Eco-industrial Park Handbook
for Asian Developing Countries

Report to Asian Development Bank
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Based upon Eco-Industrial Parks,
a handbook for local development teams (1995-98),
Indigo Development Working Papers in Industrial Ecology (1997-2001), and
field experience in the Philippines, Thailand, and China.

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This report to the Asian Development Bank should not be taken as necessarily reflecting Bank policy or viewpoints in any way.

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Table of Contents

0. Preface
  0.1 Summary of Handbook
  0.2 Acknowledgements

1. Introduction
  1.1. Applied Common Sense and Whole Systems Thinking
  1.2. Defining Eco-Industrial Parks
  1.3. EIP Benefits and Risks
  1.4. The EIP: A Menu of Opportunities
  1.5. A Brief History
  1.6. Why Developing an EIP is an Inquiry Process

2. Foundations
  2.1. Cleaner Production and Industrial Ecology
  2.2. Sustainable Architecture, Construction, and Planning
  2.3. New Organizational Relationships

3. EIPs and the Local Community
  3.1. Public Private Partnership
  3.2. Building the Context for an EIP
  3.3. Building Your Local Vision
  3.4. Closer Integration of Industrial Parks and the Community
    A Partnership Between an Eco-Park and the Community for Greenhouse Gas Reductions

4. Planning and Development of Eco-Industrial Parks
  4.1. Ownership Public or Private?
  4.2. Site selection process
  4.3. Predevelopment and feasibility studies
  4.4. EIP Marketing Analysis and Recruitment Strategy
  4.5. Project Organization
  4.6. Environmental Standards in Development
5. Financing Eco-Industrial Parks

5.1. Introduction
5.2. Levels of EIP Financing
5.3. Basic steps in forming Public Private Partnerships (PPP)
5.4. The Community Capital Investment Initiative
5.5. Partnership Between the Developer and the Tenants
5.6. An Investment Fund
5.7. An Action Foundation
5.8. Positioning Your EIP for Investment
5.9. Reducing the Risks
5.10. Funding Dedicated to Sustainable Development
5.11. Resources for Financing

6. The Emerging Sustainable Economy and EIP Recruitment Themes

6.1. Toward a Sustainable Economy
   Increased efficiency and use of renewable energy and material resources
   Ecologically-aware design of communities and the built environment
   Sustaining and renewing natural systems
   Redesign of public and private sector organizations

6.2. EIP Recruitment Themes
   Agro-Industrial Parks
   Resource Recovery Parks
   Renewable Energy Industrial Parks
   Petrochemical Parks
   Power Plant Parks

7. Eco-Industrial Policy

7.1. Introduction
7.2. Integration of Policy and Policy Organizations
7.3. Place-Based Policy
7.4. Resource-Based Policy
7.5. Incentives
7.6. Research Partnerships
7.7. Umbrella Permitting and Programmatic EIA
7.8. Energy Policy
7.9. Anti-Corruption Policy
8. Design Strategies for Eco-Industrial Parks
8.1. EIP Design Processes and Tools
8.2. Site Assessment and Planning
8.3. Design of Physical Infrastructure
8.4. Industrial Facility Design
8.5. Building Design
8.6 Sustainable Design in Asia

9. Construction and Implementation
9.1. Construction Process
9.2. Implementation of Economic and Social Programs
9.3. Redesign for Error-correction

10. Management of Eco-Industrial Parks
10.1. There Are Two Management Interests in an EIP
10.2. The Functions of EIP Management
10.3. Key Management Issues
10.4. The Operations Room
10.5. Shared Support Services
10.6 Environmental Management Systems

11. Greening Existing Industrial Parks
11.1. Working with Existing Industrial Parks and Their Tenants
11.2. Guidelines for Self-assessment Audit of Industrial Parks
11.3. Models for Cleaner Production Centers
11.4. Eco-Industrial Networks
11.5. Checklist of Other Handbook Sections Useful for Existing Parks

12. Creating By-Product Exchanges
12.1. Implications for Industrial Park Development
12.2. BPX Across Multiple Sites or in a Region
12.3. The Self-Organizing Model
12.4. The By-Product Utility

13. Appendix
13.1. Project Profiles
13.2 Supplementary Information
Preface

“The world economy is doubling roughly every twenty years. The world population is doubling every forty to fifty years. The planet that supplies the materials and energy necessary for the functioning of the population and economy is not growing at all . . . Each successive doubling of the human system causes new stresses and raises new questions, or rather brings two old questions together with new urgency. Question one is How can we provide sufficiency, security, and good lives to all people? (The development question) “The second is How can we live within the rules and boundaries of the biophysical environment? (The sustainability question)

“With the economy globally linked, the ocean fisheries depleting, the atmosphere changing in composition, open spaces filling in, and much of the human population still living in poverty, these two questions now come together with urgency. How can we and our children live good lives without eroding the health and productivity of the physical planet—and therefore the possibility for future generations to lead good lives?” Donella Meadows 1998

In this opening quotation Donella Meadows, noted systems scientist and authority on sustainable development, captures the essence of the challenge sustainable development presents. I could list many alarming statistics to build a case for environmentally and socially sound development of industrial parks but I do not feel that is necessary. I have worked with industrial developers and policy-makers in the Philippines and Thailand, as well as South Africa. They recognize the damage industry has imposed on their natural resources. I have been in touch with others in China, Indonesia, India, Malaysia, and Sri Lanka who also acknowledge this damage.

I see that across Asia there is growing awareness of the need to balance industrial development, social development and environmental protection. More and more people are accepting this challenge and finding in it an opportunity to create a new source of competitive advantage. (At the end of this preface I provide two ADB sources available online for anyone who needs more information on the challenges of sustainable development in Asia.)

The Asian Development Bank asked me to prepare this new edition of our Eco-Industrial Park Handbook specifically for developing countries in Asia. The purpose of this publication is to support the many stakeholders in industrial development who seek a sustainable path for industry in this major region: real estate developers, industrial leaders, economic and environmental policy-makers, financiers, leaders of nongovernmental organizations, and leaders of communities that host industrial parks and facilities. To serve this purpose, the new Handbook includes an overview of each facet of industrial park development. It includes many Asian examples as well as ones from elsewhere. In each chapter there are sources of print and electronic information to find more information.

I have made many changes in this EIP Handbook, based on my learning in the last six years from my work with eco-industrial initiatives as well as the experience of my many colleagues in this field. I have revised most chapters extensively and there are several completely new ones (since the 1995 edition for US-EPA). These changes are necessary because this has been a time of rapid change, both in my own understanding and in the state of industrial development and its impacts on nature and society. There are no signs that the pace of change is slowing so you will be able to find updates regularly at www.indigodev.com.

One of the changes that has most impressed me is my perception that the strongest creative force in eco-industrial development seems to be emerging in Asia. I have seen few projects in North America that match the breadth of vision and intention of a number of Asian initiatives.
These include

- Japan's many eco-town, eco-industrial park, and zero emissions projects
- The eco-industrial initiative of the Industrial Estate Authority of Thailand responsible for 28 estates.
- Eco-industrial projects in Guangzhi, Liaoling, Hebei, Jiangsu provinces of China.
- The PRIME Project in the Philippines.

(See case profiles in Appendix).

Both private and public sector real estate developers are adopting eco-industrial strategies far beyond most of their counterparts in North America. So it is very appropriate that this new EIP Handbook be addressed to developing countries in Asia, where new development practices may set a model for the world in the next decades.

Acknowledgements

First, I owe a very deep debt to Stephen R. Moran and Douglas B. Holmes, my co-authors on the earlier edition of the EIP Handbook that we prepared for US-EPA in 1995. They were responsible for much of the valuable content that carries over from that earlier edition. Dr. Moran has contributed to the present edition through his insights and extensive reworking of the environmental performance objectives section, now in Chapter 10. Dr. Holmes prepared very useful background for the section on petrochemical EIPs in Chapter 6.

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Governor Anchalee Chavanich, leader of the Industrial Estate Authority of Thailand, has created an eco-industrial estate initiative that she hopes will have impact across the 28 estates the Authority is responsible for as well as in her country’s broader industrial policy. Her example has inspired me to see the full power of industrial ecology. The Authority’s acting Environmental Director, Somchint Pilouk, facilitated successful visits to 5 of the estates.

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Finally, I am eternally indebted to John R. Warren, who provided the foundation for my becoming an industrial ecologist and authority on eco-industrial parks.

References

The opening quote is from Meadows, Donella, 1998. *Indicators and Information Systems for Sustainable Development*. The Sustainability Institute. This is the most insightful discussion I have seen of indicators that measure our progress along the path to sustainability. Available for download at http://iisd.ca/about/prodcat/perfrep.htm#donella


Executive Summary

This new edition of the Handbook for Development of Eco-Industrial Parks presents a comprehensive means of applying Cleaner Production and Industrial Ecology in Asian developing countries. The Eco-Industrial Park (EIP) concept and methods enable real estate developers, industrialists, policy makers, regulators, investors, and communities to collaborate in the vital search for sustainable development.

Chapter 1 Introduction gives the basic definitions of eco-industrial parks (EIP), eco-industrial networks (EIN), and by-product exchanges (BPX) and outlines the design strategies for EIPs. We also discuss the benefits and risks of EIP development. This chapter is a useful first introduction for stakeholders in development projects.

We define an eco-industrial park or estate as a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance.

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impacts. Components of this approach include green design of park infrastructure and plants (new or retrofitted); cleaner production, pollution prevention; energy efficiency; and inter-company partnering. An EIP also seeks benefits for neighboring communities to assure that the net impact of its development is positive.

Some developers and communities have used the term EIP in a relatively loose fashion. To be a real eco-industrial park a development must be more than:

- A single by-product exchange or network of exchanges;
- A recycling business cluster;
- A collection of environmental technology companies;
- A collection of companies making “green” products;
- An industrial park designed around a single environmental theme (i.e., a solar energy driven park);
- A park with environmentally friendly infrastructure or construction; or
- A mixed-use development (industrial, commercial, and residential).

Although many of these concepts may be included within an eco-industrial park, the vision for a fully developed EIP needs to be more comprehensive. In Chapter 6 we propose several themes for recruitment, including renewable energy and resource recovery. However, with each theme the developer would include the other aspects of EIPs outlined in this Handbook. The critical elements are the interactions among the park’s member businesses and the community’s relationship with its community and natural environment.

Clarification of terms

In the last three decades the phrase “industrial estate” or “industrial park” has had a clear meaning to developers, economic development authorities, facility managers, and tenants. It is a piece of contiguous property, owned and managed as a unit for industrial and business enterprises. Unfortunately putting “eco-” in front of “industrial estate” has led many proponents to muddy this very clear usage. In addition, some have chosen many different phrases to speak of the same basic strategies. Clarifying this language is important for business reasons since the terms “industrial park” and “industrial estate” are already in common use.
We distinguish three basic categories of eco-industrial projects:

- Eco-industrial park or estate (EIP)—an industrial park developed and managed as a real estate development enterprise and seeking high environmental, economic, and social benefits as well as business excellence.
- By-product exchange (BPX)—a set of companies seeking to utilize each other's by-products (energy, water, and materials) rather than disposing of them as waste.
- Eco-industrial network (EIN)—a set of companies collaborating to improve their environmental, social, and economic performance in a region.

We believe these distinctions are important to maintain, although there are various ways projects can overlap. EIPs and EINs may include by-product exchange programs. One or more EIPs may participate in either a BPX or an EIN.

The EIP—A Menu of Opportunities

This Handbook offers a rich menu of design options, including ideas for site design, park infrastructure, individual facilities, and shared support services. We also cover recruitment strategies and EIP management. Several basic strategies are fundamental to developing an EIP. Individually, each adds value; together they form a whole greater than the sum of its parts.

Integration into Natural Systems

Select your site using an assessment of ecological carrying capacity and design within the limits it defines.

Minimize local environmental impacts by integrating the EIP into the local landscape, hydrologic setting, and ecosystem.

Minimize contributions to global environmental impacts, i.e. greenhouse gas emissions.

Energy Systems

Maximize energy efficiency through facility design or rehabilitation, co-generation, energy cascading, and other means.

Achieve higher efficiency through inter-plant energy flows.

Use renewable sources extensively.

Materials Flows and ‘Waste’ Management for the Whole Site

Emphasize cleaner production and pollution prevention, especially with toxic substances.

Seek maximum re-use and recycling of materials among EIP businesses.

Reduce toxic materials risks through materials substitutions and integrated site-level waste treatment.

Link the EIP tenants to companies in the surrounding region as consumers and generators of usable by-products via resource exchanges and recycling networks.

Water

Design water flows to conserve resources and reduce pollution through strategies similar to those described for energy and materials – cascading through uses at different quality levels.

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1. Co-generation is the capturing and using of otherwise “wasted” heat from the electrical generating process.
2. Energy cascading is using residual heat in liquids or steam from a primary process to provide heating or cooling to a later process. For example, excess steam from a power plant or refinery may be used in a food processing plant or greenhouse.
Effective EIP Management
In addition to standard park service, recruitment, and maintenance functions, park management also:

- Maintains the mix of companies needed to use each others’ by-products as companies change over time;
- Supports improvement in environmental performance for individual companies and the park as a whole;
- Operates a site-wide information system that supports inter-company communications, informs members of local environmental conditions, and provides feedback on EIP performance.

Construction/Rehabilitation
With new construction or rehabilitation of existing buildings, follow best environmental practices in materials selection and building technology. These include recycling or reuse of materials and consideration of lifecycle environmental implications of materials and technologies.

Integration into the Host Community
Seek to benefit the local economy and social systems through training and education programs, community business development, building of employee housing, and collaborative urban planning.

Chapter 2 Foundations presents the foundations of eco-industrial development in industrial ecology, Cleaner Production, sustainable architecture and urban planning. Understanding this conceptual background enables developers of new parks, managers of existing sites, and other stakeholders to improvise within the guidelines this Handbook offers. We also illustrate the use of industrial ecology approaches to support industrial park recruitment, hazardous waste management, and reducing greenhouse gases.

Cleaner Production and Industrial Ecology
Indigo Development developed the eco-industrial park concept in the early 90s with the explicit objective of demonstrating in specific places the benefits of industrial ecology to developers, companies locating in industrial parks, and host communities. Industrial ecology seeks to find the appropriate balance between environmental, economic, and social needs of a system. Cleaner Production is a field of research and practice that overlaps with industrial ecology in many ways. Proponents of cleaner production and industrial ecology clearly share a breadth of purpose and similar objectives.

