promote a more competitive economy. Industrial ecology involves the study of industrial systems in order to achieve the same goals. The major difference is that it encourages more flexibility and a systemic approach than appears to have been the case to date in Canada.

Pollution Prevention- a federal strategy for action elaborates on government policy and sets priorities for action. The government's pollution prevention strategy focuses on five goals:

- Institutionalizing pollution prevention across all federal government activities;
- Fostering a national pollution prevention effort by working with other orders of government;

- Achieving a climate in which pollution prevention becomes a major consideration in private sector activities by working with business and industry;
- Providing access for all Canadians to the information and tools necessary to implement pollution prevention practices; and,
- Participating in international pollution prevention initiatives - working with the world community.

With some flexibility, these and other provincial pollution prevention policies form a solid policy basis for extending pollution prevention beyond individual products, firms and facilities. To some extent, this has already begun with more emphasis being given to promoting Pollution Prevention among suppliers, for example of automobile manufacturers.

5.2 Program Survey

Although there are no programs specifically designed to support EIP development in Canada, a number of programs that may be applicable have been identified. This list is by no means comprehensive but provides a good indication of some of the opportunities for programmatic support that may be available to those who are promoting EIP development. Programs have been grouped into the following categories: Infrastructure, Energy, Industrial Development, Research and Development, Environment, Pollution Prevention and Other.

5.2.1 Infrastructure-Related Programs

Few of these programs specifically target industrial parks, municipal infrastructure or explicitly encourage cooperation among industries, especially at a community level. However, there are some programs which appear to have the potential to encourage EIP and network development:

- Nova Scotia tries to assist new manufacturing and processing companies through the Industrial Incubation Program by providing rent subsidies. Although EIPs are not mentioned specifically, efforts could be made by industrial mall managers to attract industries which can use each other's products and byproducts. These malls are operated by the provincial department of Public Works and Transportation.
- Prince Edward Island has a program designed to meet the occupancy needs of new and expanding businesses in industrial parks in Charlottetown and Summerside operated by Enterprise PEI. Funding subsidizes the rental of space. Although criteria for eligibility include business viability, environmental impacts and potential economic benefit to the province, it appears that Enterprise PEI could play a more active role in creating EIPs that integrate the three criteria.
- Prince Edward Island has another intriguing program supported by a federal-provincial agreement. The Regional Economic Development

Agreement on Primary Resource Development, Agriculture and Integrated Resource Management could lend itself to agriculture and food related industrial ecosystem development. Reference to integrated resource planning is particularly interesting. It appears to have the potential to support primary resource-based industrial ecosystems.

- Northern Ontario has some interesting programs dealing with infrastructure development and strategic partnerships which could be used in an innovative manner in creating EIPs. In the case of the NOHFC Community Infrastructure Capital Assistance Program, eligible costs include design, site planning, engineering and construction costs for site improvements, materials, equipment, labour. Partnerships exist with the private sector, other levels of government and non-profit education, municipal and other organizations. Industrial parks are not specifically identified but appear to satisfy the objectives and criteria.

The federal government also has programs supporting initiatives in Northern Ontario. The Federal Economic Development Initiative for Northern Ontario (FedNor) contributes to regional or community initiatives aimed at economic development. Some of these programs could foster EIP development, especially by sharing financial risks for new infrastructure facilities and equipment.

- An Industry Canada program which might assist in planning and

coordination of EIPs is the Community Futures Development Corporations. These corporations are designed to provide "one-stop shopping" for community - based economic development initiatives, especially outside the large metropolitan areas. Establishing an EIP will require sustained human and financial resources to coordinate a variety of federal and provincial programs. Financing is available to develop long term strategic plans. Community Futures may be a source of such assistance since they will provide loans, loan guarantees or equity investments in support of long term employment.

- A related program to the one described above is the Canada Community Investment Plan. It may also be useful in providing access to risk capital for niches filled by innovative small businesses which use industrial byproducts in a creative manner.
- The federal-provincial Infrastructure Works programs which were signed across the country in 1993 or 1994 may provide the greatest future potential. There is variation between provinces but the program in Nova Scotia serves as an example. It is a partnership between the three levels of government designed to accelerate economic recovery and create jobs while renewing and enhancing physical municipal infrastructure. The infrastructure includes waste disposal, water supply, municipal transportation and "smart" infrastructure. The criteria established in Nova Scotia for eligible projects are relevant to EIP

development projects are as follows:

- Incrementality of investment;
- Job creation;
- Enhancement of competitiveness;
- Use of innovative technologies;
- Enhancement of workforce skills;
- Enhancement of environmental quality and sustainability; and,
- Use of innovative financing techniques such as public-private partnerships.

5.2.2 Energy-Related Programs

Energy related programs have received considerable attention and some of these could be used to encourage energy efficiency and conservation in industrial parks as well as the use of by-products as energy sources.

- Government of Canada provides a tax incentive encouraging business to reduce energy, waste and to use ensurable energy sources. In particular, eligible expenditures under the ACCA Class 43.1 program include heat recovery equipment that reuses industrial thermal waste and heat production equipment that consumes wood wastes, municipal wastes, landfill gases or digester gases. The productive use of these wastes or byproducts in industrial parks could occur through cooperative arrangements between businesses and a municipality or among businesses themselves. It is unclear whether two or more businesses could claim the allowance.

- Another Natural Resources Canada program includes the Industry Energy Research and Development Program providing repayable assistance for the development of products, processes and systems which increase efficiency of energy use in industry. The Bio-energy Development Program might also have some application as it involves the transformation of biomass into energy, fuels or chemicals.
- Natural Resources Canada has Integrated Energy Systems which assists communities, industries and utilities to identify and exploit opportunities for using energy-efficient integrated energy systems such as district heating, combined heat and power, thermal storage and industrial heat recovery. Another program called the Heat Management Program helps companies, manufacturers and others develop, commercialize or acquire heat management technologies. The program supports in-house applied R&D, cost sharing/task sharing in R&D projects and the provision of laboratory services on a cost recovery basis.
- The Yukon has an Energy Infrastructure Loans for Resource Development Program. The loans, up to \$3 million, are designed to assist companies in the mineral, energy, agriculture, aquaculture, forestry, fisheries and tourism sectors to meet their energy needs. Co-location of several industries might allow more efficient use of available waste materials, heat or water.

