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# Linking Industry and Ecology

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*Edited by Ray Côté, James Tansey,  
and Ann Dale*

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Linking Industry and Ecology:  
A Question of Design



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IN LOVING MEMORY OF JAMES LESLIE (1938-2001).

HE WAS AN INSPIRATION TO US ALL.

*“Those who dwell, as scientists or laymen,  
among the beauties and mysteries of the earth  
are never alone or weary of life.”*

*– Rachel Carson*

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Part 1  
Introduction



# 1

## Linking Industry and Ecology in Canada: A Question of Design

*Ann Dale*

When John Robinson and I established this series in 1993, which subsequently became part of the UBC Press Sustainability and the Environment Series, it was built upon the premise that we know enough about sustainable development to act. We have enough science, enough information and knowledge to act, but there are critical barriers to achieving sustainable development. Some of these barriers are related to the need to communicate our research more proactively and in a much more timely fashion to the wider Canadian public, and in particular to the private sector. Given the inherently interdisciplinary nature of sustainable development, we also need to communicate our applied research to researchers in related disciplines and to policy makers.

This volume departs somewhat from our original vision, in that while we are just beginning to explore industrial ecology in Canada, the authors argue for its immediate adoption throughout the industrial sector. Although industrial ecology is still an evolving field and the “industrial ecosystem” is a nascent paradigm, there appears to be agreement among the contributors to this book that full integration of industrial and ecological systems is critical to the full implementation of sustainable development in this country. Further, they argue that industrial ecology provides an organizing principle that could foster new approaches to the use of renewable and non-renewable resources that are so central to the Canadian economy. In addition, this book communicates the linkages between other related disciplines and the need for proactive policy development on the part of governments to provide the enabling conditions for its more rapid diffusion, similar to the leadership role played in the Blue Box recycling program described in Chapter 11.

Why is the adoption of industrial ecology so critical and urgent? Given our current appropriation of over 50 percent of the carrying capacity of the earth’s terrestrial and aquatic systems for human use (Vitousek et al. 1997; Pauly and Maclean 2003), it is clear that we are now approaching critical

biophysical limits and that we have become the most dominant species on the planet. Some argue that we need to accommodate rising material expectations, coupled with a 50 percent increase in population over the next fifty years, while simultaneously reducing total throughput (Wackernagel and Rees 1995). Further, the World Business Council for Sustainable Development argued in 1992 that reductions in material throughput and energy use of over 90 percent will be needed in the industrial world by the year 2040 to equitably meet the needs of a growing world population within the planet's ecological means. This has become recognized as the "factor 10" argument (Schmidt-Bleek 1994), and some analysts are arguing for factor 4 reductions (Weizsacker et al. 1997). Since industrialized countries, representing 20 percent of the world population, consume 80 percent of the available natural resources, rapidly adopting factor 10 and even factor 4 strategies would appear prudent for more equitable resource use on a planet with fixed resources (Bartelmus et al. 2002).

Regardless of the social and ecological reasons for rapidly introducing industrial ecology principles and practices in Canada, there is a crucial economic imperative: "Only one percent of the total North American materials flow ends up in, and is still being used within products six months after their sale" (Hawken et al. 1999, 81). As the costs of inputs and equally the costs of their waste disposal rise due to increasing scarcity, this kind of mal-design and continuing acceptance of waste and inefficiency will become a limiting factor of production. For instance, Canada has jurisdiction over almost 10 percent of the world's fresh water and less than 1 percent of the world's population, and yet has the second highest per capita consumption of fresh water (International Institute for Sustainable Development 2003). Moreover, we have one of the largest ecological footprints, estimated to be 7.7 hectares per capita, with only the United States and Australia being higher (International Institute for Sustainable Development 2003).

This dominance, coupled with evidence that human systems are co-evolving with ecological systems (Norgaard 1994), means that we need to engage in *deliberative design and redesign* of our present industrial systems; industries can no longer muddle along independently of one another, in isolation from other communities, and with disregard for the cumulative impacts of our activities on natural systems. Until the mid-twentieth century, neither we nor our activities occupied as much space, whereas now our industrial activities overly impact globally on the biosphere. Reports on ozone depletion and climate change indicate that we are beginning to overwhelm those systems, threatening our ecological, economic, and social systems and ultimately our very survival. These systems, services, and resources provide the critical inputs into industrial systems. These inputs are being transformed at such an unprecedented rate that the metabolic exchange of materials and energy between nature and the technosphere has become the

critical driver for unsustainable development; sooner or later most resources end up as emissions or waste (Bartelmus et al. 2002).