The definition of CP used by the United Nations Environment Program and the United Nations Industrial Development Organisation is:

“Cleaner production is the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment. The three classes of objectives CP seeks to achieve are:

- Production processes: conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes.
- Products: reducing negative impacts along the life cycle of a product, from raw materials extraction to its ultimate disposal.
- Services: incorporating environmental concerns into designing and delivering services." (Evans and Stevenson 2000)

At the policy level, CP encourages government to work through five types of instruments for shaping the environmental behaviour of industry:

- Regulation, as when the permit of a firm to operate depends on meeting environmental standards, and failure to do so incurs financial or criminal penalties;
- Voluntary Programs, such as regulators engaged in an interactive dialogue with firms with an emphasis on sharing and dissemination of information and expertise;
Market-Based Instruments, such as in the use taxes, tariffs, subsidies and other such methods to shift the financial calculations of firms toward environmentally beneficial decisions; and

Transparency, through which public awareness of the dangers of pollutants plus ready access to required reporting by firms on their discharges creates public pressure on the firms to reduce their discharges.

Information and Education, such as public health education that creates awareness of the risks to human health from pollutants. (Evans and Stevenson 2000)

Cleaner Production initiatives, such as the ADB technical assistance project that is the context for preparation of this Handbook, tend to focus on development of policy and institutional capacity.

Industrial Ecology Defined

If we accept the claim of some industrial ecologists that industrial ecology is “the science of sustainable development,” (Allenby and Graedel 1994, Lowe 1998) this establishes a broader span of research and practice than CP usually seeks to effect. Perhaps the design and development of eco-industrial parks is the strongest demonstration of this breadth. EIPs require integration of engineering, architecture, urban planning, business management, real estate development, finance, landscape design, ecology, economic development, information systems design, and many other disciplines. The strong place-based focus of EIP design contrasts with the policy and sectoral focus of many CP initiatives. EIP policy requirements can inform the design of CP’s policy recommendations. Both are essential components of the transition to a sustainable economy and complement each other quite well.

Our working definition of “Industrial Ecology” is that it is an approach to managing human activity on a sustainable basis by:

- Seeking the essential integration of human systems into natural systems;
- Minimizing energy and materials usage;
- Minimizing the ecological impact of human activity to levels natural systems can sustain.

Its objectives are:

- Preserving the ecological viability of natural systems.
- Ensuring acceptable quality of life for people;
- Maintaining the economic viability of systems for industry, trade and commerce;

Our broad understanding of industrial ecology as the science of sustainable development underlies our recommendations in this Handbook for eco-industrial park development. We envision EIPs as sources of a many benefits to their local communities as well as industrial facilities designed with great sensitivity to their natural settings. Since 1994 this embedding of eco-industrial park projects in sustainable community development has been a hallmark of the field. In turn, EIPs have become one of the most common concrete applications of industrial ecology.

Important additional foundations for EIP development are sustainable or green architecture and urban planning. In this Executive Summary we cover these themes below under Chapter 8.

Chapter 3 Community explores the ways in which EIPs can interact with their neighboring communities for mutual benefit. We explore the public private partnership structure as a source of support for the development process. We look at closer integration of industrial park and community development processes that some developers are testing. At the end of the chapter we outline a detailed program for reducing greenhouse gases as a strategy for industrial park developers or managers to build strong connections between their sites and the towns near them.
Any industrial park is interdependent with the surrounding community and relies on it for human and material resources, services, and trade. Local citizens are usually involved in hearings conducted by planning agencies, which must approve the developer’s master plan and environmental impact assessment. The workforce for park tenants generally comes from nearby towns and may require training given by local educational institutions. Employees new to the area also require housing. Local businesses provide materials, parts, and services to companies in the park. Water and sewage, energy, solid waste, and transportation infrastructure is usually operated by local jurisdictions. Local and state/provincial environmental agencies require reports and are responsible for enforcement of regulations. Citizen activists may mount major protests if industrial park developers and managers ignore their concerns about pollution and other impacts. Company site-location teams often evaluate the quality of life of the community, not just the industrial location.

For all of these reasons, it is very important that the leaders in an eco-industrial park initiative build strong relations with their host communities. Community involvement is supported by the many benefits industrial parks offer through the new jobs and businesses they create. The project may also invest in community enhancement programs to provide return for the support the public sector offers. Companies, developers, agencies, and citizens need to work together closely to capture the benefits of this innovative concept.

An EIP will be more likely to succeed if it is part of broader community initiatives such as:

- Development of housing for employees of EIP businesses;
- Creation of a community strategic plan for reducing the total waste stream (residential, commercial, public, and industrial);
- Development of a highly effective regional by-product exchange, providing markets for materials now discarded as wastes;
- Strengthening economic development planning to encourage businesses that fit the recruitment profile of the EIP or that turn wasted resources into products and jobs;
- Mobilizing educational resources to help the community’s businesses and government operations increase energy efficiency and prevent pollution;
- Reducing greenhouse gas emissions through a community action program led by the EIP. (As outlined at the end of this chapter.)
- Financing of some EIP development costs through public private partnerships.

Such initiatives offer a strong context to support the evolution of an eco-industrial park. Effective exchange of by-products may require a larger set of suppliers and users than the ones present in many industrial parks. A trained workforce, housing, and access to finance for facilities help attract tenants. At the same time, the community gains many benefits: a cleaner environment, a stronger, more efficient economy, new jobs, and a reputation as a good site for starting new businesses.

**Chapter 4 Planning and Development** considers site selection, recruitment strategies, and development project management using the learning organization form. We survey the interaction between development processes that involve setting environmental standards and expectations for a project: the environmental impact assessment, covenants, and an environmental management system.

Eco-industrial park development calls for asking new questions within the context of traditional industrial development processes. Developing any industrial park requires several rounds of planning and design. The team tests project feasibility in greater detail with each stage. The project must satisfy financial, economic development, public planning/zoning, environmental, and technical criteria at each step. Your eco-industrial park team will follow the traditional process, while considering new design options in each phase of project planning. In this chapter we explore the special implications of an EIP for several key areas of development.
A development team needs to create a strategic plan for dealing with all of these areas of concern, beginning with the project organization.

We open this chapter with discussion of ownership and the value of public private partnerships to support development projects. We consider site selection for an EIP, emphasizing the need to avoid development of virgin land whenever possible. In recent years many Asian countries have been privatizing many present public functions, including industrial park development.

We then review EIP recruitment strategies, suggesting the importance of balancing between several pairs of factors: traditional marketing strategies and an EIP’s unique advantages; economic and environmental goals; filling the park and getting the right mix of companies for by-product exchanges and external recruitment and local business development. We caution that your team needs to test the by-product exchange strategy carefully and that it may play only a minor role in some developments.

Industrial park developers are required to file environmental impact assessments and generally create property covenants. We explore how these processes support an EIP developer in setting performance objectives and creating an environmental management system.

Finally, we discuss management of the development process, the concept of the learning organization, project, communications, and processes for qualifying consultants and contractors.

**Chapter 5 Financing** discusses public private partnerships in more depth, offering guidance on the processes for forming them. We survey the types of financing specifically available for environmental, energy, and sustainable development projects. The chapter concludes with an extensive list of sources of such financing.

Large, sophisticated development companies are now responsible for most conventional industrial park development and management in Asia. They understand quite well the basics of financing major real estate projects in their own countries and often in other Asian countries. In this chapter we offer insights to complement what such companies already know, not to duplicate it. Financing an eco-industrial park may add some new potential sources of support and it may require some innovative strategies to realize the added benefits of this form of development.

In addition, as Asian countries explore the implications of the financial crisis that began in 1997, they have raised serious questions about traditional approaches to investment and industrial development. Simultaneously, a global movement is challenging the assumptions of globalization and its negative social, economic, and environmental impacts. Agenda 21 programs in each country have enlisted all sectors in creating programs for achieving the balance between these three factors in programs for sustainable development. The international development banks, including Asian Development Bank, are themselves seeking to understand how their grants and loans can contribute to sustainable development in each client country.

A specific source of sustainable investment is emerging around the need for reductions in greenhouse gas emissions. This and other environmentally related funds could support aspects of the development of eco-industrial parks. We offer an extensive listing of resources in this area.

For all of these reasons the developers of industrial parks and estates in Asia will need to explore new opportunities and be aware of new challenges, as they learn to create and finance eco-industrial parks. For instance, creating an infrastructure of public private partnerships to support the longer-term actions as well as the next steps in development of the EIP. This strategy of public private partnerships (PPP) blends different public, private, and civil sources of support at different levels. One of the primary purposes for forming PPPs is to use public funding to offset risks and to compensate for public benefits that projects offer. Thus, using public funds for the more speculative but critical elements--like the land development feasibility study for the EIP--builds the basis for more risk-averse private investors to come in at the implementation stage.
Chapter 6 discusses the emerging sustainable economy, which we believe will open important business opportunities for industries in developing countries. The five recruitment clusters we describe here could each be a theme for an EIP or several of them could work together to guide development strategy. The themes are: Agro-EIP, Resource Recovery EIP, Renewable Energy EIP, Fossil-Fuel Plant EIP, and Petrochemical EIP. We discuss the possible recruitment targets for each cluster and their potential interactions. For existing industrial parks one or more of the clusters may match the tenants already recruited or provide ideas for filling in vacant land to create such clusters.

Developing a competitive eco-industrial estate or park requires awareness of fundamental trends in the global economy as well as within one’s national and local economy. An EIP must attract and retain profitable tenants serving both emerging and established market sectors at these different economic levels. Eco-industrial parks themselves are one example of the sort of real estate development indicated by this emerging economy.

There are many signs that the global economy in its present form is unsustainable. Recent decades have demonstrated increasingly unequal sharing of wealth and income between and within both developed and developing countries. If income gaps continue to increase, who will be the customers in an increasingly productive industrial system? Climate change, local air pollution, loss of biodiversity and ecosystems, degradation of farm land, and massive depletion and waste of natural resources are some of the environmental signs of the system’s failure to respect the natural constraints upon human activity.

In addition, major challenges to the present practices of the global economy are coming from within its establishment as well as from the streets. The World Bank has been host to two of the most notable economists of sustainable development: Herman Daly and Amartya Sen, the 1998 Nobel economist. Both Daly and Sen offer powerful arguments for development as a means, not as an end in itself that takes precedence over environmental and human values. The activists who protested the World Trade Organization in Seattle and the World Bank in Washington are continuing to organize resistance to the negative aspects of globalization. At the same time, some advanced corporate leaders are charting their companies path into the sustainable economy. Sir Robert Browne, CEO of British Petroleum/Amoco, Ray Anderson, Chairman of Interface, and Gordon Forward, CEO of Chaparral Steel, are three pioneering corporate leaders redefining the way corporations operate in the global economy and biosphere.

The emerging sustainable economy offers many opportunities for start up ventures and expansion of small to medium enterprises. When a venture is in a hot area, such as hydrogen fuel cell technology, it may suddenly find its has support from major players. Ballard Power in British Columbia, Canada is in a joint venture with Daimler-Benz-Chrysler for commercialization of its fuel cell transportation innovations. Metals recycling companies have been targets of mergers and acquisitions across the US.

There is growing evidence that the variety of niches in a sustainable economy deserve attention from industrial park developers in Asia's developing countries. This is particularly important given the over-capacity in production facilities for many sectors of the of electronics and telecommunications economy. While computer and electronics companies will continue to seek plant locations, it is now time for industrial parks to diversify their recruitment targeting.

One of the particular strengths of the sustainable economy will be an increasing emphasis on production for local as well as export markets. In Chapter 6 we discuss EIPs focused on renewable energy, resource recovery, and support industries for sustainable agriculture. Such developments need not be dependent upon winning the difficult competition with other sites for a limited number of multinational candidates. Their recruitment focus can be local companies and entrepreneurial startups, supported by business incubators and public sector support. The petrochemical EIP and power plant-EIP complete this theme park section of the Handbook, offering ideas for making these fossil fuel anchored parks effective transitions to greater sustainability.
Chapter 7 Eco-Industrial Policy covers currents in policy development that will enable eco-industrial parks and networks and by-product exchanges to proceed with more support from environmental and development agencies. These include closer integration across agencies and within each agency; basing policy in regional initiatives; basing policy in resource efficiency; incentives for eco-industrial projects; research requirements; considerations in energy de-regulation and privatization; and more holistic policy regarding management of hazardous materials.

An eco-industrial park developer or manager needs to stay in close touch with the changing field of policy and regulations since it contains both opportunities and constraints to their development process. In turn, policy-makers need to be aware of the unique policy requirements of eco-industrial developments. EIPs and eco-industrial networks offer site-based opportunities for testing new policy approaches in areas like Cleaner Production. EIPs seek environmental performance better than simple compliance to regulations. This alone makes support for the innovations they request a priority in regulatory agencies.

In this chapter we discuss the challenges and benefits of developing a more integrated policy framework for industrial development. We explore the value of place-based policy as a complement to national and sector-based policy. We describe the options for linking environmental protection more strongly to policy based in resource efficiency, especially through by-product utilization. We list some of the incentives and research programs needed to support eco-industrial development. In a closely related area of policy, we also summarize some of the pitfalls of energy deregulation and privatization, based on the alarming energy crisis that began in California after a far-reaching de-regulation program there. The costs of energy are high for many industries, so it is important for industrial park developers to understand policies that can help contain them.

Since each country is at a different stage of environmental policy and regulatory development we will cover general principles and some cases to guide this process. Real estate developers may need to work with their government directly or through their trade associations to achieve a policy framework that both protects the environment and enables the innovations that seek cleaner, more resource-efficient development. We believe that the goals of policy makers in environment and industrial development will be very well supported by meeting the needs of industrial park developers and managers who wish to create eco-industrial parks.

Chapter 8 Design Strategies discusses means of achieving a more integrated design team and then provides a comprehensive survey of design options for industrial park infrastructure and buildings. The former includes sustainable infrastructure for energy, water, materials, and transportation as well as landscaping. It covers building design under these same categories. Many of these ideas will support retrofitting the infrastructure of existing parks.

This chapter describes major options to be considered in the physical design of an eco-industrial park, including support for the design process itself. It offers a broad survey of possibilities to inform each step of the development process—from vision building to completion. A growing body of architectural and engineering professionals—experienced in successfully applying these ideas—can support your team's work.

