

Fostering Industrial Symbiosis in Nova Scotia

Sustainable Prosperity Possibilities through Industrial Innovation

TABLE OF CONTENTS

About this Guide	ii
Definitions	1
1.0 Introduction to Industrial Symbiosis (IS)	3
2.0 IS Concepts	4
2.1 Industrial Ecology, Eco-Industrial Networking and Industrial Symbiosis	4
2.2 Examples of Eco-Industrial Networking Opportunities	7
3.0 Case Studies	8
3.1 Global	8
3.2 Nova Scotia	12
4.0 Benefits of IS	17
4.1 Economic	18
4.2 Social	19
4.3 Environmental	19
5.0 Action Plan for a Nova Scotia IS Program	21
5.1 2020: A look back at NSISP	21
5.2 How to build an IS program	21
5.3 Stakeholders	25
6.0 EIN Resources	27

About this Guide

This guide is intended to present the concept of industrial symbiosis (IS) and demonstrate how implementing IS in a systemic manner across Nova Scotia may bring the province closer to achieving its economic, environmental, and social goals.

In this guide you will find:

- An introduction to industrial ecology and related concepts
- Examples of eco-industrial networking (EIN)
- Cases of IS in Nova Scotia and around the world
- A description of the proven benefits of this approach to sustainable economic development
- An outline of the necessary steps to begin an industrial symbiosis program in Nova Scotia
- Information on resources available to facilitating EIN development

Definitions

Industrial Ecology – Industrial ecology is an interdisciplinary framework for designing and operating industrial systems as living systems interdependent with natural systems. It seeks to balance environmental and economic performance within emerging understanding of local and global ecological constraints. Some of its developers have called it ‘the science of sustainability’.

Source: Indigo Development (indigodev.com)

Eco-Industrial Networking – Eco-industrial networking involves developing new local and regional business relationships between the private sector, government and educational institutions in order to use new and existing energy, material, water, human and infrastructure resources to improve production efficiency, investment competitiveness, community and ecosystem health.

Source: Canadian Eco-Industrial Network (cein.ca)

Industrial Symbiosis – Industrial symbiosis brings together companies from all business sectors with the aim of improving cross industry resource efficiency through the commercial trading of materials, energy and water and sharing assets, logistics and expertise. It engages traditionally separate industries and other organizations in a collective approach to competitive advantage involving physical exchange of materials, energy, water and/or by-products together with the shared use of assets, logistics and expertise.

Source: National Industrial Symbiosis Program (nisp.org.uk)

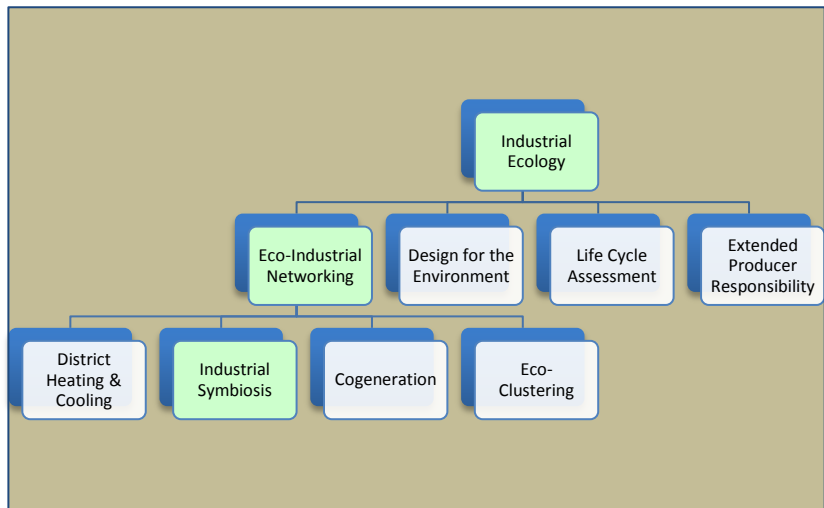


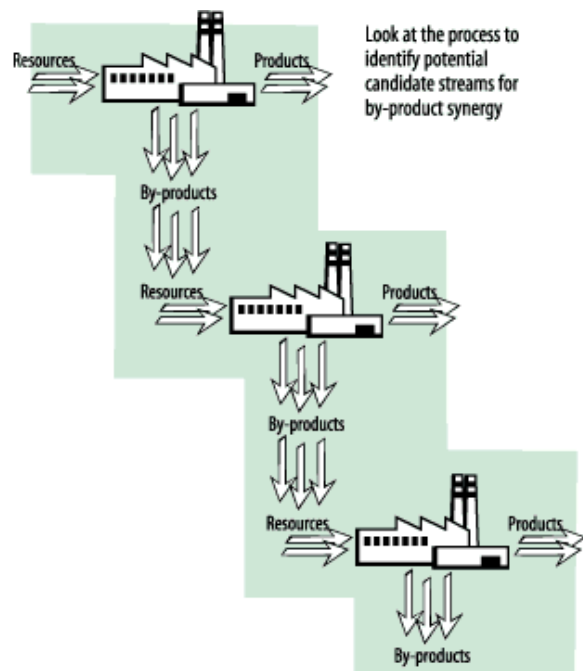
Figure 1 – hierarchy of industrial ecology

Eco-Industrial Park – An Eco-Industrial Park is a community of manufacturing and service businesses located together on a common property. Members seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues.

Source: Indigo Development (indigodev.com)

By-Product Synergy – The principle underlying by-product synergy is that one industry's waste stream can be used by another as a primary resource. It is a simple idea, but one which has enormous potential for reducing waste volumes and toxic emissions to air and water, as well as cutting operating costs. In order to facilitate an exchange of materials and resources, businesses need to work together to determine what unwanted by-products exist, and what their potential applications are. The resources can then be exchanged, sold, or passed free of charge between sites, creating a by-product synergy.

Source: Business and Sustainable Development: A Global Guide (bsdglobal.com)



Source: Business and Sustainable Development: A Global Guide (bsdglobal.com)

Eco-Efficiency – The concept of eco-efficiency was first coined in 1992 by the Business Council for Sustainable Development (BCSD) in its landmark report, **Changing Course**. Eco-efficiency was further defined at the first Antwerp Workshop on Eco-efficiency held in November 1993 as being 'reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity'.

The WBCSD has identified seven success factors for eco-efficiency:

- Reduce the material intensity of goods and services
- Reduce the energy intensity of goods and services
- Reduce toxic dispersion
- Enhance material recyclability
- Maximize sustainable use of renewable resources
- Reduce material durability
- Increase the service intensity of goods and services

Source: Eco-Efficiency and Cleaner Production: Charting the Course to Sustainability (wbcso.org)

Life Cycle Management – Life Cycle Management (LCM) is an integrated concept to assist in businesses managing the total life cycle of products and services towards more sustainable consumption and production patterns.

Source: EPA Victoria (<http://www.epa.vic.gov.au/Lifecycle>)

1.0 Introduction to Industrial Symbiosis

Nova Scotians understand that a vibrant economy, a high quality of life, and maintaining a healthy environment are all interconnected. This belief is reflected in our provincial policy and legislation with the advent of such items as Opportunities for Sustainable Prosperity and the Environmental Goals and Sustainable Prosperity Act. While these policies and legislation have set a firm goal for us, the best path to reach our goal remains unclear.

One action that could streamline various efforts and present Nova Scotia with a plethora of future opportunities would be to develop an industrial symbiosis (IS) program.

An IS program is a method to improve business efficiency and environmental performance by which business, government, and other stakeholders combine resources and information to identify symbiotic exchanges between businesses that can reduce operating costs. These exchanges include such things as material by-products, heat, water, and emergency services.

This guide introduces the concept of IS and shows how developing a large-scale program for the province

would be to the benefit of business and government.

Section 2 of this guide provides information on concepts that IS is based upon. For additional information on concepts and terminology related to IS refer to the Definitions section at the beginning of the guide.

Examples of IS working in Nova Scotia and around the world are provided in section 3.