As the contributors to this volume argue, it is clear that we need to act now in the fundamental design and redesign of our systems of commerce and production so that they maintain and restore ecological systems. Canadians, as intensive consumers of natural resources, need to move rapidly toward a cyclical and ecological model of industrial development. If all of our knowledge, our science, and our technology to date have caused only a tiny fraction of the world's and Canada's most intelligent companies to realize sustainability, then what we have is not only a management problem but also a design problem (Bartelmus 2002). Why the emphasis on design? Eighty to 90 percent of the costs of a typical product, and 80 percent of its environmental impact, are determined during the design stage (Elkington 1998). Thus, design can really be seen as the first signal of human intention (McDonough and Braungart 2001).

This book is organized into five parts: Introduction, Design and Ecology, Industrial Ecology and Environmental and Business Management, Learning from Experience, and Conclusions.

Part 2, "Design and Ecology," highlights design as a metaphor and overall organizing principle that is central to industrial ecology. Chapter 2, by Nina-Marie Lister, also argues for a broader societal context for industrial ecology by making critical connections to a similarly evolving discipline of ecological design – a critical approach for navigating a new interface between culture and nature. Both domains are associated with "modelling nature," and thus each can equally inform richer, deeper interpretations in both fields of study and practice. In fact, "nature is an analogue for design," and she argues for a critical reconnection of the present false polarizations between art and science, culture and nature. By designing adaptively, that is, responding to evolution and the unfolding landscape, we can integrate the unpredictability of change into industrial ecology, as the design process consistently demands creative interpretation of the past, the present, and the future. Lister also discusses the critical importance of a "systems perspective" to both fields and the importance of multiple perspectives at various ecosystem scales. Such a perspective is necessary since nature and ecological processes cannot be managed through prediction and control, and human agency can only be manifested through design. Lister believes that critical learning and will occur only through demonstration projects that enable us to learn by doing "adaptive, resilient, flexible, and responsive design."

Chapter 3, by Stuart Hill, emphasizes redesign as a deeper form of industrial ecology, drawing upon lessons from the fields of ecological agriculture and social ecology. He argues for the considerably expanded application of insights from ecology not only to the design and redesign of industrial practices but also to the way we approach visioning, policy development,

planning, decision making, and implementation, drawing upon personal imperatives.

The following chapter, by Jill Grant, discusses land use planning as a means of achieving sustainable development strategies for industrial production. In her review of industrial parks and planning strategies for dealing with conflicts between industrial and other uses, Grant notes that early land use planning practices advocated separating industrial from residential uses, essentially using space as a buffer for protecting people from industrial pollutants. We now recognize that unsustainable industrial practices, especially in our highly connected and interdependent world, have pervasive effects; no single community is immune to their impacts, as evidenced by acid rain and global climate change. Industrial ecology can be a strategy of planning and managing industrial parks according to ecological principles, no longer always isolated on the periphery of cities. Thus, planners and designers need to consider integrating business parks into urban forms; similarly, principles of industrial ecology need to be applied to the planning of industrial parks themselves. As Nik Luka states in Chapter 5, “professional planners, designers, and other decision makers must know how to learn from place.”

In Chapter 5, the last chapter in Part 1, Luka addresses the question of responsive design raised by Lister, looking specifically at urban design and its relationship to industrial ecology. He argues that sustainable development is possible only if we make some important changes to the ways in which we think about landscape and urban form, that is, the ways in which human settlements are organized physically, structurally, socially, and functionally. In making a critical distinction between “growth” and “development,” he argues that urban design, a complex, interdisciplinary approach to developing policy instruments and design strategies, is the locus for all human behaviour. Urban design involves processes of choice and organization about how we work, how we produce, and how we “waste.” Both fields – urban design and industrial ecology – are action-oriented and involve human settlement patterns that are themselves complex, diverse, and uncertain. If we design our industrial systems as “separate islands” from our housing and without due regard for ecosystem structures and functioning, we encourage artificial separations that lead to unsustainable development.

Part 3, “Industrial Ecology and Environmental and Business Management,” consists of five chapters, some looking at the application of tools and strategic approaches, others examining the macro policy implications for their implementation.