Many of these concepts and technologies are becoming standard practice in new industrial facility planning (energy efficiency and pollution prevention). Builders have demonstrated others primarily in commercial and residential developments but they should be evaluated for possible use in industrial facilities. They are definitely relevant to the design of an EIP commons, office buildings, or hotels. Major companies such as General Electric have cut costs with ideas once seen as 'far out', i.e., ecosystem restoration and native planting in the land surrounding manufacturing plants. The Herman Miller case we present in this chapter shows comprehensive application of green design to a manufacturing plant in the US.

Some of these ideas will cost less up-front and save money over time, such as emphasis on daylighting of facilities to cut down on dependence on electric lighting. Some may require a higher initial investment, but cut operating costs for the park or its companies over the years, i.e. a closed-loop water system like the one
Hemaraj Land and Development has built at Eastern Seaboard Industrial Estate in Thailand (we discuss this case in the water infrastructure section of Chapter 8). Others may simply cost more but give less quantifiable benefits, as with the use of non-toxic building materials. Cost savings in one area will enable your development team to make trade-offs to arrive at an overall plan that is both financially feasible and environmentally superior.

Please remember, Chapter 8 is a menu of opportunities, not a prescription. In your planning and design process, your team will need to determine the system of choices that achieves the economic and environmental objectives you have set for your project. The constraints and special needs of tenant companies will shape their design of buildings, but developers can offer guidelines and support for incorporating design options their own designers may not be familiar with.

Chapter 9 Construction outlines strategies for reducing the environmental impacts of construction, including management of construction contractors. It also reviews some of the social dynamics of enlisting companies into the community of companies that work together in an EIP.

At this stage your team implements your project's eco-industrial park vision, plans, and designs in wood, concrete, steel, and vegetation and through creating new human institutions. You will need to augment the many standard procedures and codes for construction with performance goals and measures that flow from your vision and plan. You will need to educate contractors and sub-contractors and provide them with specifications that insure your vision will not be buried in the mud of the construction process. In addition, you will need to coordinate with tenants building their own facilities to be sure their contractors are aligned with the project's objectives. A developer generally places covenants and restrictions or design guidelines in the tenant contract to achieve this. You can also offer more active support, such as design services for small to mid-size firms.

As physical construction progresses and tenants prepare to move in, you will also be implementing the design of institutions that will help them interact as a community of companies. You may work with local and national resources to set up a regional by-product exchange, training programs, or other community initiatives that support your EIP's functioning. At this time tenant employees will start the process of building ties between companies to achieve the promise of high business and environmental performance that brought them together in your EIP.

Chapter 10 Management reviews management structures and responsibilities in an eco-industrial park at two levels, 1) the management of the property and 2) the management of the community of companies. The management of an EIP entails both traditional and innovative responsibilities and generates potential new revenue streams for the property manager. This chapter concludes with discussion of environmental management systems and a process for creating environmental performance objectives.

We begin by considering the distinct business interests of the park’s community of companies and the management of the property itself. Separate but overlapping management systems are needed to adequately reflect the two systems. We then outline the basic functions of EIP management and provide a matrix indicating which would be the primary responsibility of the property management system and which would fall to the community’s self-management system. Important key functions include maintaining the community spirit and values, supporting by-product exchange, and enabling continuing evolution of the system.

An EIP encompasses two distinct but overlapping business entities. It is a real estate development property that must be managed to provide a competitive return to its owners. At the same time, an eco-park is a “community of companies” that must manage itself to gain common benefits for its individual members. The latter is a looser association in business terms, but the owners of member companies are no less concerned with their investment returns. You will need to respond to the needs of both entities in designing a management system for your EIP. Fortunately, their basic goals are very complementary.
We will first describe the full range of management functions to be performed by the combination of business community and park management systems. Some clearly belong to one or the other entity. Others require participation by both. Following this general description we will present a matrix for assessing which group may most effectively lead on each function.

After discussion of the two management entities, we review several key management issues: autonomy within a community, maintaining the by-product exchange; the importance of total quality management and quality control; an emergency management system; and the ongoing role of the public/private partnership that helped form the EIP. We then describe how a high-tech operations room could enable both management entities to work more effectively. We conclude with discussion of a number of shared support services.

The companies in an eco-industrial park need a range of general services indirectly related to their production systems. These include governmental relations, dining facilities, purchasing of common supplies, information access, and many others. By acting in common to procure these services, they can reduce indirect operation costs (especially important for smaller companies). By coordinating satisfaction of these tenant needs, the park management company can increase its revenues. Sharing services will increase opportunities for communication among employees of different companies and build the community spirit of your EIP.

A full evaluation framework for an eco-industrial park combines economic, technical, social, and environmental objectives into a whole system. This means that your project can seek a design that optimizes objectives in these four domains as a whole, not separately. Clearly articulated objectives in each area, agreed to by project stakeholders, will be essential. With this clarity you will be better able to determine the trade-offs among the objectives in all four domains: economic and environmental objectives, social and environmental, or any other pair of domains.

In an appendix to Chapter 10, we propose a framework for setting environmental performance objectives for an eco-industrial park. This framework will also enable your team to integrate these objectives with the economic, technical, and social objectives of your project. Environmental performance is not a single, simple measurement. It is a combination of four elements. At the core of environmental performance is resource utilization within industrial processes. This element is concerned with the amount and type of resources used and consumed within a plant's industrial process, (what goes on "inside the fence"). The second element, releases from industrial processes, relates to emissions or releases from processes to the environment (what “passes over the fence”). The third element, interactions of industrial processes and releases with natural system components, concerns the impacts of the industry on the natural environment. A fourth element, context management, involves local and regional or national management systems that influence the other three elements. Environmental performance is a function of combined performance in these four elements.

Chapter 11 Greening Existing Parks reviews strategies existing parks can use to qualify as eco-industrial parks. This includes a baseline assessment for the park as a unit as well as discussion of surveys for each plant. This chapter is where the Handbook covers a process for leading development of an eco-industrial network beyond the boundaries of any one industrial park.

We explore strategies and methods through which managers of existing industrial parks can gain the right to call their properties “eco-industrial parks”. Vision-building and strategic planning processes enable site managers and their tenants to evaluate the benefits of participating in a regional eco-industrial network and by-product exchange as well as other means of improving their performance. We offer guidelines for these processes and other resources to support the initiative as well as a case profile of an initiative led by the Industrial Estate Authority of Thailand.

Can an already developed industrial park become an eco-industrial park? The very large number of existing industrial parks in the world makes a positive answer to this question very desirable. Improving the environmental, social, and economic performance of companies at this scale would make a significant
contribution to the companies and park management, to neighboring communities, and to sustainable
development. The resulting EIPs would have more stable communities of tenants, supporting each other’s
business success and reducing tenant turnover. New services offered by eco-park management would yield
new revenue streams.

An industrial park demonstrates clear patterns of development, ownership, property definition, jurisdiction,
responsibility for management and maintenance, and control. The economic self-interest of the property
owner and management firm, public regulation and zoning, and the proximity of the companies on the site
make industrial parks relatively focused sites for innovation.

If the management of an industrial park and the site’s companies seek to become an EIP there are a
number of actions they can take to achieve this goal. As with an industrial park in process of first
development, these elements form a whole system to guide park redevelopment. If the park has ISO 14001
certification or another form of environmental management system, this could become the basis for setting
eco-industrial performance objectives and the means for attaining them.

Eco-industrial development is a means of achieving sustainable industry through local and regional action.
The industrial park or estate is a point of leadership and leverage for change in its region’s industrial
community. This industrial community may be able to realize innovations larger than a park’s management
could undertake, such as an integrated resource recovery system or by-product exchange. A park seeking
to become an eco-industrial park can act as the hub of a regional eco-industrial network through its own
improvement projects and through the connections of its factories with suppliers and customers outside the
estate’s border.

Formation of an eco-industrial network may entail creation of a number of supporting institutions:

- An integrated resource recovery system (For IRRS see Chapter 6);
- A system for encouraging and managing the exchange of by-products between companies (For
  BPXs see next chapter);
- Training and services in all aspects of eco-industrial development;
- A network management/coordinating unit and working groups;
- A community enhancement office to manage projects with neighboring communities.
- One or more business incubators (for small-to-medium size enterprises or SMEs).
- Public sector support in R & D, policy development, access to investment, and information
  management.

Chapter 12 By-Product Exchange offers alternative processes and structures for forming and managing
an exchange of material, energy, and water by-products. It emphasizes that this strategy may not be
effective within many single industrial parks and may require regional participation. Here we review the most
familiar industrial ecology concept, one that goes under many different names: by-product exchange, by-
product synergy, industrial ecosystem, industrial symbiosis, green twinning, and zero emissions network.
The core of this concept is creating a system for trading material, energy, and water by-products among
companies, usually within a park, neighborhood, or region. We review the benefits of participation in by-
product exchanges (BPX) for industrial parks and their companies, the challenges in their development,
steps in organizing exchanges, and alternative organizational forms for their management. We emphasize
the importance of considering by-product exchanges in the broader context of eco-industrial development.

A by-product exchange (BPX) is a set of companies seeking to utilize each other's by-products (energy,
water, and materials) rather than disposing of them as waste. The creation of BPXs has been one of the
most frequently attempted strategies for applying industrial ecology. This popularity comes from the promise
of companies gaining new revenues from some by-products and saving the costs of disposal of others. On
the demand side, customers may gain local sources of supplies at reduced costs. Joining a BPX appears to
be an easy way for a company to begin practicing efficiency of resource use and to learn other ways to improve environmental performance.

We outline the typical steps BPX organizing projects take with industries in Chapter 12:

Mobilize and organize support

Planning and analysis

- Characterize the flows of energy, water, and materials in the target region.
- Highlight and map existing exchanges of by-products
- Provide training, tools, and support to the development process and data gathering and analysis
- Gather data on resource flows of companies that have committed to the BPX
- Identify potential barriers
- Identify companies which could process selected materials, provide collection services for specific by-products, or otherwise support the operation of the BPX.

Enable business transactions for by-product utilization

- Develop alternative means for companies to begin making deals to trade specific by-products.
- Monitoring and communications
- Create a map (GIS) of the network of exchanges and opportunities for exchange.

Set performance measures and targets.

- Create an internal system for giving feedback on what is being achieved to the immediate participants.
- Set up channels of external communication and reporting.

After detailing the actions required at each of these steps, we explore an alternative model for achieving high utilization of industry by-products—the creation of a business that functions as a by-product utility. In some projects to create by-product exchanges potential participants have been wary because of the multiple contracts required. These generate transaction costs, which can offset savings or revenues from use of by-product energy or materials. Companies may fear entering into so many new relationships around issues separate from their core businesses.

These issues have prompted us and other’s involved in eco-industrial planning to formulate an alternative business model, in which a by-product utility takes responsibility. This might operate as a business within the management structure of an industrial park or as a stand-alone business that creates a profit-sharing relationship with park management. In its fullest form, this utility could manage energy, water, and materials procurement and disposal for all client companies. Its advantage lies in the capability and experience concentrated on by-product utilization. There are partial precedents for a by-product utility. Several firms reflect aspects of this business concept: Suprachem, a wholly owned subsidiary of the major South African steel company Iscor; SafetyKleen, a familiar US-based international company that manages the full lifecycle of selected chemicals; and others.

Two Appendices include a variety of case profiles in the Philippines, Thailand, India, China, and other areas. This includes a major study of eco-industrial projects in Japan. There is also a detailed review of elements in selection of a site for a new EIP, discussion of management issues, and a variety of forms and tools of use to managers, such as forms for tenant surveys.
1 Introduction to Eco-Industrial Parks

1.1 Applied Common Sense and Whole Systems Thinking

The developers of eco-industrial parks are applying previously tested concepts and practices in an innovative whole system. You can find the separate components of the EIP vision working effectively in industry today. In some cases (i.e., energy efficiency in new process, equipment, and plant design) their obvious contribution to competitive advantage is defining these “new” approaches as best business practices. Many of these tested ideas are simply applied common sense: “Why pay money to produce a product you can’t sell, call it a waste, and pay someone to dispose of it?” “Why not use the energy of the sun and wind when you locate a building and design its heating and cooling systems?”

The real innovation in creating eco-industrial parks is bringing such ideas together in a whole system. If you integrate as many of these well-tested individual strategies as possible into your initial EIP vision, your team may achieve results beyond the “reasonable” expectations of a piecemeal approach. For instance, including renewable energy sources in your site’s infrastructure can guarantee reliable and clean power for industries that experience large losses when outages occur. This becomes a valuable recruitment incentive. One such source, biogas energy, may provide a market for a food processing company’s discards.

With this integrative approach, each addition to the system adds to the value of the other elements in your design. Potential investors will see that your standard feasibility studies show the project passes their conventional tests. You will not need to convince them of the environmental or social values of the project when they can see it qualifies as a real estate investment.

1.2 Defining Eco-Industrial Parks

An eco-industrial park or estate is a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance.

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impacts. Components of this approach include green design of park infrastructure and plants (new or retrofitted); cleaner production, pollution prevention; energy efficiency; and inter-company partnering. An EIP also seeks benefits for neighboring communities to assure that the net impact of its development is positive.

Some developers and communities have used the term EIP in a relatively loose fashion. To be a real eco-industrial park a development must be more than:

- A single by-product exchange or network of exchanges;
- A recycling business cluster;
- A collection of environmental technology companies;
- A collection of companies making “green” products;
- An industrial park designed around a single environmental theme (i.e., a solar energy driven park);
- A park with environmentally friendly infrastructure or construction; or
- A mixed-use development (industrial, commercial, and residential).
Although many of these concepts may be included within an eco-industrial park, the vision for a fully developed EIP needs to be more comprehensive. In Chapter 6 we propose several themes for recruitment, including renewable energy and resource recovery. However, with each theme the developer would include the other aspects of EIPs outlined in this Handbook and summarized in the present chapter. The critical elements are the interactions among the park’s member businesses and the community’s relationship with its community and natural environment. See Clarification of Terms later in this chapter to understand the distinction between eco-industrial parks, by-product exchanges, and eco-industrial networks.

1.3 Benefits and Risks of EIP Development

1.3.1 Benefits to Industry

For the companies involved, an eco-industrial park offers the opportunity to decrease production costs through increased materials and energy efficiency, waste recycling, and elimination of practices that incur regulatory penalties. Increased efficiency may also enable park members to produce more competitive products.

In addition, some common business services may be shared by firms in the park. These may include shared waste management, training, purchasing, emergency management teams, environmental information systems, and other support services. Such industrial cost sharing could help park members achieve greater economic efficiency through their collaboration.