Finally, section 4, 5, and 6 discuss the benefits, process, and resources available for developing an IS program.

“Progress toward sustainability and improved environmental quality will come mostly from better economic policies, as influenced by environmental objectives. Eco-efficiency is the concept that allows us to create the type of information that governments need to help integrate environmental objectives into economic policies in order to achieve de-coupling of the use of nature from economic growth, thereby contributing to more sustainable development.”

DOMINGO JIMÉNEZ-BELTRÁN
EXECUTIVE DIRECTOR,
EUROPEAN ENVIRONMENT AGENCY,
COPENHAGEN

2.0 IS Concepts

2.1 Industrial Ecology, Eco-Industrial Networking and Industrial Symbiosis

IS is a sub-concept within the broader framework of the field of industrial ecology. Below, industrial ecology, eco-industrial networking, and industrial symbiosis are explained.

What is industrial ecology?

Robert Frosch and Nicholas E. Gallopoulos first coined the term industrial ecology (IE) in 1989. In an article in *Scientific American*, they posed a simple question - "why would not our industrial system behave like an ecosystem, where the wastes of a species may be resource to another species? Why would not the outputs of an industry be the inputs of another, thus reducing use of raw materials, pollution, and saving on waste treatment?"

(Frosch, R.A.; Gallopoulos, N.E. (1989) "Strategies for Manufacturing" *Scientific American* 261:3, pp 144-152.)

This simple idea of mimicking nature is at present very alien to most industrial systems, however much can be learned from even the simplest ecosystems. For beginners, there is no waste!

A good example of this is the decomposition of vegetation. Leaves and other detritus not consumed by animals do not accumulate and build up; they break down, become nutrients and feed back into the cycle. Similarly, animals that are not fully consumed by predators are made use of in other ways. Scavengers and decomposers fill a key niche in processing remains. Every waste is turned into a resource and this is the premise of industrial ecology.

Today IE includes such practices as Design for Environment (DfE), Life Cycle Analysis (LCA) and Extended Producer Responsibility (EPR). By implementing such practices industrial systems are slowly beginning to behave more like natural systems.

What is eco-industrial networking?

Eco-Industrial Networking (EIN) is networking between groups to establish eco-industrial systems – systems based on industrial ecology.

Networks can be as simple as informal dialogue between co-workers in a company or as extensive as nation-wide industrial symbiosis programs. Ideally, an eco-industrial network should bring together businesses, government departments and agencies, and the

wider community to create a holistic method for efficient resource use.

EIN is especially important to small and medium sized businesses at the local and regional levels when eco-industrial networking could be the difference between business success and failure.

For example, if two small chemical plants suddenly required improved emergency response services, this could significantly increase costs. Individually these additional costs may be too great and each plant could close. However, if these companies pursued EIN and identified each other as being in need of the same service they could purchase the emergency response services collectively, thus reducing each plants overall costs.

Developing eco-industrial networking in a region vastly improves competitiveness by matching business entities based on how they can reduce costs by working together. This goes far beyond material by-products and can also include energy, buildings, land, infrastructure, facilities, training, and people.

As the competitive advantage of being in an eco-industrial network becomes increasingly apparent we can expect business groups and governments to implement them on a growing scale. Leaders can expect to experience economic growth and foster an attractive business environment. Laggards may lose

business due to higher costs and poorer environmental performance.

What is industrial symbiosis?

Following on the IE premise that industrial systems should aim to operate more akin to natural systems, industrial symbiosis is the term for the exchanges between industrial entities that mimic those found in nature.

Industrial symbiosis can include the exchange of physical materials, energy and water, and anything else that may be considered a by-product.

IS can be done on a small scale – for example, one company selling pallets, which would otherwise have been sent to landfill, to another company - or it can be done on a large scale.

The most successful large-scale industrial symbiosis program is the United Kingdom's National Industrial Symbiosis Program (NISP). It is a nation-wide program based on 12 regional groups that work closely with regional business representatives to ensure the program is meeting the needs of local business. NISP's wide spread success is discussed further later in the document.

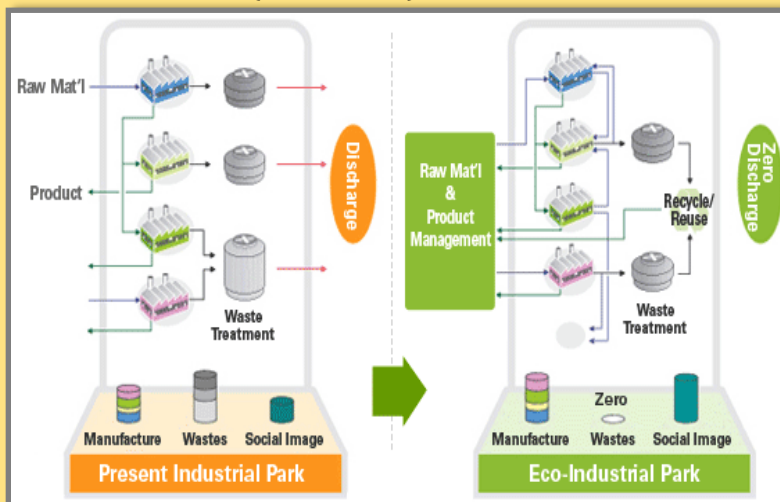
Eco-industrial parks and industrial symbiosis

A common misconception regarding IS is that it only takes place in planned eco-industrial parks. While IS is not reliant on eco-industrial parks, the close proximity of businesses and the collaborative management associated with such parks creates many opportunities for IS. This includes such examples as waste heat recovery, energy by-product exchange, and combined emergency services and training.

By grouping businesses that have obvious industrial synergies, eco-industrial parks can reduce the physical distances that by-products may have to travel and improve communication between businesses by having companies within walking distance of one another and sharing common facilities such as parking lots.

Having learned of the benefits of eco-industrial parks, many of the current industrial parks in Nova Scotia have taken steps towards becoming eco-industrial parks. These include:

- Burnside industrial park (Dartmouth)
- Debert (Truro)
- Cornwallis (Cornwallis)



2.2 Examples of Eco-Industrial Networking Opportunities

Effective eco-industrial networking is a precursor to successful industrial symbiosis. Aside from by-product exchange, here are some of the ways EIN opportunities can take place.

Consolidated Training and Emergency Services – Businesses located in close proximity and that have similar training or emergency service needs can usually lower their costs by coordinating on joint training and service options. The Canadian Eco-Industrial Network (CEIN) documented a case in Sarnia, Ontario in which 8 firms shared emergency response services reducing individual costs by 30-40%.

Waste Heat Recovery – In large-scale industrial operations, such as mills and factories, there is generally a considerable amount of heat generated by the production process. With some modifications and the installation of a heat exchange/recovery system this “waste” heat can be used to heat buildings or for industrial processes that require high heat. Minas Pulp and Power located in Hantsport is a great example of how waste heat recovery can benefit a business. The current waste heat recovery system saves the company approximately \$1 million a year.

Green Building Development – EIN can also take the form of capitalizing on green building developments. Park Place V, located in Dartmouth’s Burnside Industrial Park, is a green office space building that caters to organizations focused on high environmental performance. Features of the building include a hydrofluorcarbon (HCFC) free HVAC system, natural gas boilers, energy efficient lighting, and lavatories that significantly reduce water use.

Collective Green Procurement – Materials can be purchased in conjunction with other businesses, thus improving prices due to volume increase. Businesses that have similar material needs could go so far as to share procurement personnel and offices, further reducing costs.

3.0 Case Studies

While still a relatively new concept, IS has been quickly developing around the globe. As governments and businesses have been seeing the advantages of industrial ecology, both monetary and ecologically, there has been increasing development of large scale IS programs to coordinate efforts. The opportunities of any IS system or program increase exponentially as more organizations become involved. The below examples highlight some of the best cases, both globally and within Nova Scotia, of IS and how businesses are making positive impacts in their regions.