- The Yukon's Renewable Energy Technology Program provides support for R&D and commercialization of new technologies using renewable energy sources. Groupings of companies are eligible to apply.
- Other provinces also offer programs designed to improve energy efficiency and conservation often in association with local or provincial electric utilities. Unfortunately, given the current period of fiscal restraint, many of these programs are being cut back or eliminated.

5.2.3 Industrial Development Programs

A variety of industrial development programs have been created by federal and provincial governments. The majority of these programs appear to be directed at individual businesses although program managers may be willing to take innovative approaches when two or more industries collaborate in symbiotic relationships. For example, the Atlantic Canada Opportunities Agency (ACOA) has a Business Development Program aimed at small and medium-sized enterprises in manufacturing, processing, information technology and aquaculture, among others. Loans are provided for modernization and expansion including equipment, working capital, construction oriented to productivity and quality improvements. EIP development can result in new capital expenditures among participants and along these lines.

- There is also a variety of funding programs which could support

feasibility studies related to EIPs, again, with the interest of a program manager willing to allow some flexibility in the use of the program funds. The Sustainable Development Innovations Fund in Manitoba is one example. Under this program, funds up to \$40,000 are being provided to business associations, local round tables or community organizations for the development, implementation and promotion of environmental innovation projects. These can include waste minimization, energy conservation, water conservation, site reclamation and wildlife conservation, all of which are relevant to EIPs.

- The Industrial Research Assistance Program at the National Research Council promotes the diffusion of technologies to small and medium-sized firms across the country. The program currently provides technical advice to over 10,000 companies annually and financial support for research and development to over 3,000. The federal government announced in its "Securing Our Future Together" plan that it is expanding funding for the program by \$34 million each year up to \$130 million annually and has given the National Research Council a mandate to help small and medium sized enterprises (SMEs) implement state-of-the-art technologies and approaches for using energy, water and natural resources more efficiently and for pollution prevention. If implemented this may provide an excellent opportunity to promote EIP developments and new technologies among SMEs.

- The Canadian Environmental Industry Strategy contains a number of programs that support the further development and diffusion of environmental technologies and services. The many successes of this three year interdepartmental strategy may yet lead to a broader 'greening of industry' strategy in order to maximize the economic and environmental benefits of green technology and services.

5.2.4 Research And Development

From the point of view of research and development demonstration or commercialization of new technologies, Canadian business appears to be well-served. R&D is required to help develop new technologies that will permit economically viable linkages between industrial sectors. A wide range of federal and provincial programs dealing with energy, water, tires, agricultural byproducts as well as manufacturing and processes provide support for research and technology development. These range from very small grants of \$15,000 to large loans of \$500,000 or more.

- R&D programs include the Technology Assistance Program of the province of British Columbia; the Tire Recycling Management Association of Alberta Research and Development Program and the Canadian Network for the Advancement of Research Industry and Education.
- The federal government's "Securing Our Future Together" identifies the creation of the Canada Foundation for Innovation which may help to

stimulate further research on industrial ecology. The Foundation will have \$800 million to leverage research and development investment through partnerships with public research institutions, other governments, and the private sector. The foundation will support research in Canadian universities and hospitals.

5.2.5 Environmental Programs

Federal and provincial environment departments have adopted policies and programs in recent years which could encourage the formation of EIPs. These include pollution prevention policies and programs, recycling programs in conjunction with municipalities as well as initiatives such as the waste reduction audits in Ontario and the voluntary Accelerated Reduction of Toxic Substances (ARET) at the federal level. Although waste exchanges have received some government support, environmental agencies have emphasized individual processes, industries, chemicals and wastes rather than an ecological approach which looks at industries and products systematically. Only recently have departments of environment begun to actively consider wastes as misplaced or misused resources and the efficiency of processes and the design of products in strategies to prevent pollution.

- The Technology Partnerships Canada program can be used to help make strategic investments in technologies needed to help improve the linkages between major industrial processes used in different industries.

- Pan-Western Environmental Technologies Loan Program (ETLP) was introduced in March 1996 supported by Environment Canada, Western Economic Diversification (WED) Canada and the Toronto Dominion Bank. This \$40 million program is designed to help small and medium-sized environmental companies have additional access to debt capital. Companies in B.C., Alberta, Saskatchewan and Manitoba with less than 150 employees and \$10 million in annual sales may apply for up to \$500,000 per project to a maximum of \$1 million per borrower. The ETLF funding has significant implications in western Canada's environmental industry sector generating annual sales in excess of \$2 billion and providing almost 20,000 jobs. WED's key responsibility under the program is to provide a loan loss reserve, capped at \$5 million, to share the financial risk associated with investing in SMEs. WED also offers program applicants business support and services to assist company development and growth.

5.3 Other Programs and Initiatives

A few programs are focused on water, although water conservation does not appear to be a high priority. Saskatchewan has a partnership with the federal government in Water Based Economic Development. The processing and commercial development component of the agreement provides assistance to projects which directly or indirectly enhance benefits from water-based developments. Loans are provided for new product development, new technology and new industrial

opportunities. The program encourages partnerships, cooperatives and industry associations to apply. Another program under the agreement focuses on water supply infrastructure in rural areas.

Non- water related programs and initiatives which could support EIP development are as follows:

- Manitoba has a program encouraging the development of environmental industries. The program provides a limited amount of funding for feasibility studies, business planning, product development and demonstration projects. A mature industrial ecosystem will fill a number of niches with small businesses capable of using wasted materials or recovering or recycling end of use products. This program could assist in investigating or developing such niches.
- Quebec, in cooperation with the federal government, offers assistance to corporations and associations through a Subsidiary Agreement on Industrial Development, Product or Process Development. The eligible projects must concern the creation, adaptation, development or demonstration of technologies, products or production processes by manufacturers, industrial research centres or industrial design centres.