Small and medium size firms often have a problem in gaining access to information, consultation and know-how. The integrative approach of EIP development can support such enterprises in overcoming these barriers and gain access to investments they may require to improve performance. (Fleig 2000)

These benefits for participating companies are likely to increase the value of property for private or public real estate developers. The services generate new revenues for park management companies. Overall, EIPs may gain a competitive advantage, an especially important benefit in a time when there is over-capacity in the industrial real estate market in many Asian countries.

1.3.2 Benefits to the Environment

Eco-industrial parks will reduce many sources of pollution and waste, as well as decrease demand for natural resources. The site tenant’s will reduce their environmental burden through more innovative approaches to cleaner production. These include pollution prevention, energy efficiency, water management, resource recovery, and other environmental management methods and technologies. Decisions about an EIP’s siting, infrastructure, and recruitment targets will be reached in the context of the constraints of local carrying capacity and ecological characteristics of potential sites.

Each eco-park will serve as a working model for park developers and managers to learn how to improve their bottom line while meeting high environmental and social standards.

1.3.3 Benefits to Society

The enhanced economic performance of participating businesses will make EIPs a powerful economic development tool for communities. Such parks are likely to attract leading-edge corporations and open niches for new or expanded local ventures. Both will create new jobs in much cleaner industrial facilities. Companies in the region will gain new clients for services and buyers for products in the new firms in a park. Development of EIPs will create programs for extending their economic and environmental benefits across a community’s whole industrial sector. This promises cleaner air, land, and water, major reductions in waste, and a generally more attractive environment.
EIPs offer government, at all levels, a laboratory for creation of policy and regulations that are more effective for the environment while less burdensome to business.

1.3.4 Costs, Risks, and Challenges of EIP Development

Developing an eco-industrial park is a complex undertaking, demanding integration across many fields of design and decision-making. Success depends upon a new level of collaboration among public agencies, design professions, project contractors, and companies locating in the park. The possible inability to overcome traditional fragmentation within and between these groups is a major risk. In Chapters 4 and 8 we discuss ways of cutting this risk.

Some of an EIP’s benefits may only become apparent when costs and savings are calculated in a longer time frame than is typical in industrial park financing. Developers may need to make a strong case for banks to finance a project with a longer payback period, such as inclusion of renewable energy for critical backup power. On the other hand, some options for infrastructure may actually cost less to build and maintain. (See water treatment systems in Chapter 8.) If you are able to get contracts with major companies to locate in your EIP, this will help prove the concept to financiers. A developer with significant signed leases has a bankable project.

Some eco-industrial parks may cost more to develop than traditional parks, depending upon the design choices in a project. Added costs may come from the design process, site preparation, infrastructure features, construction processes, and aspects of building design. When this occurs, the additional costs may or may not be offset by savings in operating the park as an EIP, given the payback period acceptable to the developer. Public development authorities may be better prepared to bear this possible increase in development costs than private developers. Or the public sector may fund some aspects of the development with strong public benefits. We discuss ways of achieving this public private partnering in Chapters 3 and 5.

Companies using each other’s residual products as inputs face the risk of losing a critical supply or market if a plant closes down. To some extent, this can be managed as with any supplier or customer relationship, (i.e., keeping alternatives in mind and writing contracts that insure reliability of supply). We discuss alternatives for creating by-product exchanges in Chapter 12.

Exchange of by-products could lock in continued reliance on toxic materials. The cleaner production solutions of materials substitution or process redesign should take priority over trading toxics within an EIP site. We cover hazardous materials policy in Chapter 7 and infrastructure in Chapter 8.

Possible innovations in regulation to enable EIP development may not be allowed by regulatory agencies or they may be slow to approve environmental impact reports for innovative projects. We discuss issues in policy and regulation in Chapter 7.

Some companies are not used to working “in community” and may fear the interdependence this creates. Collaboration may be particularly difficult if your EIP includes companies from many different countries and cultures. On the other hand, many large and small companies see such interdependence as a major source of competitive advantage. We cite precedents in the last section of the next chapter.

Some industrial parks include large numbers of small-to-medium enterprises (SMEs). While they may benefit from shared environmental services they are least able to afford any technologies that may be required to improve their environmental performance. This suggests the need for financial service support in the EIP package. We discuss such EIP financing strategies in Chapter 5.

Small local industries outside industrial parks often produce a bulk of pollution, because of lack of staff, outmoded technologies, and inefficient resource uses. A broader, regional approach is needed to reach such businesses. Often these smaller firms are suppliers to companies in industrial parks, who can require them to clean up their act and perhaps offer training and even investment to support this. An EIP is a natural hub to an area-wide eco-industrial network, which we discuss later in this chapter and in Chapter 11.
By-product exchange and resource recovery may cause displacement of small businesses. “In many countries, an extended informal sector profits from wastes and by-products. Establishing recycling or by-product exchange networks amongst companies could destroy the subsistence of numerous families.” (Fleig 2000) EIP developers can offer support to such micro-entrepreneurs to strengthen their operations and follow good environmental standards. They could become participants in resource recovery parks or centers.

Many environmental policies in developing countries emphasize end-of-pipe treatment rather than the more holistic and preventive solutions of industrial ecology. Many overseas aid organizations add to this pressure with aggressive sales of their countries’ end of pipe technologies and services. (Erkman 2000) This deepens the problems of SMEs who cannot afford the technologies. Fortunately, Cleaner Production and industrial ecology are beginning to impact design of policy and even the strategies of aid organizations, such as the German, GTZ. Industrial park developers and their associations can lobby for improvements in policy and regulations that support EIPs.

1.4 The EIP—A Menu of Opportunities

This Handbook offers a rich menu of design options, including ideas for site design, park infrastructure, individual facilities, and shared support services. We also cover recruitment strategies and EIP management. We summarize some major strategies your design team can draw upon in planning your park. Their implications are briefly discussed below.

Natural systems—An industrial park can fit into its natural setting in a way that minimizes environmental impacts while cutting certain operational costs. The Herman Miller Phoenix Design plant (see case study in Chapter 8) illustrates the use of native plant reforestation and the creation of wetlands to minimize landscape maintenance, purify storm-water run-off, and provide climate protection for the building. These and other natural design concepts can be used throughout an industrial park.

At another level, design choices in materials, infrastructure, and building equipment, plant design, and landscaping can reduce your park’s contributions to global climate change and consumption of non-renewable resources.

Energy—More efficient use of energy is a major strategy for cutting costs and reducing burdens on the environment. In EIPs, companies seek greater efficiency in individual building, lighting, and equipment design. For example, flows of steam or heated water from one plant to another can be used (energy cascading) and these can also be conducted into district heating or cooling systems. (In power plants and many industrial processes, the majority of heat generated goes up the stack rather than producing value.) In many regions, the park infrastructure can use renewable energy sources such as wind and solar energy.

Materials Flows—In an eco-park, companies perceive wastes as products they have not figured out how to re-use internally or market to someone else. Individually, and as a community, they work to optimize use of all materials and to minimize the use of toxic materials. The park infrastructure may include the means for moving by-products from one plant to another, warehousing by-products for shipment to external customers, and common toxic waste processing facilities. Companies in the EIP also enter into regional exchanges.
STRATEGIES FOR DESIGNING AN ECO-INDUSTRIAL PARK (EIP)

Several basic strategies are fundamental to developing an EIP. Individually, each adds value; together they form a whole greater than the sum of its parts.

Integration into Natural Systems
Select your site using an assessment of ecological carrying capacity and design within the limits it defines.
Minimize local environmental impacts by integrating the EIP into the local landscape, hydrologic setting, and ecosystem.
Minimize contributions to global environmental impacts, i.e. greenhouse gas emissions.

Energy Systems
Maximize energy efficiency through facility design or rehabilitation, co-generation,\(^1\) energy cascading,\(^2\) and other means.
Achieve higher efficiency through inter-plant energy flows.
Use renewable sources extensively.

Materials Flows and ‘Waste’ Management for the Whole Site
Emphasize cleaner production and pollution prevention, especially with toxic substances.
Seek maximum re-use and recycling of materials among EIP businesses.
Reduce toxic materials risks through materials substitutions and integrated site-level waste treatment.
Link the EIP tenants to companies in the surrounding region as consumers and generators of usable by-products via resource exchanges and recycling networks.

Water
Design water flows to conserve resources and reduce pollution through strategies similar to those described for energy and materials – cascading through uses at different quality levels.

Effective EIP Management
In addition to standard park service, recruitment, and maintenance functions, park management also:
- Maintains the mix of companies needed to use each others’ by-products as companies change over time;
- Supports improvement in environmental performance for individual companies and the park as a whole;
- Operates a site-wide information system that supports inter-company communications, informs members of local environmental conditions, and provides feedback on EIP performance.

Construction/Rehabilitation
With new construction or rehabilitation of existing buildings, follow best environmental practices in materials selection and building technology. These include recycling or reuse of materials and consideration of lifecycle environmental implications of materials and technologies.

Integration into the Host Community
Seek to benefit the local economy and social systems through training and education programs, community business development, building of employee housing, and collaborative urban planning.

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\(^1\) Co-generation is the capturing and using of otherwise “wasted” heat from the electrical generating process.

\(^2\) Energy cascading is using residual heat in liquids or steam from a primary process to provide heating or cooling to a later process. For example, excess steam from a power plant or refinery may be used in a food processing plant or greenhouse.
**Water Flows**—In individual plants, designers specify high efficiency building and process equipment. Process water from one plant may be re-used by another (water cascading), passing through a pre-treatment plant as needed. Park infrastructure may include mains for several grades of water (depending on the needs of the companies) and provisions for collecting and using storm-water run off.

Some EIP designers have tended to emphasize one strategy over all others—the exchange of by-products between companies in an industrial park. (We discuss the advantages and limits of this strategy in detail in Chapter 12 By-Product Exchanges.) This “closing the loop” approach is an important factor, however, it is but one of a number of elements in eco-industrial park design.

**Park Management and Support Services**—As a community of companies, an EIP needs a more sophisticated management and support system than a traditional industrial park. Management or a third-party supports the exchange of by-products among companies and helps them adapt to changes in the mix of companies (such as a supplier or customer moving out) through its recruitment responsibilities. Management may maintain links into regional by-product exchanges and a site-wide telecommunications system. The park may include shared support services such as a training center, cafeteria, day-care center, office for purchasing common supplies, or transportation logistics office. Companies can add to their savings by sharing the costs of these services.

**Sustainable Design and Construction**—EIP planners design buildings and infrastructure to optimize the efficient use of resources and to minimize pollution generation. They seek to minimize ecosystem impacts by careful site preparation and environmentally sensitive construction practices. The whole park is designed to be durable, maintainable, and readily reconfigured to adapt to change. At the end of its life, materials and systems can be easily re-used or recycled.

**Integration into the Host Community**—Relations of EIP developers with neighboring communities should compensate the many benefits to the park from government services, educational systems, housing, etc. The project can return value to the community through such institutions as a business incubator to support new businesses or expansion of existing ones in the community. Some will become tenants and others may provide essential services or supplies to tenants. Training programs will build a stronger workforce in the community and strengthen the local economy, beyond the needs of the Park. A major return from this collaborative approach is the potential formation of a public private partnership to assume financing of some aspects of an EIP’s design.

### 1.5 A Brief History

Indigo Development first created the concept of eco-industrial parks (EIP) as described in this Handbook in late 1992. In the early 1990’s, innovators at Dalhousie University (Nova Scotia, Canada) and Cornell University (Ithaca NY) conceived related frameworks for industrial park development (Cohen-Rosenthal 1993; Cote 1993). Indigo introduced our concept to staff at the US-EPA in 1993. The Agency then included an EIP project in an Environmental Technology Initiative and recommended that the President’s Council on Sustainable Development adopt EIPs as demonstration projects in 1995. From 1994-95 Indigo (by then part of RPP International) collaborated with Research Triangle Institute in a major US-EPA cooperative research grant focused on EIPs. This was a remarkably short time for a proposed major change in environmental management and real estate development to move through a large government agency and into first pilot projects.

The appeal of the concept is that developers and communities that create eco-industrial parks seek to build a foundation for industrial development that is more competitive, more efficient, and cleaner than traditional industrial parks or regions. In addition, new business niches will be opened for recruitment or incubation of new companies that strengthen the local economy. EIP developers are seeking to end the apparent conflict between environmental, social, and economic values.
By early 2001, at least forty communities in the US have initiated eco-industrial development projects, some called eco-industrial parks, others called industrial ecosystems or by-product exchanges. Innovators have launched at least sixty eco-industrial projects in Asia, Europe, South America, Australia, South Africa, and Namibia. Japan alone has over 30 projects.

This rapid diffusion of the EIP from new concept into planning and implementation seems to indicate that it appeals strongly to both public and private sector interests in sustainable development. The EIP, in its fullest realization, is a concrete means of attaining a core aim of sustainable development on the local level—to simultaneously improve the environmental, economic, and social performance of industrial and community development.

However, implementation of the concept is still in process and we can not yet celebrate a fully realized, operating EIP. (There are, however, some successful examples of regional by-product exchanges.) In fact, a significant number of projects have failed or abandoned the goal of becoming an EIP. In this new Asian edition of the Handbook we will explore what the pioneers in this field have learned from their successes and failures.

It appears that problems in implementation do not indicate any basic flaw in the eco-industrial park concept itself. Indigo has sought to keep this model flexible, enabling development teams to adapt it to the specific requirements of their sites, tenants, and communities. Most difficulties in the cases we will examine stem from external factors, such as limited knowledge and vision on the part of critical public agencies or their failure to understand the business dynamics of industrial real estate development. We will explore ways of overcoming such obstacles.

### 1.5.1 Clarification of terms

In the last three decades the phrase “industrial estate” or “industrial park” has had a clear meaning to developers, economic development authorities, facility managers, and tenants. It is a piece of contiguous property, owned and managed as a unit for industrial and business enterprises. Unfortunately putting “eco-“ in front of “industrial estate” has led many proponents to muddy this very clear usage. In addition, some have chosen many different phrases to speak of the same basic strategies. Clarifying this language is important for business reasons since the terms “industrial park” and “industrial estate” are already in common use. We distinguish three basic categories of eco-industrial projects:

1. **Eco-industrial park or estate (EIP)**—an industrial park developed and managed as a real estate development enterprise and seeking high environmental, economic, and social benefits as well as business excellence.
2. **By-product exchange (BPX)**—a set of companies seeking to utilize each other’s by-products (energy, water, and materials) rather than disposing of them as waste.
3. **Eco-industrial network (EIN)**—a set of companies collaborating to improve their environmental, social, and economic performance in a region.