3.1 Global

The following IS case studies from around the world demonstrate a full spectrum of IS opportunities, from an extensive eco-industrial park in Denmark to a developing pigment company in India.

International case studies:

- Kalundborg, Denmark
- Mumbai, India
- United Kingdom

Cooperation in Kalundborg

Business: Kalundborg Industrial Park
 Location: Kalundborg, Denmark
 Type of IS: Eco-Industrial Park

If you ask anyone involved with IS research to name a case that epitomizes IS, chances are they will say “Kalundborg”. Kalundborg is a small industrial zone about 120 kilometers west of Copenhagen, Denmark and is considered by many people the birthplace of IS.

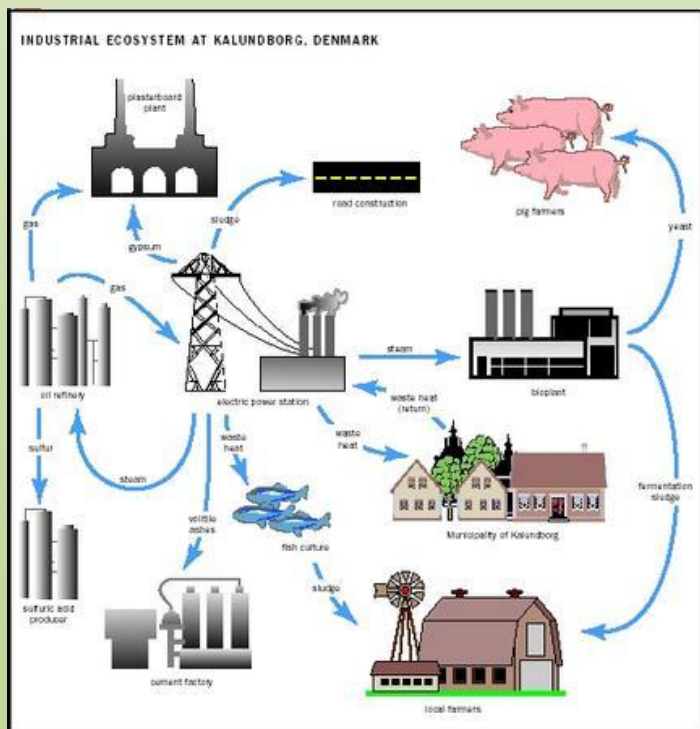
The project started in 1972 when local business leaders came together to determine what synergies they could establish that would have mutual benefits for the participants involved. What they came up with was extensive energy, water, and material exchanges that eventually evolved to include 16 negotiated contracts, an exchange of 3 million tonnes of material, and yearly savings of approximately \$10 million a year.



The initial participants consisted of a coal-fired power station, an oil refinery, a pharmaceuticals plant, a plasterboard manufacturing plant, and the municipality of Kalundborg. Today the IS system also includes farmers and partners from other districts.

Some of the synergies of this system include:

- Wastewater from the oil refinery being used as cooling water by the power station
- “Waste” steam from the power station being used for operations in the pharmaceutical plant and the refinery
- “Waste” heat from the power station is used to heat homes in the surrounding area
- Fly ash generated by the power station is used by the plasterboard plant to make gypsum, a key ingredient in the plasterboard



Kalundborg continues to expand and find new uses for the by-products generated within the system such as fertilizers for local farms and heat for nearby fish farms.

Source: Pollution Issues (pollutionissues.com)

The Colours of Ecology

Business: Heubach India
Location: Mumbai, India
Type of IS: By-product exchange, cogeneration and design for environment

To say that Heubach India is a “green” company doesn’t really do it justice. It is a “green”, “blue”, “purple”, and countless other colours company. Heubach is in the pigment business, an industry that has traditionally been very toxic and detrimental to the environment. Fortunately Heubach is taking a new approach.

The path toward eco-friendly pigment production first began with a commitment from the company to come as close to zero emissions as possible without compromising the quality of their pigments. Incidentally, Heubach’s market position and reputation has improved significantly as a direct result of balancing economic and environmental priorities.

The most impressive aspect of Heubach’s case is that as India experiences an influx of business due to its lax environmental regulations Heubach has been raising its environmental standards. This is because Heubach sees India’s business environment as an opportunity rather than an escape for improving environmental performance. To quote Heubach’s German Chairman Rainer Heubach, “By incorporating environmental practices at the very first planning stages, we have managed to save the costs of cleaning up our act afterwards.”

Heubach examined every aspect of the pigment plant to determine exactly what forms of IS could be taken advantage of. The resulting initiatives revitalized operations and diverted considerable waste. This included selling a waste, aluminum



hydroxide, generated by the green pigment plant as an ingredient for antacids in the pharmaceutical industry. Another initiative was to strip effluent from the blue pigment plant of its ammonia that was then reused in the aluminum hydroxide production process.

Other greening actions included a pipe design that maximized the use of gravity, minimizing the need for pumps, a cogeneration system that uses waste heat to produce steam necessary in the production of pigments, and the construction of a natural gas power plant to generate their own electricity.

When questioning whether or not environmental performance makes a difference the proof is literally in the pigment. Since starting in 1994, Heubach’s turnover has doubled every three years. This rate of growth is even more impressive due to the fact that almost 25% of company investments go into ecological projects.



Source: [wikimedia.org](https://www.wikimedia.org)

A Kingdom United by IS

Organization: National Industrial Symbiosis Programme

Location: United Kingdom

Type of IS: Nationwide IS network



The National Industrial Symbiosis Network, better known as NISP, is the largest, most successful coordinated IS network in the world. Officially launched in July 2005, NISP consists of 12 regional offices across England, Wales and Scotland. The success of four regional pilot projects is what initially motivated the formation of a nationwide program. The national program oversees the regional offices, secure partnerships, and most importantly “change the way business thinks.”

By helping businesses rethink how they view wastes, NISP has been able to make incredible contributions to business and the environment. Today NISP boasts a long list of accomplishments. In the article Comparison of Eco-Industrial Development between UK and South Korea (D. Kim, J.C. Powell), it is noted that between April 2005 and June 2006 NISP achieved the following:

- 1,483,646 tonnes diverted from landfill (of which 29% was hazardous wastes)
- 1,827,756 tonnes of virgin material saved
- 1,272,069 tonnes CO2 savings
- 386,775,000 litres potable water savings
- £36,080,200 additional sales for industry
- £46,542,129 of cost savings to industry
- 790 jobs created
- £32,128,889 private capital investment in reprocessing

The synergies developed by NISP have pushed the limits of innovation. Getting energy from pastries, reusing soil, and using scallop shells to build roads are just some of the ideas that have emerged from NISP’s IS practitioners. This genius is not only the result of bright minds, but also diverse minds. The 12,000 plus members include strawbale construction companies, design firms, public schools, homeless shelters and arts & crafts businesses.

Their success is credited heavily towards their engaging approach that encourages participants to contribute in a variety of ways. Upon joining each member receives training and this helps them to learn how to make the most of their membership and begins to train them to think outside the box.

Aside from creating sustainable business opportunities in the UK, NISP has been branching out internationally and have engaged in what they call “sustainable development dialogues”. These dialogues have helped to establish new IS programs in Chicago and China and is making headway with developments in the EU.