The federal government, through Industry Canada and Info-Entrepreneurs, has created the Small Business Idea Program dealing with innovative research, development and design of processes, products and

technologies. The program is targeted to joint ventures, associations and support groups. An innovative and flexible use of these funds would be the design of EIPs involving groups of small businesses.

Virtually all of the eco-industrial parks under development have been created from the "bottom up" rather than "top down." Getting started began with a local champion of the concept who has credibility with the community (and preferably, with the business community also) to inspire the vision of an eco-industrial park and to identify the key stakeholders and get them on board.

Suzanne Giannini-Spohn, U.S. EPA

5.4 Local Government Programs

The experience of the United States to date clearly indicates that local governments, related agencies and associations have a very important role to play in developing and implementing EIPs. A survey of local government programs was beyond the scope of this research. It is clear however, that they are able to mobilize the required stakeholders. They have important authority over local planning and regulatory issues, provide key infrastructures such as transportation, water and wastewater treatment and solid waste management, can be an active partner in symbiotic relationships, already provide a range of business support services, provide the required networking between firms, and most of all, have a keen interest in the economic and environmental health and prosperity of their communities.

In Canada, there are now an estimated 400 local economic development commissions, authorities or agencies and over 1,000 industrial parks (EDAC, 1997). There are variations in the responsibilities of these agencies but the shared goal is clearly one of

retaining industries, attracting new industries and job creation. There are few similar bodies dealing with environmental management. Whereas economic development agencies have financial clout and some management responsibilities, local environmental management agencies are typically advisory in nature, or have been assigned very limited management responsibilities. EIPs provide a practical focus to implementing sustainable economic development and assembling the expertise and resources of economic developers and the environmental communities.

5.5 Conclusion

Increasing support for the implementation of EIPs provides governments with a new opportunity to achieve multiple environmental and economic objectives. Experience to date strongly suggests that EIPs represent a much needed and practical approach to implementing sustainable development. Federally, many of the strategic objectives of the departmental Sustainable Development Strategies of Environment Canada, Industry Canada and Natural Resources Canada are

supportive of EIP development. Over time, encouraging an ecosystem approach to industrial and commercial development can help them achieve many of their stated objectives.

Policies and programs which promote pollution prevention, energy efficiency, action on climate change, infrastructure development, technology innovation and diffusion and toxic substances management, all represent important components required to stimulate the development of industrial ecosystems. Some of these programs can be utilized, if enough flexibility is present, to help proponents of EIPs. Two which appear to have significant potential include:

- The Pan-Western Environmental Technologies Loan Program which support technology development and commercialization. This approach to reducing the risk to capital could also be used to support selected capital projects for EIP development.
- Industrial Research and Assistance Program which has increased financing and a new mandate to promote eco-efficiency technology development and diffusion among businesses.

Elements of various programs could also be used. This would require a greater level of awareness about EIPs and could, depending on the project, require considerable coordination and cooperation between federal departments and other levels of government.

6.0 Conclusions

The concepts of industrial ecology and their implementation represent a fundamental shift in the way we engage in industrial production. Industrial ecology provides an economic and environmental framework that allows for more efficient production than traditional models, and holds the promise of significant economic and environmental benefits. EIP development also has the potential to allow all orders of government to meet many of their objectives simultaneously. These and other reasons described in the body of the report are why EIP development is quickly gaining credibility and increasing resources worldwide.

A number of broad conclusions can be drawn from this study which may help those who are actively involved in promoting this approach to industrial and commercial development in Canada.

- Given that there are approximately 1,000 industrial parks in Canada and that application of the concept is immature, significant potential exists for multiple economic and environmental benefits from EIPs. While some Canadian initiatives, (e.g.; Burnside and Bruce) predate U.S. experience, the Americans have quickly recognized the potential of eco-industrial park development. As a result, awareness in the United States is far more advanced at the local, state and federal level than it is in Canada. Hence, there is a clear need to increase the amount of awareness of the potential economic and environmental benefits of EIP development in Canada.
- Many of the concepts still remain largely untested but the 'win-win' nature of industrial ecology projects and the many drivers behind it ensure that implementation efforts will continue. A number of tools have been developed to help implement EIPs and several of these have potential application in Canada.
- EIPs are not 'one-size fits all'. The economy involves many sectors and interests. Hence, it is unreasonable to expect that one model of an EIP will satisfy all. Our research shows that many different approaches are underway to implement industrial ecology concepts and that planning flexibility is important. Some EIPs emphasize certain sectors because of their location or the nature of existing firms. Local needs for employment and diversification also help direct the nature of EIP planning and development initiatives. For example the concept may prove helpful in resource based "one industry" towns. In locations such as the Prairie provinces, the Okanagan, the Niagara peninsula and the Annapolis Valley, EIPs built around agriculture and food processing may predominate.
- Examples of regional Eco-industrial networks, as in the case of Styrian, Austria, demonstrate that there are clear advantages in implementing a broader approach to implementing industrial ecology than through a more geographically restricted park. With material byproduct exchanges, the trend in the United States has been to conduct research on a region rather than a park scale.

- For the most part, economic *not* environmental benefits are driving most EIP activity. There is lots of potential for multiple environmental objectives for business, local, provincial and federal governments and communities.
- A number of important barriers have emerged in response to efforts to develop EIPs. These range from the need for better information about energy and material flows and technical obstacles to securing financial support for long term development work and effectively promoting industry cooperation. Progress is being steadily made in overcoming many of these barriers, particularly in the United States.
- Successful EIP development requires 'top down' and 'bottom up' support and activity. This combination in the United States has led to an explosion of EIP projects across the country that is currently lacking, for the most part, within Canada. Most EIP projects in the United States are in the early stages, involve local economic developers and are not generally being led by industry.
- While there are no federal government programs in the United States focused on EIP development a number of programs are being used to support current efforts. Senior-level discussions are underway to look at earmarking some economic development spending for EIP development. In

Canada, a number of programs have the potential to support EIP development but there are no high profile champions, such as the President's Council on Sustainable Development in the United States.