We believe these distinctions are important to maintain, although there are various ways projects can overlap. EIPs and EINs may include by-product exchange programs. One or more EIPs may participate in either a BPX or an EIN.
An eco-industrial network may include stand-alone companies, companies in industrial parks, and the park management organizations. EIN members collaborate to enhance their performance and to create shared services and facilities. One form of collaboration is to exchange by-product materials, energy, or water among companies, when feasible.

1.5.1.1 Eco-Industrial Park or Estate

An industrial park demonstrates clear patterns of development, ownership, property definition, jurisdiction, responsibility for management and maintenance, and control. The economic self-interest of the property owner and management firm, public regulation and zoning, and the proximity of the companies on the site usually make industrial parks relatively focused sites for innovation.

So to maintain common business usage, an eco-industrial estate or park is a set of companies usually located on a piece of contiguous property and operating as a community of self-interest around environmental, economic, and social issues. The community usually includes the property ownership and/or management business, which supports the common activities of the businesses. It also often includes a tenant association. (At some locations, where all companies own their own land, their business association may be the only organization to handle common needs.)

We have avoided using the term “eco-industrial park” for any of the other related collaborative activities described below. We should not confuse a term that is so commonly used by developers and managers of conventional industrial parks. We also seek to discourage the use of phrases such as, “virtual EIP”, which is sometimes used to describe a regional exchange of by-products.

This clarification of language is not an academic exercise. There is leverage for innovation in the development and management of a commonly owned piece of property that is lacking in a looser regional network of companies. The management of an industrial park benefits from having a location known for its
low pollution and for the superior performance of its tenants. Additional services to tenants improve the property management's bottom line. A tenant’s association opens doors for many forms of collaboration beneficial to business. We will explore in depth the many ways that the coherence of an industrial park or estate offers a strong opportunity for improving both the financial and environmental performance of the property and its tenants.

1.5.1.2 By-Product Exchange (BPX)

The most familiar industrial ecology concept is that of the industrial by-product exchange (BPX). Companies and agencies around the world are seeking to create BPXs under many different names: industrial ecosystem, by-product synergy, industrial symbiosis, industrial recycling network, green twinning, and zero emissions network, among others. The core intention is creating a system for trading material, energy, and water by-products among companies, within an industrial park, a neighborhood, and/or a region. Participants expect to use previously discarded resources rather than wasting them, to reduce pollution, to cut disposal costs, and often to gain new revenues. There are also instances of single companies constructing networks of plants designed to utilize their by-products. For instance, a sugar company in southern China built a paper mill, alcohol refinery, concrete plant, and other facilities. See Appendix, Cases.

We offer detailed guidelines for developing BPXs in a later chapter devoted to this topic. Here we want to emphasize that systems for exchanging by-products are not, by themselves, eco-industrial parks.

1.5.1.3 Eco-Industrial Network

An eco-industrial network extends beyond the development of a by-product exchange to a broader agenda for improvement of environmental and business performance. An EIN may include eco-industrial parks or it may be a network of stand-alone firms. In the Philippines PRIME project, for instance, five industrial estates are collaborating as an eco-industrial network to create a regional by-product exchange and to assess the feasibility of a common resource recovery system and a business incubator. (PRIME 2000) An eco-industrial initiative of the Industrial Estate Authority of Thailand will focus initially on individual estates and then expand to support networks of companies related to the factories at the pilot estates. BPXs and resource recovery systems will also play a role in this Thai initiative, supported by the German technical development corporation, GTZ. (Koenig 2000, Lowe 2000) Eco-industrial networks may include all of the elements just described as well as environmental training programs for member companies, community service programs, and many other joint programs. (Cohen-Rosenthal and McGalliard 1999)

1.6 Why Developing an EIP is an Inquiry Process

There are no blueprints for eco-industrial parks. Each one must be unique. This book offers guidelines, processes, and resources to support your site-specific exploration. For your design to work, you will need to pull this EIP vision down to earth, matching the economic, ecological, social, and cultural characteristics of your community and region. As you do this, you will also need to stay responsive to currents of change at state or provincial, national, and global levels.

1.6.1 Development Is Very Site-Specific

The “eco” in eco-industrial park stands for a basic EIP principle: design your park in relationship to the characteristics of your local and regional ecosystem. “Eco” also refers to the more traditional principle that your development concept must match the resources and needs of your local and regional economy. These dual meanings reinforce the need for working in an inquiry mode when designing an EIP. Learn from the experience of other countries and communities developing eco-parks. But remember, you need to discover the right solutions for your specific site and community within the broad principles of industrial ecology, sustainable planning, architecture and construction. The turbulence of the time will open many new
opportunities for those who keep asking, “How do we create an eco-industrial park suitable to this community and this ecosystem in this amazing time?”

1.6.2 Designing in Turbulent Times

In 1980 Peter Drucker wrote a book entitled Managing in Turbulent Times. He stated,

“Planning starts out . . . with the trends of yesterday and projects them into the future with very much the same elements and the same configuration. This is no longer going to work . . . strategies for tomorrow are required . . . that enable a business to take advantage of new realities and to convert turbulence into opportunity.” (Drucker 1980)

The period during which Drucker wrote actually looks like a fairly tranquil time compared with our new millenium era. We’re in a time of even more rapid change in business, technology, economics, society, and politics.

A few of the changes most relevant to EIP teams include:

- Climate change, resource depletion, and loss of biodiversity are global changes requiring transformation of industrial systems.
- An emerging sustainable economy is beginning this transformation process, defining new venture opportunities and posing new challenges to business.
- Governments in many countries are privatizing, downsizing, eliminating programs, deregulating, decentralizing functions, and cutting funds available for local development.
- In a global economy, national economies are becoming increasingly interdependent and less able to control the value of their money or their interest rates. (These are critical issues in financing development projects.)
- A strong movement is challenging the assumptions of the dominant trade organizations and development banks that have guided the process of globalization.
- Waves of corporate mergers, downsizing, and outsourcing, driven in part by continuing technological change, continue to eliminate jobs while opening entrepreneurial niches.
- The World Wide Web and Internet have created a dynamic new forum for business relationships and transactions.

These and many other changes will affect the planning of any industrial park. Will familiar programs and departments that have funded development projects continue to exist? What regions and features will attract corporate site-location managers? What resources will be available for local business development? How far will environmental reform or deregulation go? How will e-commerce and telecommuting impact business practices? Elimination of many old certainties will open the door to new solutions and raise new barriers.

Planning major projects in this truly turbulent time calls for EIP development teams to work with flexibility, learning rapidly from their errors and successes. Companies like AT&T and Electronic Data Systems have adopted the concept of learning organization to build these capabilities into their very corporate systems and structures. If your EIP team adopts this model you will better manage inevitable surprises and recover more quickly from inevitable errors. You can find more information on how an EIP development team can function as a learning organization in Chapter 4 on planning and development and Chapter 10 on management.

1.7 General Resources and References


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2 Eco-Industrial Park Foundations

The eco-industrial park concept is based upon several fields of research and practice that have emerged in the last decade, including industrial ecology, cleaner production, and sustainable urban planning, architecture, and construction. These fields contribute to the broader movement to demonstrate the principles of sustainable development in policy and concrete projects. New patterns of inter-company relationships and organization design offer an additional support for the EIP concept.

Familiarity with the principles of these foundations for planning EIPs will help your development team plan an effective project. View them as complementary to traditional development principles and practices, not as a substitute.

2.1 Cleaner Production and Industrial Ecology

Indigo Development developed the eco-industrial park concept in the early 90s with the explicit objective of demonstrating in specific places the benefits of industrial ecology to developers, companies locating in industrial parks, and host communities. Industrial ecology seeks to find the appropriate balance between environmental, economic, and social needs of a system. Cleaner Production is a field of research and practice that overlaps with industrial ecology in many ways. Proponents of cleaner production and industrial ecology clearly share a breadth of purpose and similar objectives. The Journal of Cleaner Production has produced two industrial ecology issues, demonstrating this common vision. (Journal of Cleaner Production 1995 and 1997). Many papers in The Journal of Industrial Ecology deal with basic CP themes, such as life-cycle analysis or efficient design of production processes. So we will discuss the basic dimensions of these two disciplines, their similarities, and what makes them distinct. Throughout this Handbook we offer specific examples of their application. Here we will consider IE and CP as the foundations for such application.

2.1.1 Cleaner Production

The definition of CP used by the United Nations Environment Program and the United Nations Industrial Development Organisation is:

"Cleaner production is the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment. The three classes of objectives CP seeks to achieve are:

- Production processes: conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes.
- Products: reducing negative impacts along the life cycle of a product, from raw materials extraction to its ultimate disposal.
- Services: incorporating environmental concerns into designing and delivering services." (Evans and Stevenson 2000)

At the policy level, CP encourages government to work through five types of instruments for shaping the environmental behaviour of industry:

- Regulation, as when the permit of a firm to operate depends on meeting environmental standards, and failure to do so incurs financial or criminal penalties;
- Voluntary Programs, such as regulators engaged in an interactive dialogue with firms with an emphasis on sharing and dissemination of information and expertise;
- Market-Based Instruments, such as in the use taxes, tariffs, subsidies and other such methods to shift the financial calculations of firms toward environmentally beneficial decisions; and
Transparency, through which public awareness of the dangers of pollutants plus ready access to required reporting by firms on their discharges creates public pressure on the firms to reduce their discharges.

Information and Education, such as public health education that creates awareness of the risks to human health from pollutants. (Evans and Stevenson 2000)

Cleaner Production initiatives, such as the ADB technical assistance project that is the context for preparation of this Handbook, tend to focus on development of policy and institutional capacity. In Thailand, for instance, a CP project's objectives and mission are described as,

“The overriding objective . . . is to strengthen Thailand's capacity for environmental management at the regional level. Special focus will be given to the promotion and dissemination of cleaner production (CP) principles and practices. The specific objectives are to (i) strengthen the capacity of Ministry of Science, Technology and Environment (MOSTE) regional offices, in cooperation with local government, private sector and NGOs to undertake their mandate through practices appropriate to local conditions; and (ii) strengthen the capacity of MOSTE's Center for Transfer of Cleaner Technology (CTCT) to promote CP, and to support the operations of the regional offices as end disseminators of CP technology and practices.” (www.adb.org, TA AOTA: THA 32442-01)

This high level program will create the knowledge and capacity required by government to support developers and industries in adopting CP practices. This is very complementary to the place-based strategies of eco-industrial park development. By working through the concrete issues that a park manager or developer must address to create a home for industry, the EIP process becomes a proving ground for innovations from the higher level CP policy and capacity development process. In turn the EIP process provides practical guidance to the policy level.

For instance, the Industrial Estate Authority of Thailand (IEAT) is launching a major eco-industrial estate initiative, with four estates selected as pilot sites. The Authority will be seeking to achieve many Cleaner Production objectives through this initiative, including efficiency of resource use, reduced emissions to all media, utilization of factory by-products, resource recovery, and effective management of hazardous materials. In time, each of the pilot sites will act as the focal point for an area-wide eco-industrial network, seeking to share learning with each site’s customers and suppliers outside the estate.

There is a strong potential for synergy between IEAT's industrial ecology initiative and the CP capacity development project funded by ADB. At each step, the Authority and its industrial estates will need clear channels of communication to and receptive personnel in the Ministry of Science, Technology, and Environment and other ministries. They will need policy changes, training programs, research, and technology transfer to support their efforts to become EIPs. Their requests and suggestions will help the CP capacity development to achieve full relevance for the industries it seeks to impact. The IEAT base in industrial ecology can probably also help expand the range of what the CP Center ultimately includes in its offerings.
Some Principles of Industrial Ecology

The word 'industrial' is used here to also denote service and construction, not just manufacturing industries.

Connect individual firms into industrial ecosystems

- Close loops through reuse and recycling.
- Maximize efficiency of materials and energy use.
- Minimize waste generation.
- Define all wastes as potential products and seek markets for them.

Balance inputs and outputs to natural ecosystem capacities

- Reduce the environmental burden created by releases of energy and material into the natural environment.
- Design the industrial interface with the natural world in terms of the characteristics and sensitivity of the natural receiving environment.
- Avoid or minimize creating and transporting toxic and hazardous materials (when needed; synthesize locally).

Re-engineer industrial use of energy and materials.

- Redesign processes to reduce energy usage.
- Substitute technologies and product design to reduce use of materials that disperses them beyond possibility of recapture.
- Do more with less (technically called dematerialization).

Align policy with a long-term perspective of industrial system evolution.

The above principles were adapted from Tibbs 1992. We add the following:

Design industrial systems with awareness of the social and economic needs of local communities.

- Optimize local business and job development opportunities.
- Offset impacts of industrial development on regional systems through investments in community programs, as needed.
2.1.2 Industrial Ecology Defined

If we accept the claim of some industrial ecologists that industrial ecology is “the science of sustainable development,” (Allenby and Graedel 1994, Lowe 1998) this claims a broader span of research and practice than CP usually seeks to effect. Perhaps the design and development of eco-industrial parks is the strongest demonstration of this breadth. EIPs require integration of engineering, architecture, urban planning, business management, real estate development, finance, landscape design, ecology, economic development, information systems design, and many other disciplines. The strong place-based focus of EIP design contrasts with the policy and sectoral focus of many CP initiatives. EIP policy requirements can inform the design of CP’s policy recommendations. Both are essential components of the transition to a sustainable economy and complement each other quite well.

Our working definition of “Industrial Ecology” is that it is an approach to managing human activity on a sustainable basis by:

- Seeking the essential integration of human systems into natural systems;
- Minimizing energy and materials usage;
- Minimizing the ecological impact of human activity to levels natural systems can sustain.

Its objectives are:

- Preserving the ecological viability of natural systems.
- Ensuring acceptable quality of life for people;
- Maintaining the economic viability of systems for industry, trade and commerce;

Our broad understanding of industrial ecology as the science of sustainable development underlies our recommendations in this Handbook for eco-industrial park development. We envision EIPs as sources of a many benefits to their local communities as well as industrial facilities designed with great sensitivity to their natural settings. Since 1994 this embedding of eco-industrial park projects in sustainable community development has been a hallmark of the field. In turn, EIPs have become one of the most common concrete applications of industrial ecology.