Image Source: <http://www.emra.gov.uk/what-we-do/regional-communities-policy/sustainable-development/>

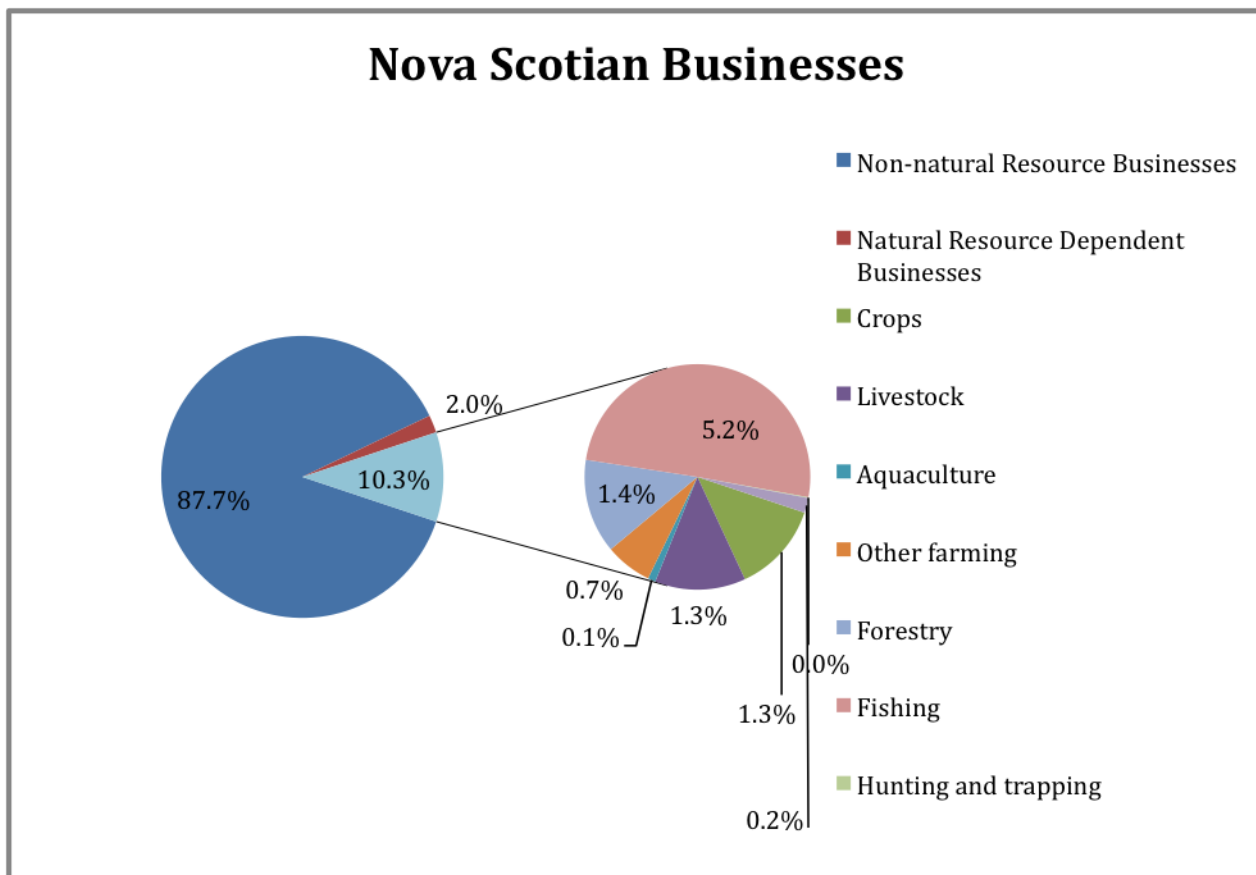
3.2 Nova Scotia

The previous global case studies show the incredible potential of IS, but the challenges and accomplishments of each case are unique. This can make it difficult to envision how Nova Scotian businesses can develop a broader IS network. Well a good starting point is to look at the IS initiatives that are currently taking place in Nova Scotia and to build off their success.

Nova Scotia case studies:

- BioGas Energy
- Minas Basin (Scotia Investments)
- Ocean Nutrition/Wilson fuels
- SF Rendering

Below diagram shows composition of Nova Scotia's natural resource industries



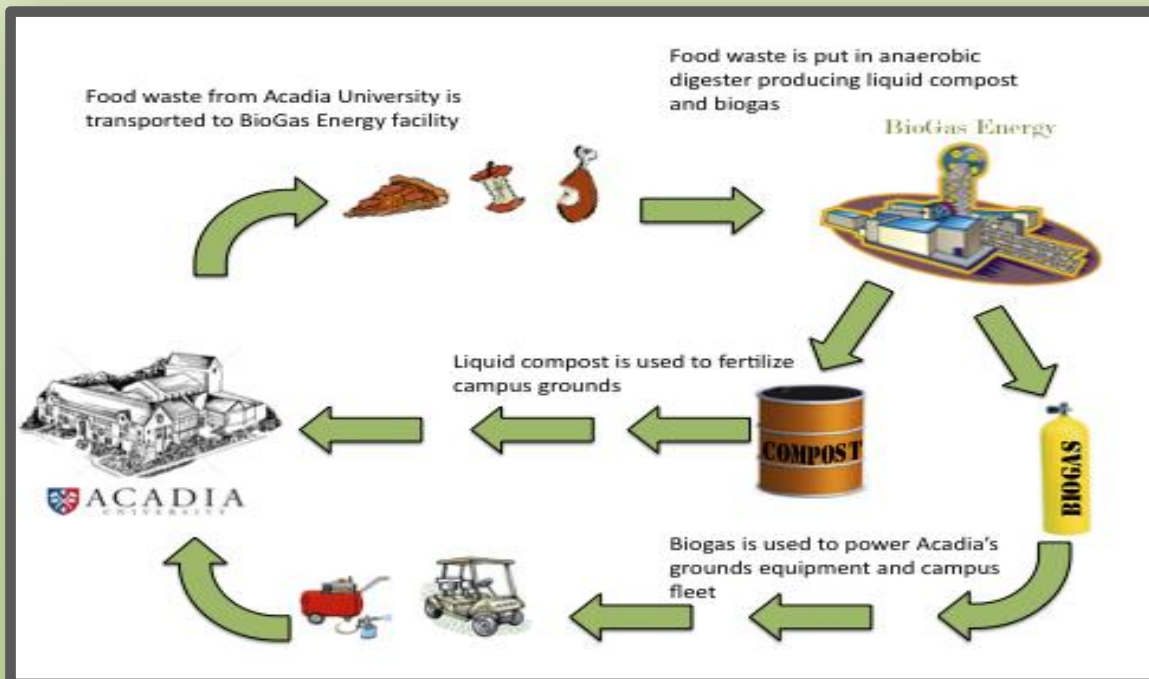
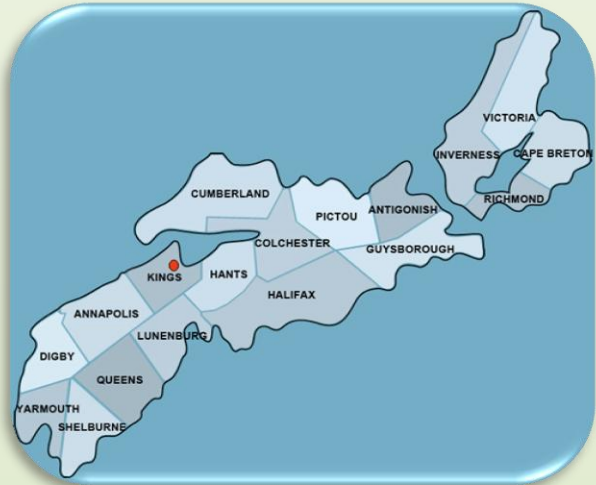
Pizza crust powered golf carts

Business: BioGas Energy

Location: Port Williams

Type of IS: Organic material/biogas exchange

Six years ago Tom Harz of **BioGas Energy** envisioned bringing a new form of organic waste processing to Nova Scotia: biogas production. As of September 2009 that vision will become a reality. By taking the food waste from Acadia University that would normally be used for compost, placing it in an oxygen free system (anaerobic digester), and heating it to 37°C, BioGas Energy's new facility in Kentville is able to produce biogas that can be used in much the same way as natural gas. The other by-product of the process, liquid compost, is exactly what its name suggests except the compost has fewer pathogens and fewer odours than conventional compost. What is more is that this facility is 100% solar powered 9 months of the year, with 40% of its power still coming from solar during the three winter months. Not only are the economic returns for this method of organic waste processing considerably more than conventional methods, but also the process completely eliminates methane emissions, a natural occurrence from composting and a major contributor of greenhouse gases.