Chapter 6, by Nonita Yap, clarifies the relationship between two approaches that fall under the umbrella of industrial ecology: cleaner production and eco-efficiency. When applied to production processes, the former involves conserving raw materials and energy, eliminating raw materials, and reducing the quantity and toxicity of all emissions and wastes. Applied



to products, a cleaner production strategy focuses on the reduction of impacts in the entire life cycle of the product, from raw materials extraction to its ultimate disposal. Applied to services, cleaner production would incorporate environmental concerns into design and delivery of services. Eco-efficiency starts from issues of economic efficiency, which have positive environmental benefits, while cleaner production starts from issues of environmental efficiency, which have positive economic benefits (World Business Council for Sustainable Development n.d.; United Nations Environmental Programme 1994). Yap wisely points out that the pursuit of cleaner production or facility-level eco-efficiency is a simpler implementation process than industrial ecology. Closing the loops implies vertical and/or horizontal integration of manufacturing processes; in effect, establishing symbiotic relationships among these processes while integrating production processes across several facilities that otherwise have no relationship to each other introduces a whole new level of complexity and consequently higher transaction costs.

Shifting the focus to business management, Raymond Côté and Heinz Wallner argue in Chapter 7 that since we don't know enough about the nature of the limits human societies are now confronting, it may be prudent to design industrial systems that are complex rather than simplistic, and multi-functional rather than uni-dimensional systems. They discuss industrial clusters and networks, again in the context of adaptation (as previously discussed by Lister), innovation, and networking and "islands of sustainability." Industrial clusters are amalgamations of competing and collaborating industries in a region, networked into horizontal and vertical relationships, involving buyer/supplier linkages, and relying on a shared foundation of special economic institutions. Such clusters are based on the ecological principle that what is waste for one company may be a resource for another. It is the cycling of materials and energy that is important in natural systems, and we need to actively recover misplaced and misused resources combined with more sustainable energy use. Such industrial networks range from localized symbioses, such as the Big Bend project described in Chapter 13, to by-product exchanges examined in Chapter 12, to broader interactions such as regional, provincial, and national waste exchanges.

Chapter 8, by Robert Gibson and Steven Peck, warns that the robust implementation of industrial ecology requires totally new systems of production and consumption that mimic ecosystems well enough to be socially, economically, and ecologically viable, locally and globally over the long term. Once again, however, the authors argue that most significant environmental and economic gains are likely to be found by redesigning systems of production and consumption, not simply products and production processes. In order to realize its full potential, industrial ecology must provide incentives to participating firms and must influence consumers to move

beyond eco-efficiencies, for if efficiency savings simply provide more resources for expanded production and consumption, there may be no net gain at all. The authors emphasize the crucial role governments can play in facilitating the transition to an economy that is much more efficient, fair, and ecologically benign – governments that lead will be in a stronger position to set the agenda and to establish advanced positions for their industries and cities.

Moving to a specific sector case study, R. Anthony Hodge uses a non-renewable resource sector (mining) to argue for situating industrial ecology in a larger framework of sustainable development. He explains that the mining industry has had problems finding a place in this framework because of the tensions between the concept of sustainable development and the debate about the meaning of renewable (or non-renewable) resources. He states that the most useful approach is not one focused on the management of resources, but rather a results-based approach designed to do what is required to achieve human and ecosystem well-being together. He articulates, as others do in this volume, the principles at the core of systems thinking: wholeness, emergent properties and synergy; hierarchy; and feedback, communication, and control as key to industrial ecology. The practical application of sustainability and industrial ecology ideas in the mining and minerals sector is founded on the sector as a set of systems within systems operating within a time horizon of centuries.

In Chapter 10, the last chapter in Part 3, James Tansey highlights some of the dangerous oversimplifications of industrial ecology and warns against inaction in our attempts to define the perfect hypothetical industrial system while the world continues to evolve unsustainably. As other chapters demonstrate, there is a broad spectrum of views about what industrial ecology is and ought to be. Tansey warns that there is no panacea for reducing the impact of human activity on the environment, and the danger is that the rhetorical attraction of industrial ecology will provide false comfort for policy makers. He argues that industrial and technical systems are embedded in wider social, economic, and environmental systems, and need to be embedded in a wider institutional context of technology, particularly information communications, science, and knowledge systems.