2.1.3 Industrial Ecosystems

One popular theme of industrial ecology is that design of industrial systems can, to some extent, be modeled upon ecosystems. In 1989 Robert Frosch and Nicholas Gallopoulos (at that time General Motors research executives) recommended that “...the traditional model of industrial activity—in which individual manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of—should be transformed into a more integrated model: an industrial ecosystem. In such a system the consumption of energy and materials is optimized, waste generation is minimized and the effluents of one process...serve as the raw material for another process.” (Frosch and Gallopoulos 1989)

While there is potentially great value in this approach of designing by analogy to natural systems, most of the efforts have been naive and full of cliches. Relatively few industrial ecologists have written of “industrial ecosystems” with much insight into how ecosystems actually function. We hear too often that the waste of one organism becomes the food for another and little more. Fortunately a major effort to apply the ecological metaphor resulted in a conference in 2000 sponsored by the University of Florida, School of Construction. In this meeting ecologists, industrial ecologists, architects, and construction researchers worked to understand the systems of building design and construction as analogues to ecosystems. The book resulting from this conference, Construction Ecology, (Kibert 2001) is a valuable resource for developers, architects, planners, and building contractors working on eco-park projects. (Chapter 8 has more information on this publication.)
Ecosystems in nature demonstrate many strategies beyond consumption of “waste” that are relevant to industry and to designers. For instance:

- The sole source of power for ecosystems is solar energy.
- Concentrated toxic materials are generated and used locally.
- Efficiency and productivity are in dynamic balance with resiliency. Emphasis on the first two qualities over the third creates brittle systems, likely to crash.
- Ecosystems remain resilient in the face of change through high bio-diversity of species, organized in complex webs of relationships. The many relationships are maintained through self-organizing processes, not top-down control.
- In an ecosystem, each individual in a species acts independently, yet its activity patterns cooperatively mesh with the patterns of other species. Cooperation and competition are interlinked and held in balance.

Industrial ecologists propose that sustainable industrial systems will better reflect such strategies. They will more closely resemble an ecosystem than a machine or even a computer, the dominant metaphors that have guided design in the last century. This suggests that designers of eco-industrial parks (and their individual plants) could increase the viability and resilience, as well as the efficiency, of their projects by seeing them as industrial ecosystems.

This analogic approach of industrial ecology may be most useful when practiced in terms of ecosystem dynamics and interactions. Rather than simply drawing isolated principles from ecology, designers can model ecosystems to create more effective complex industrial systems. Ecosystems are tested viable systems, evolved over millennia. They have great resilience in the face of challenges. Insights into how they maintain viability could help create and improve industrial systems in both financial and environmental terms.

The process would involve a dialogue between industrial system designers (at the appropriate level) and an ecosystem researcher, comparing notes . . . laying out models side by side . . . asking “how does nature handle this issue we’re stuck with in our Bangalore operation?” For instance, in planning a resource recovery EIP (see Chapter 6) a developer could recruit an interdisciplinary team including ecologists expert on decomposition, civil and ecological engineers, entrepreneurs in resource recovery, policy-makers, and business managers. They would model the total pattern of ‘recycling’ in one or more specific ecosystems while building a model of recycling in industrial and consumer systems. Typical questions in the inquiry would be:

- What do the ecosystem dynamics in natural decomposition suggest for integration of recycling technologies into a more unified system?
- What are the principle strategies for breaking down and reusing materials in natural systems that could inspire new processes for recycling society’s wastes?
- What are major energy expenditures in natural decomposition processes? How do they balance between different parts of the process? What does this suggest about the energy requirements of resource recovery parks?
- How do the specific roles of organisms and interactions among them suggest new technical innovations and their interrelations? Are there promising specific biological processes not now utilized in recycling and treatment?
- How are the processes of decomposition integrated with the productive processes in ecosystems? What implications does this have for industrial systems of production and consumption?
2.1.4 Guidance from Nature in Setting Objectives

Up to the present, objectives for environmental performance of public and private industrial operations have largely been set by law and regulations written to protect separate domains of nature, such as water, air, oceans, etc. The objectives industry then sets are fragmented and sometimes mutually contradictory. They do not stem from a systemic understanding of the environment the laws aim to protect. Regulated objectives are just beginning to take into account the global impacts of human activity apparent in the last 15-20 years.

Industrial ecologists seek to form a more immediate connection between objective setting and a systems awareness of natural needs and constraints. IE emphasizes an active role for industry in this process, working in collaboration with government, researchers, and citizens. (See Chapter 7 for detail on policy, regulations, and objective setting.)

2.1.5 Three Applications of Industrial Ecology in EIPs

We offer three examples that illustrate how the systemic framework of IE can help EIP development teams solve significant problems in the development and management of industrial parks: tenant recruitment, hazardous materials management, and greenhouse gas reductions. Major Cleaner Production goals are addressed in these examples.

### Industrial park recruitment

In many Asian countries is heavily focused on large multinational companies producing for export. The local community may gain jobs and contracts for smaller service firms or suppliers, but the local economic benefits are relatively weak and the impacts of development often offset these gains (traffic, pollution, demand for housing, etc.) The community may actually become a less attractive site to teams seeking a location for a new plant.

A developer who works with the holistic foundation of industrial ecology will find that it suggests ideas for recruitment that are really good business sense.

- Diversity recruitment rather than solely targeting the same large companies every other industrial park in Asia is trying to attract. *(Chapter 4 and 6)*
- Create a business incubator that enables new or expanded local companies to succeed. The incubator is itself a tenant that creates new tenants as you build out your park. *(Chapter 4)*
- Target emerging industries that help your country become more self-sufficient in energy and materials through technologies for renewable energy, energy efficiency, and resource recovery. *(Chapter 6)*
- Work closely with local community leaders as members of a public-private partnership that supports achievement of local business development objectives. *(Chapter 3)*
- Create a Cleaner Production Center and seek consulting and service firms that improve environmental and financial performance for your park and its tenants. *(Chapter 12)*

All of these elements of industrial park recruitment strategy are based on one of industrial ecology’s most basic assumptions: environmental protection can be achieved in a way that supports business profitability.

### Hazardous materials management

Is our second illustration of how industrial ecologists approach difficult issues of environmental management. Industry uses tens of thousands of hazardous substances which may be emitted to atmosphere, water, or the ground and which need to be safely handled and disposed of or recycled. A large number of these substances persist in the environment and often accumulate and concentrate as they move up food chains. Policies and regulations dealing with hazardous materials are often poorly designed and enforcement is often under-funded and subject to corruption. Many toxic by-products go to poorly designed landfills or are dumped illegally. Finally, legal liabilities for mismanagement of hazardous materials can be quite costly and even result in criminal charges against company executives.
Industrial ecology’s systems view suggests designing policies, regulations, and practices for hazardous materials management that set short-term initiatives and innovations in a long-term context. Thus, the planners of covenants, guidelines, facilities, and services at an eco-park would act to:

- Impact policy at local and national levels to set long-term goals for a cleaner economy and elimination of the highest risk materials (like persistent organic compounds or high impact greenhouse gases).
- Seek policies that encourage adoption by industry of green chemistry products, effective treatment and recycling technologies, and Cleaner Production practices for source reduction and process redesign.
- Build a Cleaner Production center in the park to provide tenant services and training on toxic use reduction, separation of toxic materials to enable recycling, and basic good housekeeping practices.
- Work with government and industry to encourage building of state-of-the-art hazardous materials recycling and treatment facilities. In some cases, these could be recruitment targets for your park.
- Create both incentives and a whistle-blower system for toxic materials collection and transportation companies to prevent illegal dumping.

These actions will help reduce the risks and liabilities of hazardous materials management at the same time that they prepare the way for an industrial system much less dependent on such substances. With this broader framework your design team can better understand the specific policies, services, and facilities needed to help your tenants manage their hazmats. (See Chapter 8 for detail on these issues.)

A local program for **Greenhouse Gas Reductions** is our third illustration of industrial ecology at work. EIPs have been an important application of industrial ecology because they are a high leverage point of intervention with industry and communities. Their concentration of industries and channels for communication, learning, and action may enable more rapid change than simply approaching companies individually. This is especially important with a global impact like climate change, which a scientific near consensus attributes to the release of greenhouse gases by industry, transportation, and energy.

While the global community has been slow to achieve a political consensus on dealing with this crisis, there are already significant opportunities for EIP developers in acting in this area. The most direct potential benefit is the public and private sector funding that may be drawn upon in the financing of eco-industrial parks. *(More on these sources in Chapter 5, Financing.)* Manfred Klein at Environment Canada describes another significant benefit of reducing GHGs: “In almost all cases, when GHGs are prevented, all other emissions tend to drop dramatically. Cleaner energy choices such as conservation, renewable energy, and cogeneration can address reductions in all pollutants with about the same long term financial costs.” *(Klein 1999.)*

Ray Côte, a noted industrial ecologist at Dalhousie University in Canada, is directing a research program on how practices at an existing industrial park in Nova Scotia could reduce or mitigate GHG emissions. The project web site describes its subject thus, “Strategies which will be assessed include vegetation and natural ecosystems as sinks; land use planning and landscaping; building design and construction; transportation management; economic incentives and instruments; and the potential for emissions trading.” *(http://www.mgmt.dal.ca/sres/eco-debert.html)*

While we do not yet have results from this Canadian research, we can expand upon this concept to indicate the GHG reducing strategies that could be based in an industrial park. We will summarize such an EIP-based initiative here and present a fuller outline at the end of Chapter 3. The primary areas for action are the industrial park design, programs to improve tenant performance, and collaboration in GHG reductions with the local community and industry outside the park.
Design of the eco-park infrastructure, landscaping, and buildings could reduce greenhouse gas emissions through passive solar design, energy efficiency, use of renewable energy sources, landscaping to enhance CO₂ absorption, use of low-energy water treatment systems, materials systems to support recycling and reuse of water and materials, and transportation infrastructure favoring rail, among many other options. (Chapter 8 discusses all of these options for the physical design of EIP infrastructure and buildings.)

An EIP can support reductions in tenant GHG emissions through covenants, training, services, and collaborative programs (provided by service companies, a Tenant Association, or a Cleaner Production Center). Some of the key strategies that reduce GHGs are more efficient use of inputs, reduction of the volume of pollution and wastes, utilization of energy, water, and material by-products, use of alternatives to GHG producing chemicals or processes, and employee transportation programs. Recruitment could also target companies with technologies that directly contribute to GHG reductions such as biomass energy generators or plants producing alternatives to GHG chemicals.

Collaborative programs with local communities and industries would support municipal, residential, commercial, and industrial GHG reduction programs throughout the region. EIP management could enlist government agencies and local universities to create handbooks, toolkits, and competitions supporting CO₂ and other GHG reductions.

This initiative would need to develop a process and tools to monitor and account for all reductions achieved within the eco-park system and in the community. Support for this might come from environmental or energy agencies and universities, who would also track the procedures for financing GHG reductions and for trading credits. While serving a worthy cause, this is action that deserves a cash return to the EIP, its tenants, and its community.

2.2 Sustainable Architecture, Construction, and Planning

Another major foundation for EIP development is the greening of architecture, industrial facility design, and construction. Designers in these fields are beginning to apply principles parallel to those of industrial ecology. (See box below and Chapter 8.) The need is great since the ‘built environment’ (buildings and infrastructure) absorbs a large proportion of the planet’s material and energy resources. In energy alone, buildings (heating, cooling, lighting, and other systems) utilize approximately 25% of all energy consumed in the US (Rejeski 1994). The construction and operation of buildings and infrastructure have major impacts on local ecosystems and communities, as well as world-wide effects such as global climate change and depletion of natural resources.

Fortunately many design strategies such as energy efficiency can cut the costs of operating buildings and industrial facilities, and reduce their environmental impacts. The aerospace corporation, Lockheed, for instance, saves over $300,000 a year on energy in its Building 157, the engineering development and design facility. The key innovation was designing the building to optimize use of daylight. Decreased dependence on electric lights also reduced the size of heating, ventilating and air conditioning (HVAC) systems, further cutting costs and energy use. (Romm 1994). The computer manufacturer, Compaq, estimates it saves close to a million dollars a year through efficient lighting and the systems integration of lighting with HVAC and building design. Notable green office projects like Audubon Society’s retrofitted headquarters building in New York also demonstrate bottom line results from this new approach to design. (See the Audubon case in Chapter 8.)
Some Principles of Sustainable Design and Construction

Apply these principles across time to each stage of a project: development, planning, design, construction, operation, and deconstruction. The bullets suggest a few ways to apply these principles to energy, water, materials, and land resources.

Minimize resource consumption. (Conserve)
- Design for energy efficiency in building design, HVAC systems, and lighting.
- Use passive solar and daylighting features.

Select materials and design for durability. Maximize resource reuse. (Reuse)
- Redevelop existing sites rather than breaking new ground.
- Reuse construction materials, assemblies, and products.
- Include greywater systems to reuse water.

Use renewable or recyclable resources. (Renew/Recycle)
- Use building materials with recycled content, i.e. tiles with recycled glass.
- Specify woods from sustainable forests.

Protect the natural environment (Protect Nature)
- Minimize disruption of the natural environment in site preparation and construction.
- Select materials for low impact in their extraction and processing.

Create a healthy, non-toxic environment. (Non-Toxics)
- Select non-toxic materials and equipment.
- Provide fresh air for all occupants.

Integrate building and infrastructure design into the natural and human environments.
- Landscape the site using native plants of the region and ponds or wetlands to capture stormwater runoff.
- Incorporate features to reduce impact of development on community transportation systems.

Integrate design teams across professional, business, and agency boundaries in applying these principles.

( Architects, engineers, and other designers have created many strategies, technologies, and tools for realizing these principles in buildings and infrastructure. See Chapter 8 for more detail on design options.) The first five principles are based on Kibert 1994a.

"Optimization implies looking at all the data available about the products or systems (of a building) related to their initial cost, the potential savings in energy and/or benefit to productivity and health of the occupants and the environment over their life-cycle and then incorporating this intelligence into the design solutions. It means having an attitude regarding design as a signal of an intention to ‘invest’, in every profitable sense of the word, in a program that understands: there will be a tomorrow." From the 1994 project description for a new Herman Miller office systems factory, designed by William McDonough + Partners.
2.2.1 Industrial Facility Design

Architects and planners have led the sustainable design initiative first in residential and commercial buildings and new approaches to urban design. The American Institute of Architect's (AIA) Environmental Resource Guide is a large compendium of principles, guides to practice, and life-cycle analysis of materials. While many of these ideas apply to industrial facilities as well, there is little direct exploration of the unique plant design needs of industry in this guide. The majority of case studies in sustainable design are commercial and office buildings and master planned residential/commercial developments. Generally, architects play a secondary role in designing factories.