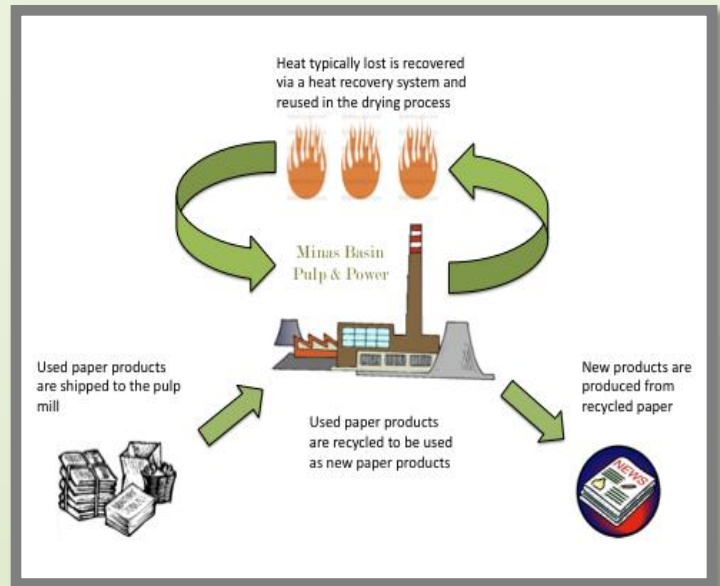


Waste heat recovery: the value of blowing hot air

Business: Minas Basin Pulp & Power
 Location: Hantsport
 Type of IS: Waste heat recovery

Industrial symbiosis does not always take place between two businesses. Much of the time it happens in the same business when an internal use is identified for what before was considered a waste. Nor does industrial symbiosis always involve the exchange of material by-products. It can also include water and energy use. This is the case for Minas Basin Pulp & Power.

Minas Basin Pulp & Power, founded in 1927, has a long list of environmental achievements. The company has incorporated environmental performance directly into its corporate policy, their products are produced from 100 percent recycled materials and Minas Basin has also been a major proponent and developer of green energy within Nova Scotia.



One of the company’s most profitable endeavors was the installation of a state-of-the-art heat recovery system to be used in conjunction with its dryer exhaust system. The drying processes involved in pulp and paper manufacturing require a considerable amount of energy, but by reusing the heat that is generated from other parts of the factory the company was able to reduce energy consumption by 25 percent, a cost-savings of approximately \$1 million dollars a year.

This improvement also has the added benefit of reducing air emissions. Approximately 92 tons of sulfur dioxide, 8,350 tons of carbon dioxide and 16 tons of nitrogen are eliminated. This incredible reduction in emissions equates to even more revenues for Minas Basin as they provide \$180,000 worth of certifiable emission credits per year. With savings like that businesses must cease the opportunity to practice industrial symbiosis.

Fish trimmings: Fueling cats and cars alike

Business: Clearwater Seafoods – Ocean Nutrition/Wilson Fuels

Location: Mulgrave

Type of IS: Fish by-product/biodiesel production

Ocean Nutrition Canada (ONC), one of Clearwater Seafoods subsidiary companies, is a research, development and production company for marine-based natural ingredients. ONC fulfills a very important role for Clearwater Seafoods: making value-added products from the various products harvested by the company. The main focus of ONC is the production of dietary supplements, such as omega-3 capsules.

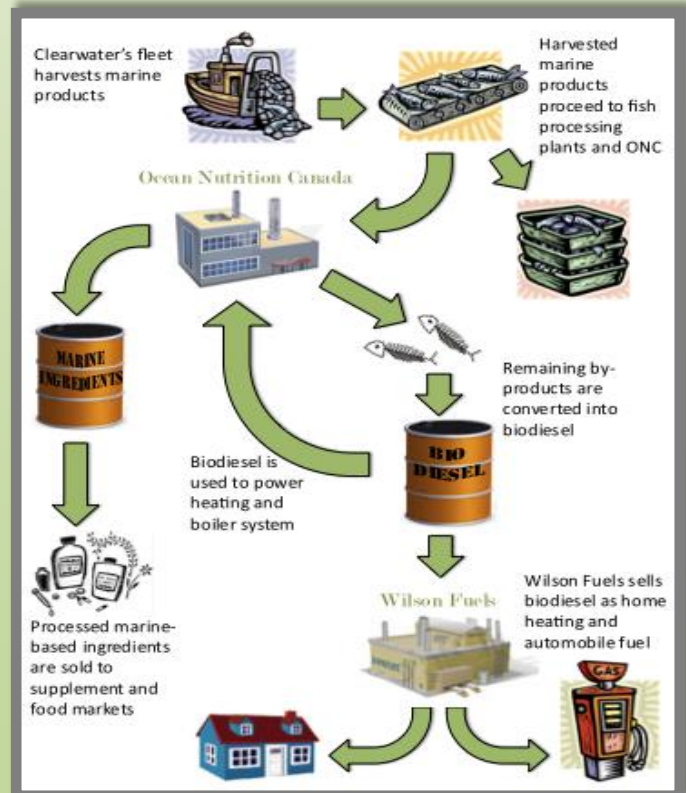
Today ONC produces more than just dietary supplements. Since 1999 the company has produced biofuel from the waste by-products created in fish oil manufacturing. This improves profit margins and reduces waste generated at the facilities.

The biofuel produced powers ONC's boiler and heating system in Mulgrave, but through an agreement with Wilsons Fuel supplies the biofuel as an alternative fuel option for individuals, businesses, and government. Wilsons Fuel now provides biofuel for home heating and automobile use. Some of the larger clients include Halifax Regional Municipality which use the fuel to operate Metro Transit buses and the provincial government which heat many government buildings with the fuel.

There are direct and significant economic benefits to ONC for diverting a waste by-product into usable fuel. ONC saves money



through using biodiesel as fuel rather than purchasing a fuel from an outside source. ONC also saves money by using the by-product waste instead of paying for disposal of this waste. Finally, ONC has taken what was formerly a waste and developed it into a marketable commodity.



Making the most out of an offal situation

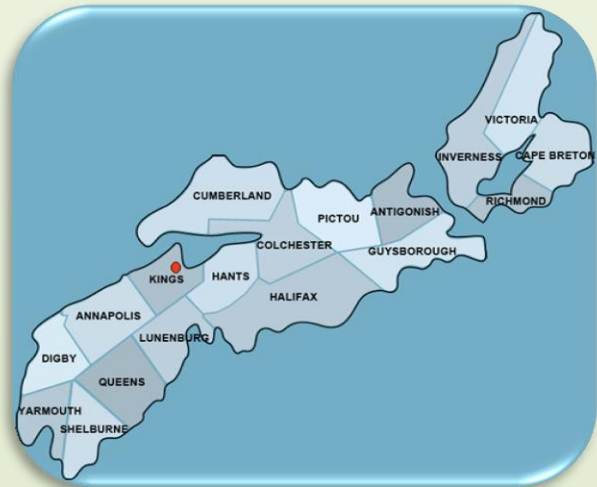
Business: S.F. Rendering

Location: Port Williams

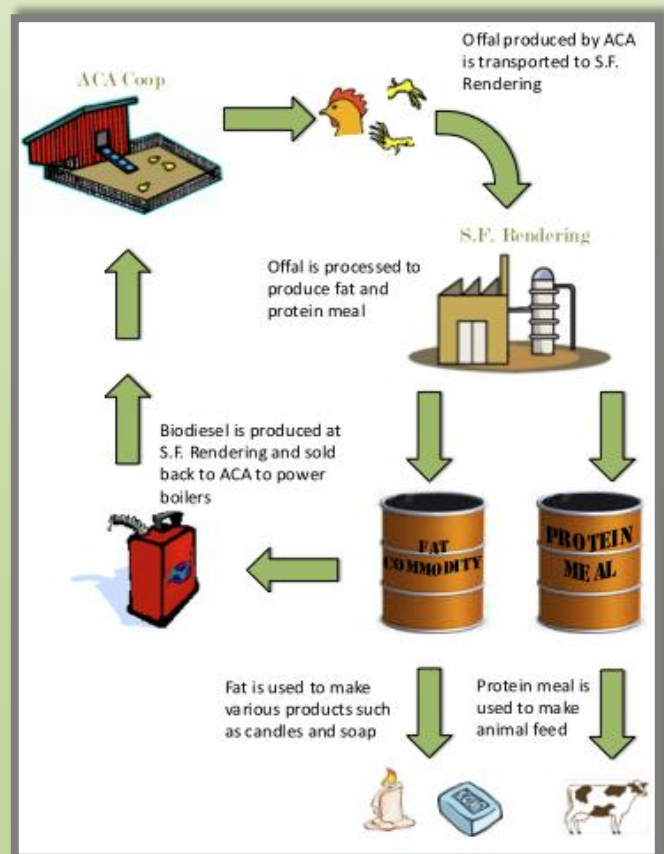
Type of IS: Poultry offal/biodiesel exchange