- A number of innovative regulatory approaches have been identified as supporting EIP development. Common to all of them is increased flexibility of response for industry.
- There are technologies available that will benefit from increased emphasis on EIP development. There are also many by-products that cannot currently be utilized. A significant amount of research and development and technology commercialization will be required in order to fully realize the economic and environmental promise of industrial ecology.

As with all new concepts, industrial ecology faces many challenges before becoming more widely accepted. As an important approach to the practical implementation of sustainable development, the issue is largely whether Canadians will choose to be leaders or followers. The recommendations provided in Section 7.0 are intended to ensure that Canadians do not fall behind their trading partners in efforts to promote more economically and environmentally sustainable approaches to industrial development.

7.0 Recommendations

If the federal government is interested in promoting EIP development in existing industrial parks and integrating these concepts into green field industrial developments, the following recommendations provide a clear pathway to accomplish these objectives, based upon proven approaches taken in the United States and elsewhere.

- **The foundation of the federal government support for EIP development should be a program that provides financial support for five demonstration projects across the country.** This support should total at least \$1.5 million over three to five years (\$100,000/year for each project) and be designed to leverage at least an equivalent amount of provincial and local government and non-government financial support. A competition should be held to select winning proposals, as was done by the PCSD in the U.S. While only four sites were selected by the PCSD, sixteen are now under development. The program could be implemented on a competitive proposals basis along a similar model as that used for the development of the Canadian Environmental Technology Advancement Centres.

If implemented, this program would represent the initial backbone of EIP development in Canada, stimulating local interest, resources, and action on specific EIP developments. This program helps to build industrial capacity in Canada for the 21st century along the lines of the information highway. The five pilot

projects can be used to accomplish a number of specific federal government objectives such as:

- Improved industrial competitiveness and job creation;
- Reduction in greenhouse gas emissions;
- Improved energy use efficiency;
- Solid waste reduction;
- Stimulation of markets for environmental products and services; and,

Pilot projects can also help to:

- Develop baseline information on energy and material flows in different regions in order to identify potential linkages;
- Generate a greater level of awareness of the economic and environmental benefits among key government and non-government organizations throughout the country;
- Build on recent work in Sarnia, Ontario and East Montreal;
- Influence the planning of new green field developments such as those underway in Downsview, Ontario.
- The research conducted by ThermoShare Inc. (1997) on 10 potential EIP sites across Canada represents a possible starting point for this type of initiative.

- **Identify a champion or champions at the federal level.** In the United States, the President's Council on Sustainable Development has played a catalytic role through its Eco-Efficiency Task Force. The National Round Table on the Environment and the Economy also has an eco-efficiency committee but has not identified industrial ecology as a strategic approach in working toward sustainable development.
- **Promote the introduction of the concepts of industrial ecology among local and regional industrial and economic development officials.** Education of these people who have direct and indirect influence over industrial development will help to integrate industrial ecology concepts into decision making and assist in the establishment of EIPs and eco-industrial networks.
- **Establish an ad hoc Interdepartmental Committee for EIP development to promote awareness of the concept and coordinate activities and resources.** If industrial ecology is to progress in Canada, five core federal agencies appear to be the key players at the federal level: Industry Canada, Environment Canada, Natural Resources Canada, the National Research Council, and Human Resources Canada; as well as the regional economic development agencies. The ad hoc committee can undertake to review R&D programs for their potential support for new technological developments required to facilitate energy and byproduct exchanges.
- **Provide financial support for a national conference on EIP development.** This would help to bring together the existing loose network of stakeholders involved in EIP development in Canada. Workshops and conferences played a key role in building broad support for EIP development in the United States.
- **Support the development of an industrial ecology web site.** This could be done in partnership with an academic institution, general business association and/or the private sector. One of the components could include a List Serve of key stakeholders and proponents as a vehicle for sharing information. The web site could lead to the establishment of a virtual industrial Ecology Network in Canada. This initiative would compliment the Business Environmental Performance Office currently being developed by Industry Canada as part of the Canadian Environmental Industry Strategy.
- **Support the application and further development of U.S. EPA EIP software programs in Canada.** This could be accomplished by one of the five pilot projects and would help give Canadian EIP promoters a valuable tool to identify potential opportunities.
- **Develop a resource guide on federal and provincial programs that may be used to support industrial ecology, building on the programs already identified in this report.** This information could also

be posted on the Internet and made available at workshops and conferences.

- **Partner with one or more universities to develop an Industrial Ecology Training Initiative.** Support should be provided for the development of teaching materials in industrial ecology for use in engineering, business, planning and design programs at universities and community colleges. This could be incorporated into the current work of the National Round Table on the Environment and the Economy in advocating sustainable development in business school curricula. The federal government should also encourage the formation of research, development and extension centres to move this concept into reality in Canada.

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Appendix 1: Interviewees and Survey Instrument

Michael Krause, Green Institute, Minneapolis, Minnesota.

Peter Lowitt, Director of Planning and Economic Development, Town of Londenberry, New Hampshire.

Sam MacGregor, President and CEO, Integrated Energy Development Corporation.

Gil Friend, Principal, Gil Friend and Associates.

Ernest Lowe, Indigo Development Corporation, California.

John Stephanson, Ontario Hydro.

Roan Conrad, Chief of External Affairs, Office of Sustainable Development, US Depart. of Commerce.

Tim Hayes, Director of Sustainable Economic Development, North Hampton County, Virginia.

Michael Palumbo, Baltimore Development Corporation.

David Cobb, Bechtel Corporation R&D.