Part 4, “Learning from Experience,” contains one chapter on the genesis of the Ontario recycling program as well as two Canadian case studies. R.A. Flemington asks whether there are any lessons to be learned from past efforts and describes lessons learned from the Blue Box program. He points out that although transaction costs may be high, the costs have to be paid somehow if systemic waste and inefficiencies are to be addressed. He further outlines the importance of voluntary agreements based on performance targets, transparency, and accountability. Flemington also emphasizes the critical leadership role that government policy can play in knowledge diffusion, resource

management, and incentive frameworks that can encourage the unprecedented levels of cooperation, transparency, innovation, and creativity needed to promulgate industrial ecology principles and practices on a national scale.

Chapter 12, by Sumita Fons and Rebekah Young, builds upon Chapter 7 on the relevance of networks for “clusters of sustainability” by discussing these formations in the Alberta oil and gas sector and its ancillary services. Four case studies are discussed: two early-stage developments and two other, more mature examples at the regional level. In particular, the By-Product Synergy Project encompasses the entire province. The projects represent a continuum from single-material exchanges to multi-material exchange networks, although the By-Product Synergy Project focuses less on direct material exchanges and more on broader collaborative opportunities such as shared research and transportation networks. Diversity and redundancy, again two key characteristics of natural systems, are critical to these multi-material symbiosis projects at different scales. The objectives of the By-Product Synergy Project are to strengthen existing multi-material exchanges through increased information flows (similar to the Blue Box program discussed in Chapter 11), although it expands beyond a simple waste-material exchange to a solution-oriented network of business leaders, academics, and government.

Part 4 concludes with Chapter 13, by Jonah Spiegelman, which evaluates the potential of an industrial park called the Big Bend, located in the Greater Vancouver Regional District (GVRD), as a future model for regional waste management. This study examines materials, energy, and waste flows and the role of incineration. Spiegelman describes three evolutionary approaches to implementing industrial ecology parks: “green twinning,” or the springboard approach, the “anchor tenant model,” and the exploitation of “small mental gaps” as they apply to this particular industrial park. Crucial lessons learned are that cooperation develops over time and that a stepwise approach often works best, as Yap articulates further in Chapter 6. Both talk about trust in scaling up and argue that without trust and understanding, the relations may be seen as overly undesirable. Spiegelman describes public/private sector partnerships that are becoming an increasingly attractive model for infrastructure development, and argues that this site already engages in some level of industrial symbiosis. He cautions, however, that the relationships involved in developing or scaling up these kinds of systems are rarely linear, and that it is only through significant intervention that any of the spin-off social implications will be achieved.

Chapter 14, by John Robinson and Asoka Mendis, concludes the book and neatly draws together many of the arguments set out by the other contributors. The authors discuss critical questions they believe should be addressed to reduce the environmental impacts of human activity to avoid

exceeding ecological limits. They argue that it is a critical imperative to reduce matter and material flows per unit of human activity. Robinson and Mendis also provide a brief history of the “limits to growth” debate of the 1970s, and the nature of these limits. They make a critical distinction between efficiency and conservation with respect to these limits, and argue that one of the strategies of industrial ecology should be a dissolution of the boundaries between the industrial and the ecological, which renders the issue of limits meaningless. The authors point out that the problem of consumption is not typically addressed through industrial ecology, with its current emphasis on production and sovereignty of markets. Consequently, they envision situating this emerging field within the deeper context of sustainable development and its overall strategy of reconciling the three imperatives (ecological, social, and economic), which will then allow us to accomplish broader and yet critical societal goals in substantially more elegant and efficient ways.

Clearly, this volume is a call to action for the rapid diffusion of industrial ecology principles and practices throughout the Canadian industrial sector, even before we know the answers to many of the questions posed by the various authors. Hopefully we have convinced our readers that we need a new model of *design* for industrial systems, as well as *redesign* of current production systems, based on critical learning from natural system functions and processes. But redesign of existing industrial practices and design of new practices cannot fully succeed until the disciplines, the vested interests, and our institutions become involved in the necessary design and redesign of our current industrial systems of production. Moreover, we must bridge our respective disciplinary and professional gaps. Are we in Canada capable of the critical dialogue among designers, planners, ecologists, and engineers that would reduce the silos and stovepipes that characterize decision making in our country? Are we capable of building bridges between the academy, industry, and government sectors to deliberately design cooperative industrial ecology systems that will bring industrial production and consumption into line with the limits of natural systems? Beware of Beckett’s trousers!

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