Many people don't know where our soap, candles, animal feed and cooking grease come from. The answer to all of the above is rendering plants. Rendering is a process that converts waste animal by-products, also known as offal, into forms that can be used for various products. By taking the offal and putting it through a chemical process two by-products emerge: a fat commodity and a protein meal. The protein meal is primarily turned into animal feed, while the fat commodity is used to produce everything from lard and glue to industrial lubricants and chemicals.

When Dale Scott, owner and operator of S. F. Rendering in Port Williams, began producing a surplus of fat commodity at his plant he decided to get involved in a non-traditional use for the fat. He began making biodiesel. Rendering is already a highly efficient industry making use of what otherwise would be a waste and turning it into value-added products, but by producing biodiesel at his rendering facility he created a value-added product that his company could produce on their own. What is more, S. F. Rendering had a pre-established buyer for the entirety of biodiesel produced with whom they already had a strong business relationship with: ACA Coop, the same business that supplies the majority of offal for S. F. Rendering. ACA now uses



the biodiesel produced by S. F. Rendering to power the company's boilers. Another symbiotic solution that increases efficiency, improves the environment, and makes money for its participants.



4.0 Benefits of IS

As Nova Scotia embraces Opportunities for Sustainable Prosperity and the Environmental Goals and Sustainable Prosperity Act strategies that affirm a triple bottom line approach should be considered as a means to achieving provincial goals. The below table shows how an IS program would apply to various governmental goals.

While benefits such as reduced resource use, decreased waste, improved production, and additional employment can be expected to increase with the development of an IS program, precise benefits are difficult to calculate due to regional variables such as local business environments, available labour, legislation and policy, etc. Some general expectations for economic, social, and environmental spheres are noted in the following sections.

Provincial Goal	Industrial Symbiosis
“To create a business climate that attracts out-of-province investors and encourages local businesses to start and grow in ways that support sustainable competitiveness”	IS creates local business growth by improving efficiency through innovative collaboration, thus increasing profitability and encouraging new business development
“To promote increased productivity through innovative products and processes that eliminate waste of all kinds”	IS identifies sources and new uses for various wastes and provides a network to connect users and producers
“Manage natural capital to sustain our quality of life, our economy, and our environment”	IS promotes the responsible and efficient use of resources by increasing the life-cycle of resources
“Take a long-term view to ensure that Nova Scotia’s workforce continues to be a magnet for business”	IS seeks to establish long-term business relationships that add value to participants and subsequently attract new business

4.1 Economic

The social and environmental benefits of IS take into regard public interests such as clean water and stronger communities, but it is economic benefits that ensure longevity for IS programs. The most successful IS networks, such as those found in Kalundborg, Styra, and Jyvaskyla, credit economic benefits as the main motivator for participation (source M. Mirata / Journal of Cleaner Production 12 (2004) 967–983 pg 981).

Economic benefits of an IS program include:

- Cost reductions from waste management
- Savings on energy consumption
- Attraction of new business
- Development of value-added products
- New employment opportunities
- Improved communication networks

As previously mentioned, numerous variables of an IS program makes it difficult to estimate exact economic returns, however programs such as NISP and the Chicago Waste to Profit Network paint a clear picture of the economic impact that can be achieved. Since 2006, the Chicago Waste to Profit Network has generated over \$11 million for its

members. The project has also diverted 122,000 tons of solid waste and created 37 new jobs. In 2004, after its first year of operation, NISP generated approximately 60 million pounds in savings with only an initial investment of 1.5 million pounds in the program. This included a waste disposal cost saving of 30 million, a CO2 reduction equating to 13 million, and 2 million generated from new jobs and training (Source NISP: A Year of Achievement). Many of the metrics that are more difficult to measure, such as new business start-ups and the spin-offs for communities, were understated to keep the estimate conservative, but returns are estimated to be approximately 60X for regions that participate in NISP.

The UK's greater density of businesses gives them an advantage over Nova Scotia, but even a quarter of that, a potential return of 15X, would warrant the consideration of an IS program. With an investment of \$500,000 returns could be 7.5 million. If Nova Scotia were to create an IS program one of the first steps would be to have a coordinating body investigate where the greatest potential for IS is located and begin to estimate potential returns.

4.2 Social

The main social benefit that can be expected from an IS program would be an increase in jobs. New businesses may be attracted to services offered by a program and existing businesses may be able to afford to expand as a result of cost savings. As shown in the case studies, there is any number of ways that a business can add value to itself, thus creating growth and improved market conditions. With an increase in jobs in companies developing synergies there would also be spin off jobs in communities to support additional work force. As such, companies adding jobs in rural areas could have a significant effect on local communities.

Beyond jobs created by the positive impact of synergies, there would also be jobs created within an IS program. There would be a need for educators, data gatherers, and support staff to work within the program. Fortunately, Nova Scotia's considerable knowledge-based labour force is well situated to meet such labour needs.

Additional jobs are only one part of the social benefits. Pursuing industrial ecology in this manner can promote better working conditions, healthier workspaces, incentives for employing local people, and encouraging more community/business

communication (source D. Gibbs, P. Deutz, A. Proctor "Industrial Ecology and Eco-industrial Development: A Potential Paradigm for Local and Regional Development?").

Social benefits of an IS program include:

- Job creation
- Improved health and well being
- Better work conditions
- Citizen development and engagement opportunities

Positive changes such as these have always been of importance to Nova Scotians and with an IS program many of the goals of "Weaving the Threads", Nova Scotia's social prosperity framework, would be furthered, such as improving citizen health, creating safer workplaces, and greater opportunities for participation in work, community networks, culture and recreation.

4.3 Environmental

The linkages between businesses within an IS program provide a multitude of environmental benefits. Energy savings, waste diversion, emission reductions, and reduced use of natural resources are all common findings in instances of industrial symbiosis.

The focus of efficiency in an IS program can have an impact on several areas simultaneously creating many benefits. In the Biogas Energy case the relationship between Acadia and Biogas Energy not only diverts waste and reduces emissions, but also helps to provide a renewable source of energy. A holistic approach to sustainability such as this will generally provide greater benefits than addressing issues in silos.

Environmental benefits of an IS program include:

- Improved natural resource use
- Reduced emissions
- Improved water-resource management
- Waste diversion
- Reduced energy use

Conveniently, many of the goals set forth in the Environmental Goals and Sustainable Prosperity Act would be advanced by an IS program, such as the 20% reduction in emissions, bettering water-resource management, maintaining the solid-waste disposal rate below 300 kilograms per person per year, and adopting a strategy to ensure the sustainability of the province's natural capital.

5.0 Action Plan for a Nova Scotia IS Program

5.1 2030: NSISP

The brochure 2030: NSISP is a fictional brochure about how an industrial symbiosis program, started in 2010, may affect Nova Scotia in 20 years time. By imagining the benefits we may reap in 20 years we hope to motivate people to take the necessary steps today.