Rick Luna, Brownsville Economic Development Council.

Mary Ortendahl, Economic Development Alliance for Business, Alameda County, California.

Suzanne Giannini-Spohn, Office of Policy Planning and Evaluation, US EPA.

Bruce Steadman, U.S. Facilities Management Inc., Plattsburgh, New York.

Jill Edwards, Eco-Industrial Roundtable, Trenton, New Jersey.

Dr. Don Huisingh, International Institute for Industrial Environmental Economics, University of Lund.

Preamble: Peck & Associates is currently conducting research on the status of eco-industrial park world-wide with a focus on the roles of government. This research is being conducted for the Canadian federal government, namely Industry Canada and Environment Canada. We would appreciate the opportunity to conduct a brief interview with you or a suitable member of your staff. The questions are as follows:

1. What are the objectives/emphasis of your eco-industrial park project if you are engaged in one?
2. What are the benefits of eco-industrial park development over traditional forms of industrial development?
3. What policy and or program role(s) do governments (federal, provincial/state and local) currently play in the development of your eco-industrial park or eco-industrial parks in general?
4. What, if any, programs or policies are needed to spur on the development of eco-industrial parks?
5. What, if any, government barriers have you had to overcome in your work?
6. What is driving eco-industrial park development in your area? Nationally? Internationally?
7. What roles have the private sector played? Have any barriers been identified and overcome in the private sector?
8. Are there any tools required to help you promote eco-industrial park development?
9. What do you see as the future of eco-industrial park development?
10. Do you have any general comments?

APPENDIX 2: Eco-Industrial Park Development Tables

TABLE 1: North American Inventory of Eco-Industrial Park Developments

	Brownsville	Burnside	Bruce Energy Centre	Volunteer Centre
Location	Brownsville, Texas	Dartmouth, NS	Tiverton, ON	Chattanooga, Tennessee
Year Established	One year feasibility study commenced late 1995, Implementation in 1997	Initial survey 1992, Cleaner Production Centre 1995	1985	Study initiated in 1994. Still in development stage.
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field - converting former military land
Number of Firms/Size of Firms	To incorporate 50 specific and 100 generic local industries	1300 single and small unit firms (mostly small-medium) representing a variety of industries	7 firms and Ontario Hydro	Unknown
Cogeneration	Potential	Potential	Yes	Unknown
Development Participants	President's Council on Sustainable Development (PCSD), City of Brownsville, Research Triangle Institute, Indigo Development, Industry Advisory Board, other local, regional, state, and federal partners	Dalhousie University, Halifax Regional Municipality, Environment Canada	Integrated Energy Development Corporation	PCSD, City of Chattanooga, River Valley Partners, LDR International, National Environmental Test Center
Financing Source(s)	U.S. Department of Commerce, Texas Natural Resource Conservation Commission, City of Brownsville, Port of Brownsville	Federal-Provincial Sustainable Development Fund, The Donner Foundation, Halifax Regional Municipality, Federal and Provincial government, Dalhousie University and 2 other academic institutions	Integrated Energy Development Corporation	Partial funding from local agencies
Current Management	Brownsville Economic Development Council	Business Parks Office, Halifax Regional Municipality	Integrated Energy Development Corporation	River Valley Partners (private company)
Quantified Economic Benefits	Unknown	Waste management costs of some firms reduced through cleaner production techniques	Unknown	Unknown
Identified Environmental Benefits	Unknown	Reduced discharges to air and sewers. Reduced disposal of solid wastes through exchanges.	Reduced emissions of 43,000 tonnes CO ₂ , 487 tonnes SO ₂ , 93 tonnes NO _x , 1.7 tonnes VOC, other	Unknown
Distinguishing Characteristics	Regional eco-industrial network (park is just one component). Includes small business and agriculture. Features industrial database for matching material and energy by-products.	The first endeavour of its kind in Canada but very much a work in progress. Strong links to university research community.	Utilizes excess steam from Bruce Nuclear Power Station as the start of an energy cascade which is utilized to produce a variety of products.	Part of larger revitalization plan for Chattanooga. Not much data pertaining to industrial area part of project.

	Civano	Duwamish Corridor	Fairfield	East Shore
Location	Tucson, Arizona	Seattle, Washington	Baltimore, Maryland	Oakland, CA
Year Established	Still in planning stages. Grand opening for development project (residential and business) took place in July 1997	Duwamish Coalition first met in 1994 to address project, still need to specifically discuss EIP project	Currently studying potential through inventory and directory of potential industrial partners. No specific linkages to date.	Seeking funding for Feasibility Study
Brown field vs. Green field	Green field	Brown field	Brown field	Green field
Number of Firms/Size of Firms	Currently one large manufacturing firm located in the Civano Industrial Park	Unknown	Over 60 firms on 1300 acres	Unknown
Cogeneration	No	Unknown	Unknown	Unknown
Development Participants	Case Management, and others	Numerous local, regional, state, and federal partners	PCSD, Cornell University's Work and Environment Initiative, other local, regional, state economic development agencies	Indigo Development, Urban Ore, Economic Development Advisory Board
Financing Source(s)	Still seeking funding	U.S. EPA	Federal Empowerment Zone fund (\$100 M), City of Baltimore, U.S. Department of Commerce, various economic development agencies	Unknown
Current Management	Case Management	Unknown	Baltimore Development Corporation	Indigo Development and Urban Ore
Quantified Economic Benefits	Unknown	Unknown	Creation of 2500 jobs in next 10 years. Estimated 30- 50% return on investment.	Unknown
Identified Environmental Benefits	Unknown	Unknown	Unknown	Unknown
Distinguishing Characteristics	Part of the Civano Master Plan to improve on seven specific environmental performance standards. Mandated to reduce energy consumption to 1991 levels.	Part of overall strategy to preserve and reclaim industrial land to create jobs and protect natural environment. Have yet to address planned EIP component of project.	Represents the only Empowerment Zone City grantee with a designed EIP. Looking to redefine area's regulatory framework. Focus on education, training, and network development to facilitate linkages.	Anchor for EIP will be a resource recovery facility encompassing reuse, recycling, re-manufacturing, and composting. Will also be "landscaped" to reflect native ecosystem characteristics.