Construction engineering firms such as Bechtel and Flour-Daniels usually play the central role in design of industrial facilities. David Cobb, an industrial ecologist at Bechtel, says that design for energy efficiency is standard operating procedure. This includes co-generation projects and using waste heat as a supply to lower temperature processes (energy cascading). The extent to which CP or pollution prevention plays a role in their projects depends upon the industry and the client. Engineering firms often encourage clients to realize the cost savings possible in eliminating wastes. Cobb and several industrial designers we interviewed indicated there has been no effort in plant design comparable to the AIA's institutional leadership for sustainable architecture.

Eco-industrial park development can provide an important opportunity for the newly emerging field of sustainable industrial facility design. EIP projects will offer a laboratory for integrating architectural and landscaping innovations with the engineers' new green approaches in infrastructure, plant, production process, and equipment design.

Two industrial facility designs illustrate the potential of these new approaches: a Herman Miller office systems and furniture plant in Zeeland, Michigan (designed by William McDonough + Partners and associated firms), and the Ecover soap and household products ecological factory in Belgium. We describe the former in Chapter 8 and the latter in the Appendix.

2.2.2 Sustainable Urban Planning

Design of eco-industrial parks calls for strong integration into their communities. In the next chapter we discuss the relations of an EIP with its host community or communities. Another level of integration implies broader urban planning. Sustainable urban planning seeks to integrate land use, transportation, waste treatment, and infrastructure into a unified plan optimizing community use of energy and materials and reducing urban sprawl. While seeking a healthy relationship to ecosystems, a sustainable community plan also addresses issues of social and economic equity.

The necessary interaction of your EIP team with planning agencies may offer an opportunity for your community to adopt principles of sustainability in local and regional planning processes. For instance, when selecting sites for EIPs your design team needs to consider land-use and transportation with local planners. Must your park cover presently undeveloped land or are there brownfield sites that can be redeveloped? Will your site selection add to urban sprawl? How will it impact traffic density? Will the EIP's energy, water and waste infrastructure effectively avoid increasing demand on the public infrastructure? How will new workers attracted to the area affect the housing market?

Since many industrial park developments in Asia now include employee housing at or near the site, sustainable urban planning practices enable the developer to better integrate this total pattern of land-use. In the US the geographically separate housing tract, shopping mall, and industrial or office park became the source of sprawl, traffic gridlock, and increased pollution. Planners in developing countries have often emulated this model of fragmented land-use.

New Urbanist planning is the strongest challenge in the US to this dysfunctional style of development. Major planners like Peter Calthorpe. Stefanos Polyzoides, Elizabeth Plater-Zyberk, and Andres Duany have led a
return to planning based upon cohesive neighborhoods. These “traditional neighborhoods” are more densely organized than suburbs and integrate housing at various income levels, commercial and office space, and public space. Land-use is organized around walkable neighborhoods and public transportation hubs, to make it easy for residents to avoid using automobiles for most trips. Coffee Creek in Northern Indiana is the first project to propose integration of an eco-industrial park into the master plan for a New Urbanist community. Developers in the Philippines have made the first applications of New Urbanist design in Asia.

2.3 New Organizational Relationships

When we define an eco-industrial park as a “community of companies” we assume a collaborative model of business. There is a great deal to support this assumption in recent trends for both large and small firms. Many companies, including direct competitors, are recognizing strategic partnering as a key source of competitive advantage. For instance, Canon co-invested with HP in advancing laser printer technology in the 1970s. The company supplies HP with laser print engines but continues to compete in inkjet printers.

Large corporations often ally closely with smaller companies to insure a critical supply or even to conduct research and development. GM has struck deals with electric car manufacturers in order to gain the flexibility and speed of innovation an entrepreneurial venture affords. In 1991 S.C. Johnson, a producer of household cleaning materials, brought environmental excellence into its Partners in Quality program with 70 top suppliers (Schmidheiny 1992). “Supply-chain management” is one term for this collaborative planning between suppliers and customers.

To prepare for European legislation requiring auto manufacturers to take back their products, Renault and BMW formed a partnership to research disassembly and recycling technology and to share networks of recycling companies (BATE 1992). Automobile and electronics companies have formed similar partnerships for product take-back in Japan.

Small to mid-size firms are forming alliances variously called value-adding partnerships, flexible networks, or manufacturing networks (Hatch 1991). This form of partnership relies on a hub company that coordinates marketing, and in some cases, research and purchasing for the loosely bound network. Companies in EIPs may be able to draw upon this strategy for managing their business relations. (See Chapter 4 for more information on such value-adding networks.)

A growing number of companies are contracting to purchase material and energy by-products in one-to-one partnerships. For instance, U.S. Gypsum buys gypsum from utilities (where it is generated in flue gas desulfurization scrubbers) and paper from recycled paper companies for its completely recycled sheet rock (BATE 1992). See Appendix, Supplementary Content, for an extensive list of such exchanges.

An advertisement from Nippon Steel, a major Japanese corporation, expresses this spirit of corporate partnership in explicitly ecological language (using the same term companies at Kalundborg have chosen to describe their relationship):

“Symbiosis is one of the natural world’s truly beautiful systems. In reality, this principle of dynamic natural relationships exists not only among plants and animals, it also applies to animals and humans, humans and humans, companies and companies, companies and the environment, humans and the earth. It is this very relationship, expressed in the term “Symbiosis:ism, that is our goal for bringing about better business global partnerships. Through both free competition and harmony, based on a spirit of mutual benefit and trust, Nippon Steel will continue to make these interactions more productive and fruitful for our lives.”
2.4 Resources and References


**Industrial Ecology**

A web page of industrial ecology bibliographies [http://www.yale.edu/jie/biblink.htm](http://www.yale.edu/jie/biblink.htm)


Dalhousie University School for Resource and Environmental Studies IE and EIP research: [www.mgmt.dal.ca/sres/research](http://www.mgmt.dal.ca/sres/research); Burnside EIP: [www.dal.ca/eco-burnside](http://www.dal.ca/eco-burnside);

Research project on greenhouse gas emissions reductions at industrial park: [www.dal.ca/sres/eco-debert](http://www.dal.ca/sres/eco-debert)


Journal of Industrial Ecology [http://mitpress.mit.edu/journal-home.tcl?issn=10881980](http://mitpress.mit.edu/journal-home.tcl?issn=10881980) This site includes full table of contents for each issue, article abstracts and selected papers which can be downloaded. A second site for the Journal of IE is [http://www.yale.edu/jie/](http://www.yale.edu/jie/) yale journal site

The Industrial Ecology Universe. A site created by the AT&T Environment, Health and Safety (EH&S) Organization. The site includes an introduction to industrial ecology, articles, other links, and updates on the field of industrial ecology. [www.att.com/ehs/brad/](http://www.att.com/ehs/brad/)


Philippine Board of Investments, Industrial Ecology Module [www.iephil.com](http://www.iephil.com)

Rockefeller University, Program for the Human Environment [http://phe.rockefeller.edu/](http://phe.rockefeller.edu/)

University of Michigan, Center for Sustainable Systems [http://www.umich.edu/~nppcpub/index.html](http://www.umich.edu/~nppcpub/index.html)


UN Environmental Program Industry and Environment Division [http://www.unepie.org/home.html](http://www.unepie.org/home.html)

**Cleaner Production**

Cleaner Production Web site with links to many resources: [www.cleanerproduction.com](http://www.cleanerproduction.com)


Sustainable Architecture and Construction

Cyrubia, internet resources for the built environment http://cyurbia.ap.buffalo.edu/pairc/index.html

Sustainable Architecture, Building, and Culture http://www.sustainableABC.com/


Forum: Habitat in Developing Countries http://obelix.polito.it/forum/welcome.htm

Architecture Asia http://www.architectureasia.com

See also resources in the Chapter 8.

Sustainable Urban Planning


Congress for the New Urbanism http://www.CNU.org for information on membership, online and print publications, and events for planners, architects, and other design professionals.

Human Settlements in Asia, Gateway site to urban planning and management practices in Asia. Hosted by Urban Management Centre, Asian Institute of Technology, Thailand. http://www.hsd.a.i.t.ac.th

New Urban News, an independent newsletter on New Urbanism www.newurbannews.com

New Organizational Relationships


3 EIPs and the Local Community

Any industrial park is interdependent with the surrounding community and relies on it for human and material resources, services, and trade. Local citizens are usually involved in hearings conducted by planning agencies, which must approve the developer's master plan and environmental impact assessment. The workforce for park tenants generally comes from nearby towns and may require training given by local educational institutions. Employees new to the area also require housing. Local businesses provide materials, parts, and services to companies in the park. Water and sewage, energy, solid waste, and transportation infrastructure is usually operated by local jurisdictions. Local and state/provincial environmental agencies require reports and are responsible for enforcement of regulations. Citizen activists may mount major protests if industrial park developers and managers ignore their concerns about pollution and other impacts. Company site-location teams often evaluate the quality of life of the community, not just the industrial location.

For all of these reasons, it is very important that the leaders in an eco-industrial park initiative build strong relations with their host communities. Community involvement is supported by the many benefits industrial parks offer through the new jobs and businesses they create. The project may also invest in community enhancement programs to provide return for the support the public sector offers. Companies, developers, agencies, and citizens need to work together closely to capture the benefits of this innovative concept.

An EIP will be more likely to succeed if it is part of broader community initiatives such as:

- Development of housing for employees of EIP businesses;
- Creation of a community strategic plan for reducing the total waste stream (residential, commercial, public, and industrial);
- Development of a highly effective regional by-product exchange, providing markets for materials now discarded as wastes;
- Strengthening economic development planning to encourage businesses that fit the recruitment profile of the EIP or that turn wasted resources into products and jobs;
- Mobilizing educational resources to help the community's businesses and government operations increase energy efficiency and prevent pollution;
- Reducing greenhouse gas emissions through a community action program led by the EIP. (As outlined at the end of this chapter.)
- Financing of some EIP development costs through public private partnerships.

Such initiatives offer a strong context to support the evolution of an eco-industrial park. Effective exchange of by-products may require a larger set of suppliers and users than the ones present in many industrial parks. A trained workforce, housing, and access to finance for facilities help attract tenants. At the same time, the community gains many benefits: a cleaner environment, a stronger, more efficient economy, new jobs, and a reputation as a good site for starting new businesses.
3.1 Public Private Partnership

In a very real sense, an EIP represents a public/private partnership between the community, the development company, the firms involved in the EIP, and possibly national agencies. (See Chapter 5 on financing EIPs for guidelines for forming public private partnerships.) Many of the opportunities for improved environmental performance may require that costs be born by the private firms, with the majority of benefits accruing to the larger community. When developing and operating an EIP, it will be important to recognize the possibility that such opportunities may be lost unless the stakeholders identify methods to match costs and benefits across the public and private sectors. With some public benefits, the most sensible approach may be for the community to negotiate ways of providing additional investment to enable the developer to include amenities not otherwise affordable.

In other instances, the negotiation may not shift costs, but will create a way for the industrial park to share in public benefits resulting from the private investment. Such sharing of costs and benefits will require all parties to see the whole picture clearly, not just their individual interests.

For example, private investment in an EIP’s infrastructure may result in substantial savings for the community through reduced costs of solid waste management and waste water treatment. The public works department of the city government will receive the benefit of not having to increase capacity. If the community can enable the park management to share some of these savings (possibly through discounted rates for city services), the investors in the EIP are likely to be more inclined to finance the additional infrastructure. The savings might be passed on to the EIP through a project to build recreational facilities within the park at a reduced rate. Alternatively, the municipal transit system might provide enhanced services to the EIP at a reduced rate. A third example might involve the community providing day care facilities or technical training programs for employees within the park that otherwise would have represented costs for the firms in the park.

Outreach to the local community is a practice gaining favor with estate developers and managers in a number of Asian countries. This may take the form of education and training programs for workers from neighboring towns, support for development of micro-enterprises to serve tenant needs, support for cleaner production in businesses outside the park, and other such programs. When the developer approaches the community as a good neighbor, the time for gaining necessary approvals and permits may be reduced.

Our experience in developing countries has strengthened our perception of the need for EIPs to connect closely to their local economies. While recruitment of transnational corporations may provide significant numbers of jobs, it does not engender the higher level of development that expansion and incubation of local firms achieves. Therefore, we believe industrial park managers need to balance these two complementary strategies for filling their property with viable tenants. We cover these issues in Chapter 4.
Community Programs of a Petrochemical Park in the Philippines

The Petrochemical Development Corporation (PDDC) of the Philippine National Oil Company is implementing community programs as part of its project in Bataan, which aims to become an EIP.

- The company has built new housing and created a resettlement program for “informal dwellers” on the site.
- Livelihood training programs have prepared community residents for employment in the complex as well as community businesses, like carpentry, masonry, and sewing.
- A medical outreach program delivers services to the local residents in cooperation with the medical staff of PNOC subsidiaries and the local government units.
- The site’s Community Relations Program interacts with local residents and government units to keep them informed of significant developments in the project that directly affect them.
- PPDC led a tree planting program with residents from the resettlement area, who were employed to prepare the site and take care of the newly planted seedlings, acquired from local nurseries.
- The Petrochem Park has provided employment opportunities to local residents, recruiting around 60% of the site’s 3,800 employees from neighboring towns. (PRIME 2000)

3.2 Building the Context for an EIP

Creating the broad community support and participation so basic to the success of an eco-industrial park begins with recruitment of important players and groups in the community. You should seek to balance the interests of all of the major stakeholder groups while also including the town or city’s most innovative players. The candidates include:

- Leaders in the city’s industrial and financial community.
- Representatives of local companies and potential future tenants in the EIP.
- The Chamber of Commerce.
- Public sector stakeholders from city government, as well as County, State, and Federal agencies. (economic development, urban planning, environmental protection, public works, and recycling).
- Labor representatives.
- Community and environmental organizations (including any potential opponents of development).
- Educational institutions.

Initially few of these people may have any idea what an eco-industrial park is, therefore educating the community is an important early step. Options for this enlistment process include networking with key individuals and organizations; organizing public events with media coverage; conducting workshops or conferences; and planning activities in local colleges. A Worldwide Web site for community education and involvement can provide an overview of the project, means of inputting ideas or questions, and links to other eco-industrial projects. Whether your team chooses to use a conference or a series of interviews with stakeholders, the following guiding questions are important to answer.
### Some Guiding Questions for the Inquiry

**What is the larger national and global context?**
- What economic, business, environmental, and cultural trends support or impede development of this EIP? (i.e., the trend toward closer partnering between major companies and their suppliers and customers.)
- What surprises would be critical to EIP development? How might they be handled? (i.e., the potential for a national or regional recession.)
- What global environmental issues must be taken into account in planning an EIP? (i.e., global warming and depletion of non-renewable resources.)
- What scientific, technical, and intellectual currents are likely to facilitate EIP development? (i.e., the increasing use of natural systems models in economics, engineering, computer systems, and organizational design.)