5.2 How to build an IS Program

There are many different options in constructing an IS program, such as the mix of government, business, NGO, and academic participants, but the general process of creating an IS program remains similar from program to program. There are typically four stages: awareness raising, data-collection, analysis, and implementation. This methodology, created by Andrew Mangan, CEO of the US Business Council on Sustainable Development, “aims to overcome economic, regulatory and habitual obstacles to realizing such synergies” (WBCSD By-Product Synergy from http://www.wbcds.org/industrial_symbiosis).

Awareness raising – Education and promotion is the first step towards an IS network. Companies need to understand how a network would operate and how being a part of that network could be of benefit. It is also important at this stage to address the reservations businesses may have about becoming a participant. For business owners, confidentiality agreements can negate many fears and examples of businesses in their industry that have profited from participating in an IS network can be a powerful persuader.

Along with addressing reservations, this stage, depending on the program, can be used to instill ownership of a program. This has been a key element of NISP’s program. By getting top level commitment NISP encourages businesses to part of the decision making process rather than passive participants. Integrating business people into developing their own synergies and promoting diverse collaboration engages the participants at a higher level.

In an IS programs infancy, awareness raising should focus on a small group of core companies that can form the foundation of a network. Once this foundation is

created participating businesses can offer expertise on how to expand the network to maximize profitability for participants.

In Nova Scotia, awareness raising could be conducted by regional development authorities (RDAs). Their close ties to local businesses and their pre-existing communication networks make their role as awareness raisers an obvious choice.

Data collection – Once awareness has been raised and businesses begin to sign on accurate data on businesses inputs and outputs needs to be obtained. This information would then be entered into a database so that engineers can begin to determine potential synergies. In developing a database attention has to be given to how the inputs and outputs are classified with consideration given for the time and resources of companies. This can be very challenging as a database needs to obtain the information required to analyze a wide variety of synergies without becoming too complicated that it discourages participation. Dalhousie University has conducted by-product synergy projects in the Annapolis Valley and the Canso Strait regions that provide a foundation of research that can be used in the formulation of a province wide data base.

There are a variety of options for data collection. This can be done by IS program representatives or

by standard forms or any number of methods. Web-based data collection tools are used in programs in the UK, Chicago, and Mexico. The benefits of a web-based application are that it is convenient, it is a direct input into a database, it can be easily manipulated, and it reduces the personnel required for data collection by placing the onus of reporting material flows on the company.

Typically, there is a training component with data collection to educate participants on how to use data collection tools. This can include familiarizing them with the tool, reviewing the various input options, and advising on how often updates should be done. In addition to training, if pertinent data is not recorded by a business it may be necessary to conduct an audit detailing an operation's material flows. Audits of this nature could be performed by existing environmental auditing organizations in Nova Scotia, such as the Eco-efficiency Centre, that have extensive experience in the area.

Analysis – Analysis can take place at a number of levels. Many synergies, such as heat exchange between adjoining businesses, are easily identified and can be determined on an ongoing basis by engineers and other analysts working within a program. More in-depth analysis usually takes place in periodic brainstorming meetings

that bring together experts and participants. Meetings can be used to examine gaps and needs in an IS network and develop strategy or they may be used to bring different expertise together to tackle difficult synergy problems.

Continuous working groups for particular industries or regions can often help to focus efforts on particular areas. Members of a working group could include industry leaders, government representatives, academic experts and RDA agents or community liaisons. For example, a fisheries working group may include representatives from various Nova Scotia seafood processing companies, Department of Fisheries and Aquaculture employees, and academics specializing in fishery management.

Another method for breeding innovation to deal with specific subjects is workshops. These conventions can bring together a large, diverse group of businesses to engage in exercises and discussion that can lead to collectively beneficial synergies. Activities such as “haves” and “wants” exercises and industrial speed dating sessions have proven to be very effective at cultivating new innovation.

If a company has a particular need they could also put out a general enquiry. This option can be useful for new members of a program to

quickly find unconventional by-products. Whatever the analysis method, collaborating minds are crucial to expanding and diversifying the types of relationships within a program.

Implementation- Once analysis is completed the decision makers of an IS program will decide which identified synergies should be implemented based on economic return, environmental benefits and social impacts. Depending on the synergy being implemented this may primarily be between two companies in direct communication or by multiple companies and facilitated by a coordinator. No matter the synergy, economic viability must be determined to ensure that a relationship is sustainable and that it adds value to all participants.

Once a synergy is established there is typically a minimal amount of involvement from program personnel and the ongoing exchange is left for the companies to manage. Resources of an IS program should be focused on maintaining every synergy but in establishing new synergies and expanding the overall network and membership. It is important, however, to follow up with companies on the status of coordinated synergies. Not only does this information help to improve processes and develop best practices, but it is necessary to document the impact an IS program is having in a region.

Keys to success – In addition to the four stages of building an IS program, Mangan identified four keys to success that support IS networks.

Diversity

The more diverse a network's members are, the more opportunities there will be for creative exchanges of by-products.

Communication

The security and trust found in an IS program encourages participants to think outside their corporate boundaries and engage in a new level of problem solving.

Partnerships

The widespread collaboration of both public and private expertise reduces barriers to implement synergies.

Quantifiable benefits

Programs carefully track benefits associated with their work in order to maintain funding and attract new partners.

The above methodology shows in a broad sense the elements of an IS program, but the operating structure is much more individual to an area's characteristics. Determining how a region should proceed with development depends on a variety of factors. Murat Mirata of Lund University and Richard Pearce of Enviros Consulting Ltd classify these determinants into the following categories: *technical, political,*

economic, informational, and organizational. Based on their research, the success of an IS network is largely related to how well each of these categories are analyzed and adjusted for by a coordinating body, such as an IS program. Regardless of the makeup (government, private, agency, NGO, etc.), a coordination body needs to take into consideration these factors so that the most promising development strategy can be pursued. When determining what factors are in support of an IS network, it is also important to determine what factors are in opposition and what can be done to mitigate these effects. Some of the factors that a coordinating body in Nova Scotia would have to take into consideration are listed below.

Business environment

- Increasing pressure from consumers and suppliers to adopt sustainable practices
- Pressure to improve competitive advantages through improved natural resource use efficiency, improved energy efficiency, and reduced waste costs.
- Rising environmental stewardship commitments from competition
- Legislation that raises environmental performance requirements (EGSPA)
- Barriers to certain profitable environmental business ventures (e.g. lack of a feed-in energy grid)

Government policy and legislation

- Implications of enacted environmental legislation (EGSPA)
- Barriers created by legislation that impedes IS
- Policy that supports economic opportunities with positive social and environmental impacts (Opportunities for Sustainable Prosperity)

Regional and economic development

- RDA's increasing commitment to sustainability
- Trend of industrial parks shifting towards eco-industrial parks
- Resources and agencies devoted to economic development (e.g. InNOVAcorp, Nova Scotia Business Inc., etc.)

5.3 Stakeholder action

Developing and coordinating an IS program is a collaborative undertaking between various stakeholders. The following section provides some basic tips on how each stakeholder could help to facilitate IS development in Nova Scotia.

Provincial Government

The power of regulatory tools to create an environment that fosters

IS development cannot be understated. Taxes, subsidies and policy can all dramatically affect the formation of an IS network. Creating cross-departmental relationships, which is already well done in Nova Scotia, can also help to break down silos in government. Additionally, conferring with RDAs and other development agencies could help to define potential roles in a future IS program. Building relationships with business and consulting with business leaders to determine how they might structure an IS network would also be instrumental in the formation of an IS program.