	Green Institute	Plattsburgh	Port Cape Charles	Riverside
Location	Minneapolis, Minnesota	Plattsburgh, New York	Eastville, Virginia	Burlington, Vermont
Year Established	In feasibility study stage, implementation to begin in 1997	Currently in baseline study phase	Implementation planned for September 1997	Currently in planning stages
Brown field vs. Green field	Brown field	Brown field	Green field	Brown field
Number of Firms/Size of Firms	Unknown	Unknown	Unknown	Unknown
Cogeneration	Unknown	Unknown	Unknown	Planned
Development Participants	Green Institute, local organizations	Plattsburgh Airbase Redevelopment Corporation	Joint Industrial Development Authority of Northampton, numerous other local, regional, state, federal, and industry partners	Unknown
Financing Source(s)	Federal Enterprise Community program, local Neighbourhood Revitalization program, Minneapolis Foundation, Northwest Area Foundation	U.S. EPA Region I	17 different funding partners (local, regional, state, federal, and private industry)	Community Development Block Grant, Burlington Electric Department, Department of Public Works, other support
Current Management	Green Institute, University of Minnesota	Plattsburgh Airbase Redevelopment Corporation	Joint Industrial Development Authority of Northampton	Burlington Electric Department
Quantified Economic Benefits	The goal is to create 200 new jobs	Unknown	Unknown	Unknown
Identified Environmental Benefits	Unknown	Unknown	Unknown	Unknown
Distinguishing Characteristics	Project initiated by a grassroots, neighbourhood effort. Attempt to develop a small EIP on 3.5 acres by integrating existing businesses. Commitment to environmental education throughout project.	Conversion of Air Force Base to civilian uses	Part of a comprehensive community Sustainable Development Action Strategy. Has a Zero Emissions design goal. Selected as a PCSD EIP demonstration project in 1994.	It is an Agricultural-Industrial Park in an urban setting. Focus on generating energy from bio-mass fuels and using thermal energy for production of fish, vegetables, and water purification.

	Skagit County	Trenton	Raymond Green EIP	Shady Side Eco-Industrial EIP
Location	Skagit County, Washington	Trenton, New Jersey	Raymond, Washington	Shady Side, Maryland
Year Established	Feasibility study completed 1995, currently identifying funding sources.	Currently conducting feasibility study	Seeking funding for feasibility study	Currently in planning stage
Brown field vs. Green field	Brown field	Brown field	Green field	Brown field
Number of Firms/Size of Firms	Unknown	Unknown	Unknown	Unknown
Cogeneration	Unknown	Unknown	Unknown	Unknown
Development Participants	Numerous local, regional environmental, state, federal, and industry participants	Cornell University's Work and Environment Initiative (conducting baseline study)	City of Raymond, Port of Willapa Harbor, Weyerhaeuser Company, Ecotrust, Shoretrust Trading Group	Business Ecology Network (BEN)
Financing Source(s)	Northwest Area Foundation, EnviroCenter, Center for a Clean Washington, U.S. Department of Commerce	City of Trenton, New Jersey DEP, New Jersey Urban Zone Assistance Fund, U.S. Economic Development Administration, U.S. EPA (potential)	Unknown	Unknown
Current Management	Economic Development Association of Skagit County	City of Trenton, Division of Economic Development	City of Raymond	Unknown
Quantified Economic Benefits	Unknown	Unknown	Unknown	Unknown
Identified Environmental Benefits	Unknown	Unknown	Protection of coastal forest	Unknown
Distinguishing Characteristics	Features resource recovery centre, manufacturing centre, community centre, sales and marketing centre, and environmental business centre.	Park will be more of a virtual network of businesses with a management structure in place to assist with linkages, matchmaking, and other technical assistance. Have Advisory Round Table made up of government, business, non-profit and educational institutions.	Park will be developed within a second growth coastal forest that will continue to be selectively harvested. Firms will be targeted that make new uses of local natural resources with low impact manufacturing processes.	Renovation of an existing facility in an under-employed and under-served community. Plan to integrate successful community-based tools and approaches from U.S. and abroad.

	Stonyfield Londonderry	Sarnia-Lambton	East Montreal	Becancour
Location	Londonderry, New Hampshire	Sarnia, Ontario	Montreal, Quebec	Montreal, Quebec
Year Established	Currently in planning stage, implementation in Summer 1997	Feasibility study conducted in 1996	Unknown	Unknown
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field
Number of Firms/Size of Firms	4 medium to large, currently undergoing expansion	6	14 major industries in petrochemical and minerals/metals sectors	12
Cogeneration	Unknown	Yes	Planned- on hold	Unknown
Development Participants	Advisory Board made up of local, regional, state, federal, non-profit, environmental, and academic organizations	Private sector driven, Ontario Hydro also participates	Environment Canada, local industry	Environment Canada, local industry
Financing Source(s)	Unknown	Unknown	Private funding	Private funding
Current Management	Town of Londonderry	Unknown	Unknown	Unknown
Quantified Economic Benefits	Plan to create 500-2000 jobs, increase tax base of community	Energy efficiency increases of 38 -85%. New cost effective source of gypsum.	Planned cogeneration: Potential \$20 M in cost savings, 100- 210 jobs, \$38 M into Quebec's economy	Unknown
Identified Environmental Benefits	Unknown	Estimated 926 tonnes of CO ₂ , 4.5 tonnes of SO ₂ and 1.5 tonnes of NO _x daily from a cogeneration project	Replacement of conventional fuels, reduction of air emissions, value added use for NH ₃ , energy reduction	Reduction of waste to landfill, replacement of H ₂ from primary sources, recovery of aluminum
Distinguishing Characteristics	Eco-Auditing system to evaluate performance.	Significant potential given the clustering of chemical industry firms. Several projects under development, several completed.	Looking to promote industrial development in area which offers available industrial land, access by road and pipeline, and potential for cogeneration of electricity and steam.	Park offers: water transport all year, low cost electricity, natural gas, pool of skilled labour, competitive construction cost, access to North American markets by rail and road.