Actions:

- Review policy that is in line with the benefits of IS and see how IS may be applied toward goals
- Review and redevelop policy that hinders IS (e.g. certain waste regulations, subsidies, energy policy, etc.)
- Coordinate with other departments and agencies on sustainable development issues that span economic, social and environmental dimensions to determine how to better integrate resources
- Set up meetings with existing IS programs, such as NISP, to learn how one may be started in Nova Scotia
- Consult with business on their "haves" and "wants" to begin to understand how an IS may begin to fill in gaps

Business

Devoting some time and resources to identify inputs and outputs and how they may be better used is one of the first steps to creating synergies. As most IS networks started from business necessity, communication with other firms on “haves” and “wants” can be beneficial to finding solutions previously unknown. Beyond other businesses, approach government, RDAs, and the local community to investigate IS possibilities.

Actions:

- Identify inputs and outputs and review processes to determine where changes could be made
- Advocate to business organizations the possibilities of developing IS
- Inquire with other businesses on successes they have experienced with IS
- Integrate IS into business strategy and product innovation
- Support government policy that improves IS network capacity
- Meet with RDAs to determine possibilities for local partnerships

RDAs

Regional development can benefit greatly from encouraging sustainability. As RDAs are constantly in contact with local businesses, one of the best ways they can assist with encouraging sustainability is to inquire about the wastes and needs of companies. Facilitating regional workshops is also within their capacity and can be very beneficial. Devoting staff positions to regional sustainability can put a stronger emphasis on developing IS.

Actions:

- Contact existing IS programs to learn how one may be started in the region
- Collaborate with other RDAs to see how regions could integrate IS efforts
- Hold regional workshops to educate businesses on IS and identify possible synergies
- Provide information on audit services, such as those done by the Eco-Efficiency Centre, to assist businesses with recording inputs and outputs
- Support government and business initiatives that facilitate IS development

6.0 IS Resources

The following are some of the best sources of information on Industrial Ecology and related areas.

Websites

Eco-Efficiency Centre has researched industrial ecology, industrial symbiosis, and options for creating a circular economy in Nova Scotia since its beginning. A plethora of documents have been produced on this research.

www.eco-efficiency.management.dal.ca

World Business Council for Sustainable Development provides information on a wide variety of business related actions that promote sustainability including successful cases of industrial ecology and industrial symbiosis.

www.wbcso.org

NISP has a multifunction website providing information on the program, regional programs, international efforts and information on their founding and success.

www.nisp.org.uk

Chicago Waste to Profit Network highlights the success that has been achieved in the Chicago area with their IS program.

www.wastetoprofit.org

The Canadian Eco-Industrial Network educates and coordinates eco-industrial networking across the country with the goal to create new opportunities for business development.

www.cein.ca

The International Society for Industrial Ecology “promotes industrial ecology as a way of finding innovative solutions to complicated environmental problems, and facilitates communication among scientists, engineers, policymakers, managers and advocates who are interested in better integrating environmental concerns with economic activities”.

www.is4ie.org

Journals and Books

The Journal of Cleaner Production “serves as an interdisciplinary, international forum for the exchange of information and research results on the technologies, concepts and policies designed to help ensure progress towards sustainable societies”

The Journal of Industrial Ecology is the official journal of the International Society for Industrial Ecology and discusses a broad variety of topics related to the field including industrial symbiosis

Cradle to Cradle by William McDonough puts into question traditional manufacturing and environmentalism calling for a new paradigm with which to view waste

Biomimicry: Innovation Inspired by Nature by Janine M. Benyus shows how looking to nature for lessons can often be the best way to approach problems we find in processes and products

References

- Frosch, R.A., Gallopoulos, N.E. (1989), "Strategies for manufacturing", *Scientific American*, Vol. 3 No.189, pp.94-102.
- Gee, D., Bonazzi, C., Allen, P. (2001), "Metaphors for change: partnerships, tools and civic action for sustainability", Sheffield: Greenleaf, 2001.
- Gibbs, D., Deutz, P., Proctor, A., (2005) "Industrial Ecology and Eco-industrial Development: a New Paradigm for Local and Regional Development?", *Regional Studies*, Vol. 39, pp. 171-183.
- Gordon, I., McCann, P., (2000), "Industrial Clusters: Complexes, Agglomeration and/or Social Networks?", *Urban Studies*, Vol. 37, Issue 3, pp. 513-532
- Harris, S., van Berkel, R., Kurup, B., (2006), "Fostering Industrial Symbiosis for Regional Sustainable Development Outcomes", Centre of Excellence in Cleaner Production, Curtin University of Technology, Perth WA, Australia
- Hodge, M., (2007), "Quantifying Potential Industrial Symbiosis: A Case Study of Brick Manufacturing", Completed as part of Master of Science in Technology and Policy at Harvard University.
- Jacobsen, N.B. (2006), "Industrial symbiosis in Kalundborg, Denmark", *Journal of Industrial Ecology*, Vol. 1/2 No.10, pp.239-55.
- Karaev, A., Koh, S.C.L., Szamosi, L.Y. (2006), "Could a cluster approach really improve the competitiveness of SMEs", in Bruce Ho, Ch.-T. Dr (Eds), *Proceedings of the 4th International Conference on Supply Chain Management & Information Systems (SCMIS) 2006*, National Chung Hsing University, Taiwan, Vol. I pp.276-83.
- Kokic, M. (2006), "The influence of clusters foundation, development and interconnection on export and business in South East Europe region", in Ketikidis, P., Koh, S.C.L. (Eds), *Supply Chain Management and Information Systems Handbook: Supply Chain Management and Logistics in South East Europe*, SEERC, Thessaloniki, pp.92-106.
- Korhonen, J., Snakin, J., (2005), "Analyzing the Evolution of Industrial Ecosystems: Concepts and Applications", *Journal of Ecological Economics*, Vol. 52, pp. 169-186.
- Korhonen, J., (2002), "Two Paths to Industrial Ecology: Applying the Product-based and Geographical Approaches", *Journal of Environmental Planning and Management*, Vol. 45, Issue 1, pp. 39-57.

- Kuosmanen, T., (2005), "Measurement and Analysis of Eco-efficiency: An Economist's Perspective", *Journal of Industrial Ecology*, Vol. 9, Issue 4, pp. 15-18.
- Lowe, E.A., Evans, L.K. (1995), "Industrial ecology and industrial ecosystem", *Journal of Cleaner Production*, Vol. 1/2 No.3, pp.47-52.
- Lowe, E.A., Moran, S.R., Holmes, D.B. (1998), *Eco-industrial Parks – A Handbook for Local Development Teams*, Draft Indigo Development, RPP International, Oakland, CA.
- Massard, G., Erkman, S., (2006), "A regional Industrial Symbiosis methodology and its implementation in Geneva, Switzerland", Industrial Ecology Group – Institute for Land Use Policy and Human Environment – Faculty of Geosciences and Environment – University of Lausanne.
- Mitchell, L., (2000), "Eco-Industrial Development Workbook", *National Center for Economic Development*, School of Policy, Planning, and Development – University of Southern California.
- Raines, P. (2000), "Developing cluster policies in seven European regions", European Policy Research Centre (ed.), *Regional and Industrial Policy Research Paper*, No. 42, December, University of Strathclyde, Glasgow, pp.2-34.
- Seppala, J., Melanen, M., Maenpaa, I., Koskela, S., Tenhunen, J., Hiltunen, M., (2005), "How Can the Eco-efficiency of a Region be Measured and Monitored?", *Journal of Industrial Ecology*, Vol. 9, Issue 4, pp. 117-130.
- UNEP-TEAP (2004), United Nations Environment Programme and Technology and Economic Assessment Panel, TEAP Report on 2004 CUNs
- UNEP-TEAP (2005), United Nations Environment Programme and Technology and Economic Assessment Panel, Progress Report of TEAP
- Weslyne, A. (2008), "Understanding the Organization of Industrial Ecosystems: A Social Network Approach", *Journal of Industrial Ecology*, Vol. 12, Issue 1, pp.34-51
- World Resource Institute (2005), "Business and ecosystems", in EarthWatch Institute, IUCN, WRI and WBCSD (ed.), *Brief Issue of Ecosystem Challenges and Business Implications*. Earthwatch Institute, World Resource Institute, WBCSD and World Conservation Union, Switzerland, pp.2-20.