	Varenes	Sorel- Tracy	Springhill, Nova Scotia	South Central EIP
Location	Montreal, Quebec	Montreal, Quebec	Springhill, Nova Scotia	Chattanooga, Tennessee
Year Established	Unknown	Unknown	Unknown	Unknown
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field
Number of Firms/Size of Firms	9 major industries	Unknown	4	Unknown
Cogeneration	No	No	Yes	Unknown
Development Participants	Environment Canada, local industry	Local industry and industry associations	Local industrial development commission	PCSD, River Valley Partners, United Nations University (ZERI), William McDonough Architects, Calthorpe Associates, Chattanooga/Hamilton County, Planning Commission Chattanooga Neighborhood Enterprise, plus others
Financing Source(s)	Private Funding	Private Funding	Environment Canada, municipality	Some local agency support
Current Management	Corporation de Developpement de Varenes	Societe d'aide au developpement de la collective du Bas-Richelieu (SADC)	Springhill Industrial Commission	River Valley Partners
Quantified Economic Benefits	Unknown	Unknown	Estimated energy savings of \$50- 160 K per year	Unknown
Identified Environmental Benefits	Reduction in energy consumption, reduction in waste to landfill, decrease in pollution into environment	Recovery of products from scrap tires, manufacturing compost, and recovery of recyclables from waste	Unknown	Unknown
Distinguishing Characteristics	A number of existing linkages between firms in the area	Area looking to promote industrial, commercial, and tourist development	Employs energy cascading similar to that of Bruce Energy Centre and Kalundborg. One of the firms is an aquaculture facility for warm water fish species.	Ecological design and zero emissions is a goal

TABLE 2: Inventory of European Eco-Industrial Park Developments

	Kalundborg	Styrian Region	Linkoping	Rotterdam- Europort
Location	Kalundborg, Denmark	Styrian Region, Austria	Sweden	Rotterdam, Holland
Year Established	Industrial ecology linkages instituted early 1980's	Recycling network initiated in the 1980's	Planning began in 1996	Cleaner production and waste exchange study began in 1995
Brown field vs. Green field	Brown field	Brown field	Brown field/Green field	Brown field
Number of Firms/Size of Firms	5 very large firms and several smaller organizations such as the local municipality	Large number of sectors and firms involved. Population of 1.2 M inhabitants.	Small number of firms and institutions in a research park around Linkoping University	85 medium to large
Cogeneration	Yes	Yes	Unknown	Unknown
Development Participants	Resident industry	State, industries, and university	University and industries	Erasmus University, Port of Rotterdam
Financing Source(s)	Resident industry	Industries and state	Unknown	Government and local industries
Current Management	Resident industry	Largely self-actuating	Planning stage	Unknown
Quantified Economic Benefits	\$120 M (US) return on \$60 M investment (5 years). Annual revenue estimated \$12-15M.	Significant quantities of waste are being diverted from disposal or being substituted for virgin material	Unknown	Not quantified at this time but could be calculated
Identified Environmental Benefits	Reduced consumption of: 19,000 tonnes oil, 30,000 tonnes coal, 600,000 m3 water. Reduced emissions: 130,000 tonnes CO ₂ , 3,700 tonnes SO ₂ .	Examples of material recycled in 1994: 34,000 tonnes power plant gypsum, 200,000 tonnes of steel mill slag, 28,300 tonnes of sawmill dust, 100,000 tonnes of recyclable paper and board, 5,500 tonnes of used tires, etc.	Unknown	Unknown
Distinguishing Characteristics	The first EIP development involving multiple public and private organizations. Evolved without government or outside assistance. Undertaken purely for profit.	Regulations and cost of waste disposal played an important role. Strong regional approach.	Planned as a demonstration project	Unknown

Table 3: Potential Asian/Pacific Rim and Middle Eastern Eco-Industrial Park Developments

	Bandung	Manila	Fujisawa Factory	Eco-Cities Project
Location	Bandung, Indonesia	Manila, Phillipines	Japan	Japan
Year Established	1997	Planning began in 1997	Slated to open in 2000	No information available at this time
Brown field vs. Green field	Green field	Green field	Green field	Green field
Number of Firms/Size of Firms	Planned for 20 textile firms	Unknown	Fully integrated industrial development and community residences	Unknown
Cogeneration	Unknown	Unknown	Unknown	Unknown
Development Participants	SPM from Geneva, EBARA from Japan, Radiant from USA, META EPSI from Indonesia, Governor of East Java	Local development company, national and regional development institutions	EBARA Corporation	Unknown
Financing Source(s)	Local	Largely private	EBARA Corporation and others	Unknown
Current Management	META EPSI	Unknown	Unknown	Unknown
Quantified Economic Benefits	Unknown	Unknown	Unknown	Unknown
Identified Environmental Benefits	Zero emissions and total recovery of all dyes which are largest contaminants in the city	Unknown	Unknown	Unknown
Distinguishing Characteristics	Targeting zero emissions	Unknown	Targeting zero emissions. Appears to be the first comprehensive eco-industrial development. Includes residential, agricultural, recreational, and industrial facilities.	Unknown

	Kashima Industrial Complex	Jubail Industrial Complex	Yanbu Industrial City	
Location	Japan	Eastern Saudi Arabia	Western Saudi Arabia	
Year Established	Limited information at this time	Limited information available at this time	Smaller sister project of the Jubail Industrial Complex. No further information available at this time.	
Brown field vs. Green field	Unknown	Unknown	Unknown	
Number of Firms/Size of Firms	Major industries include a petroleum refinery, a petrochemical plant, several chemical producers, a large steel plant, and a power generation station. Mix of small, medium and large industries.	Mix of approximately 100 primary, secondary, and support industries. Crude oil and methane are feedstocks for primary industries and they in turn provide feedstocks for other industries.	Unknown	
Cogeneration	Unknown	Unknown	Unknown	
Development Participants	Unknown	Unknown	Unknown	
Financing Source(s)	Unknown	Unknown	Unknown	
Current Management	Unknown	Unknown	Unknown	
Quantified Economic Benefits	Unknown	Unknown	Unknown	
Identified Environmental Benefits	Unknown	Unknown	Unknown	
Distinguishing Characteristics	Unknown	Unknown	Unknown	

Appendix 3: PALME Industrial Park “Eco-logo” Criteria

1. Management and regulatory framework.
2. Landscape planning and design.
3. Monitoring.
4. Abandonment planning.
5. Green space planning.
6. Agricultural land management.
7. Biodiversity assessment.
8. Remediation of the shoreline.
9. Define hunting areas.
10. Information programs on natural areas.
11. Baseline study.
12. Create HSE competency.
13. Technical assistance program.
14. Environmental impact assessment capacity.
15. Environmental services management.
16. Clean workplace program.
17. Remediation planning for "Themeroil".
18. Solid waste management.
19. Waste water management.
20. Rain water management.
21. Noise control strategy.
22. Noise control materials.
23. Encourage low pollution vehicles.
24. Monitor air and noise quality.
25. Energy management.
26. Develop wood energy plan.
27. Bury electricity lines.
28. Rationalize rail lines.
29. Extend bus service.
30. Set up experimental bus-taxi service.
31. Bicycle trails.
32. Stakeholders' committee.
33. Coordinating and operational centre.

Appendix 4: Initial Results of CANLOC Program Review

INDUSTRY ENERGY RESEARCH & DEVELOPMENT PROGRAM
IRAP, TECHNOLOGY ENHANCEMENT PROJECTS
IRAP, RESEARCH, DEVELOPMENT AND ADAPTATION PROJECTS
PAWBED, PROCESSING AND COMMERCIAL DEVELOPMENT
PARTNERS IN SCIENCE AWARENESS PROGRAM
SCIENTIFIC RESEARCH & EXP DEV INVESTMENT TAX CREDIT
ACOA, BUSINESS DEVELOPMENT PROGRAM
CANARIE, TECHNOLOGY AND APPLICATIONS DEVELOPMENT
ACCA, AIR AND WATER POLLUTION CONTROL
BIOTECHNOLOGY LOAN FUND
ACCA, CAPITAL COST ALLOWANCE (CLASS 43)
ACCA, MANUFACTURING AND PROCESSING
RENEWABLE ENERGY TECHNOLOGY (RET)
INDUSTRIAL TARGETED PROGRAM (ITP)
BIOENERGY DEVELOPMENT PROGRAM (BDP)
ENERGY INFRASTRUCTURE LOANS FOR RESOURCE DEVELOPMENT
TRMA, TIRE RECYCLING INDUSTRY INCENTIVE PROGRAM
RESEARCH & DEVELOPMENT SUPER ALLOWANCE
PRODUCT OR PROCESS DEVELOPMENT
FEASIBILITY STUDIES
INDUSTRIAL MALLS
TECHNOLOGY PARTNERSHIPS PROGRAM
NS BUSINESS DEVELOPMENT CORPORATION LOANS AND GUARANTEES
INDUSTRIAL INCUBATION PROGRAM
GREEN PLAN, AGRICULTURE COMPONENT: COMMUNICATION
GREEN PLAN, AGRICULTURE COMPONENT: RESOURCE MANAGEMENT
GREEN PLAN, AGRICULTURE COMPONENT: WASTE MANAGEMENT
DEVELOPMENT ASSISTANCE PROGRAM
TECHNOLOGY BC, COLLABORATIVE/TECHNOLOGY TRANSFER
TECHNOLOGY BC, INDUSTRY-BASED RESEARCH AND DEVELOPMENT
NOHFC, STRATEGIC PARTNERSHIPS, RESEARCH AND DEVELOPMENT AND
NOVA SCOTIA RESEARCH AND DEVELOPMENT CREDIT
ENERGY TECHNOLOGY DEVELOPMENT PROGRAM
ENERGY PRODUCTIVITY PROGRAM
SUSTAINABLE DEVELOPMENT INNOVATIONS FUND
FEASIBILITY STUDIES PROGRAM
TECHNOLOGY COMMERCIALIZATION PROGRAM
ENVIRONMENTAL INDUSTRIES DEVELOPMENT INITIATIVE
MANITOBA INDUSTRIAL OPPORTUNITIES PROGRAM
MANITOBA INDUSTRIAL RECRUITMENT INITIATIVE
RESEARCH COORDINATION PROGRAM
NOHFC, INFRASTRUCTURE, COMMUNITY INFRASTRUCTURE CAPITAL ASSISTANCE
RESEARCH AND DEVELOPMENT TAX CREDIT
NEW BRUNSWICK RESEARCH AND DEVELOPMENT TAX CREDIT
SMALL BUSINESS IDEA PROGRAM, INNOVATION, R&D, DESIGN
AGRICULTURE, INTEGRATED RESOURCE MANAGEMENT
PAN-WESTERN LOAN PROGRAM FOR ENVIRONMENTAL TECHNOLOGY FIRMS
INDUSTRIAL DEVELOPMENT, INFRASTRUCTURE
INDUSTRIAL DEVELOPMENT, TRAINING
TRMA, RECYCLING TECHNOLOGY UPGRADING PROGRAM
TRMA, BUSINESS DEVELOPMENT PROGRAM
TRMA, RESEARCH AND DEVELOPMENT PROGRAM
NOHFC, INFRASTRUCTURE, RESEARCH AND OPPORTUNITIES IDENTIFICATION
TECHNOLOGY ASSISTANCE PROGRAM (TAP)