**What is the local context?**
- How does our region express the trends identified at national & global levels?
- Can the local economy support new industrial development or should we focus on greening our existing industrial infrastructure?
- Are there older parks that would benefit from rehabilitation and retrofitting through participation in eco-industrial networks?
- What environmental and economic objectives do we want to achieve with an EIP?
- What local companies might consider expansion into an EIP?
- How could an eco-industrial network improve local business, economic, and environmental performance?
- How do current economic and community development plans, urban planning, and zoning support or impede development of an EIP?
- What local environmental factors must be considered in planning an EIP?
- What human and material resources are available? What’s missing?

**What is the conceptual context?**
- How are the ideas of industrial ecology, sustainable architecture, and sustainable development relevant to our community?

Your team may compile the results of this first inquiry into a report available to the whole community.

In a kick-off workshop or conference, stakeholders can learn basic principles of industrial ecology and eco-industrial parks; explore EIP initiatives in process elsewhere; examine the application of these ideas to local development patterns; and define the next steps for forming a local project.

In many US EIP projects the design team held a conference early in the process to introduce the concept and enlist support from community stakeholders. This would include the critical players we’ve already listed, as well as professionals like architects and engineers. The agenda could include...
An introduction to eco-industrial development, including cases of EIPs, eco-industrial networks, and by-product exchanges.

Presentation of the development vision.

Evaluation of community needs that the development must account for.

Breakout groups to evaluate the concept and brainstorm resources and obstacles.

A tour of the proposed site.

3.2.1 Assessing resources

Early in the context setting process your EIP project can benefit from an inventory of resources available at local, state, and national levels. These may include individuals, organizations, sources of information/data, and anything else that can support the project. A survey of existing local resources should address the following questions:

- How can existing resources, programs, and development strategies contribute to EIP development?
- What are the resources that we already have in place?
- What type of financing is available?
- What organizations or businesses could make in-kind contributions?
- What are our local design capabilities?
- What are our research capabilities?
- Do we have necessary education and training programs?
- What existing and past plans can we build upon?
- What are the opportunities for community involvement?

This integrative survey across public and private sectors, should cover economic development, finance, environmental protection, urban planning, community development, and education/training. In the process you will identify missing resources for development of the park and options to supply them. The electronic database and print report that results from this survey will be a resource in itself for the EIP and other community projects.

3.3 Building Your Local Vision

The next step is integrating the input obtained during the context setting phase of the project into a compelling vision of an eco-industrial park. One of the most important elements of the vision of the EIP is a clear statement of the over-arching, high-level purpose of the park with respect to environmental, social, and economic performance. A clearly articulated vision and mission will guide daily practice at all levels of the enterprise. This statement should also reflect the initial environmental and economic performance objectives of the park. The environmental vision of an EIP should address the impacts of the park on the larger eco-system and the principles of ongoing improvement and progress toward goals. A simple mission statement might read: “The XYZ Industrial Park supports a community of profitable companies, working together to achieve their business objectives with no net negative environmental impact.”

Groups often develop project visions in a “looking backward” mode. For an EIP this would mean describing the functioning park from the future and identifying the key strategies that resulted in its successful development. This “idealized planning” approach helps a team break out of the constraints of conventional
development practice. The method calls for forming the future vision; reviewing the present situation and all of its limits (what systems scientist Russell Ackoff calls “the mess”); and then tracing pathways to “get from here to there” (Ackoff 1981).

The fields of architecture and urban planning offer a meeting format for building your project vision known as the design charrette. This is an intensive, two-three day session with the core team, key stakeholders, and a variety of design and development experts. The group moves between plenary and task group discussion to achieve its objectives. Charrettes may be held at regular intervals during the course of a project in order to integrate different streams of work.

For the park to be successful in the long-term, this vision and mission—the strategic intent of the park—must be “owned” by all of the players. It is imperative that each one be involved in forming and articulating the vision, at least through consultations by members of the core team. It will be important over time to revisit and renew this vision in workshops involving all current stakeholders.

3.4 Closer Integration of Industrial Parks and the Community

Many industrial parks and estates in Asia are linking closely to broader community development initiatives. For example, Laguna Technopark in the Philippines will eventually form part of a new regional growth center being developed by Ayala Land. Called Ayala South, the master planned development will integrate a business district, commercial centers, residential villages, and community facilities on over 2,500 hectares of prime property.

South of Ayala’s site, in Batangas Province, the LIMA Technology Center integrates industrial sites with over 100 hectares of commercial area and a residential development. Tomas I. Alcantara, Lima Land President, said, “What we envision our LIMA project to be is a complete township where a full-fledged commercial and retail center and a residential subdivision complement our industrial estate. Bordering the industrial zones will be separate commercial and residential areas that will cater to the needs of all LIMA citizens. Shopping areas, business and food centers, and entertainment complexes will round out the options available at LIMA. There will also be an on-site international school, church, and medical center to take care of the needs of LIMA’s citizens. From LIMA Technology Center, http://www.lima.com.ph/"

In Thailand, Amata Development has planned a similar community in the Eastern Seaboard area southeast of Bangkok. This company’s concept is to integrate industrial estates with employee housing, commercial areas, educational facilities, and other social amenities. Unfortunately the first Amata City project is essentially a large industrial estate with a narrow strip of land along the entrance road for residential and commercial development. The property does not include land adequate for a true community. Development of this project was hit by the 1997 SE Asian economic crisis and remains on a slow track four years later. (Amata Development 2000 http://www.amata.com)

In a more limited effort, another Thai development—the Eastern Seaboard Industrial Estate—included an apartment building with 160 units within the estate for factory employees. However, employees have rented relatively few apartments, preferring to not expose themselves to being “on call” at any time. This may indicate a social barrier to locating housing near to the place of employment in some cultures. (Hemaraj 2000) (Amata Development 2000)

These projects indicate that developers are taking a more integrated approach to their projects. This trend is in line with the widespread interest in sustainable development where economic development is closely coordinated with environmental protection and community development. See our discussion of New Urbanist planning in Chapter 2. This approach is gaining popularity in the US. Developments following this more compact, mixed-use plan are selling at above market rate.
3.5 Resources


Amata Development. 2000. [www.amata.com](http://www.amata.com) and interview with Amata VP Kamjorn Vorawongsakul.


A Possible Partnership Between an Eco-Park and its Community for Greenhouse Gas Reductions

This program would generate many direct benefits for both the EIP and the town residents and businesses, including revenues from the sale of emissions credits. The local partnership would benefit the planet.

Design of the eco-park infrastructure and buildings

- Incorporate passive solar building design to reduce heating/cooling requirements, including tree plantings.
- Use integrated renewable energy sources, with parallel benefits of high quality and reliability of supply.
- Build to rooftop capacity and feed surplus energy into grid at green energy premium price.
- Use energy and water cascading between tenants as far as possible.
- Lower energy consumption of waste water treatment systems.
- Provide tenants with guidelines and support for energy efficiency in building and process design.
- Optimize carbon absorption in landscaping.
- Provide rail access and logistics to support to tenants use rail over truck.
- Build employee housing within walking or quick van trip distance.

Improvements in tenant performance (through services, covenants, collaborative programs)

- Promote efficient use of inputs (energy, waste heat, raw materials, water and wastewater and waste byproducts).
- Encourage alternatives to GHG-generating chemicals in tenant processes.
- Greatly reduce the volume of pollution and wastes which need to be treated and removed.
- Develop by-product exchange within the park and beyond.
- Reduce the transportation requirements for industrial process inputs and waste and product outputs through waste reduction strategy, reuse, and recycling.
- Reduce impacts of employee transportation through renewable energy or hybrid van transport, car pooling, disincentives in parking.
- EIP tenant association and info system maintains forum for education and sharing.

Tenant recruitment and incubation

- Recruit on-site Plants or distributed companies that generate renewable energy from biomass, agricultural and animal wastes and solid wastes.
- Recruit manufacturers and distributors of renewable energy systems.
- Seek green chemistry companies producing non-GHG generating industrial, home, and janitorial substances.

Community programs

- Partner with neighboring communities to support municipal, residential, commercial, and industrial GHG reduction programs.
- Create “toolkits” and competitions supporting reductions of CO₂ & other GHGs for homes, industry, commerce, and municipal operations.
- Set up university, college, or high school interdisciplinary design competitions with awards.
- The park and tenant personnel collaborate for tree planting programs in community and region.

Monitor and account for all reductions achieved within the eco-park system and in the community and trade GHG reduction credits. Use the proceeds for common programs or distribute to partners.
Planning and development of Eco-Industrial Parks

Eco-industrial park development calls for asking new questions within the context of traditional industrial development processes. Developing any industrial park requires several rounds of planning and design. The team tests project feasibility in greater detail with each stage. The project must satisfy financial, economic development, public planning/zoning, environmental, and technical criteria at each step. Your eco-industrial park team will follow the traditional process, while considering new design options in each phase of project planning. In this chapter, we explore the special implications of an EIP for several key areas of development. A development team needs to create a strategic plan for dealing with all of these areas of concern, beginning with the project organization.

We open this chapter with discussion of ownership and the value of public private partnerships supporting development projects. We consider site selection for an EIP, emphasizing the need to avoid development of virgin land whenever possible.

We then review EIP recruitment strategies, suggesting the importance of balancing between several pairs of factors: traditional marketing strategies and an EIP’s unique advantages; economic and environmental goals; filling the park and getting the right mix of companies for by-product exchanges and external recruitment and local business development. We caution that your team needs to test the by-product exchange strategy carefully and that it may play only a minor role in some developments.

Industrial park developers are required to file environmental impact assessments and generally create property covenants. We explore how these processes support an EIP developer in setting performance objectives and creating an environmental management system.

Finally, we discuss management of the development process, the concept of the learning organization, project, communications, and processes for qualifying consultants and contractors.

4.1 Ownership – Public or Private?

4.1.1 Public/Private Partnership in Development

Industrial parks always require close coordination between public and private sectors, no matter who actually owns the development. An eco-industrial park may require even closer partnership in order to capture the full benefits for the community, industry and the natural environment. This will be true whether or not an EIP is publicly or privately owned and developed.

In the last decades private development companies have taken a larger role in the construction of industrial parks and estates in most Asian countries. Several major companies in Japan, Singapore, and the Philippines are developing sites in other countries, including China, where the government has generally played that role. At the same time, the role of government agencies like the Industrial Estate Authority of Thailand is being cut back, with development and management of estates there joint ventured between the Authority and private developers. In some cases, the government may invest the land for a project, offer incentives for recruitment, and channel international development funds for infrastructure such as common waste water treatment facilities. The private firm manages the rest of the development tasks.
This pattern contrasts with that in the US, where public development agencies have taken responsibility for most US industrial parks with larger scale (and often more polluting) manufacturing industries. Private developers have tended to focus on parks developed for light industry, warehousing, and distribution. In Mexico, on the other hand, private developers build most industrial parks and are often responsible for bringing the power and water infrastructure on-site.

Whether developed under public or private ownership, an eco-industrial park inevitably needs a strong public/private partnership to make it a success. A public agency or authority brings several advantages to the project:

- Initial pre-development planning may be financed from a variety of public budgets (economic development agency, public works department, or a special industrial development authority.)
- The development may be financed in part through economic development and infrastructure bonds.
- Property owned by a public or quasi-public agency may be used as the project site.
- The development agency may have (or can gain) a mandate for environmentally sensitive development seeking performance beyond regulatory and zoning requirements.
- Gains realized from EIP design may reduce the need for other public investment (for instance, a pre-treatment plant in the park reduces demand on civic water facilities).
- A public entity can offer direct incentives to companies as part of the recruitment strategy.

The private sector plays a vital role in publicly developed parks. Private companies are the tenants, and often the managers of, industrial parks and private developers often work as consultants on public projects. Development firms have the capability to manage the complex process of acquiring land, managing planning and feasibility studies, and putting together the investment strategy. (Private developers often work as consultants on public projects.) Existing community industries and utilities who will benefit from a stronger local economy may support recruitment of outside companies. Participation from local firms in a by-product resource exchange will also strengthen the EIP.

See Chapter 5 on financing EIPs for more detail on creating public private partnerships.

4.1.2 A University as Developer

The development office of a university could bring many resources to the development of an eco-industrial park. In the US and Europe, universities have established research parks used as sites for labs, new ventures commercializing campus research, and, in some cases, a broader mix of industrial and service companies. Such universities include Yale, John Hopkins, Princeton, and Stanford. In China there is a network of 52 science and technology industrial parks, many affiliated with universities (see the web site: http://www.chinatorch.com/stipark/english/content.htm).

Most such university developments now focus on electronics and biotechnology industries; however, the creation of environmental and energy businesses for a sustainable economy makes university related EIPs a desirable next step.

A university with the necessary intellectual capital and land would bring strong resources to a joint venture with a development company. Business, engineering, environmental sciences, architecture, and other disciplines could support planning, conduct action research on the project, and provide technical and management training. A university with a strong sustainable agriculture program would link naturally to an agro-EIP. Development of an EIP focused on renewable energy would benefit from co-location with an institution doing R & D in energy technology and business models. Once the park is in operation, tenant companies could benefit from continuing university
research and student internships or work study programs. The developer would have a strong partner that could
invest the land required, provide research and training, and create a powerful recruitment theme.

University participation in the development of an EIP would be a natural companion program to an initiative for
greening the physical plant and operations of the school’s campus. George Washington University, for example, has
embarked upon an ambitious project to enhance energy efficiency, pollution prevention, water management,
materials recycling, and other aspects of operating its large urban complex. A school with land available for an eco-
research park could gain from the synergy between the park and campus projects. Much of the R & D would overlap.

4.2 Site selection process

Traditionally, industrial park developers consider environmental factors only as required by regulations and
permitting requirements. Developers of an EIP make a deeper assessment of potential sites in locating the park.
They consider the characteristics of the local and regional ecosystem, the site’s suitability for industrial development,
and potential constraints on the pattern of development. This ecological evaluation complements the usual
evaluation of transportation, infrastructure, zoning, and other human systems. For the customary category of
transportation, rail access should be a high priority because of the significant financial, environmental, and social
benefits it provides.

In Puerto Rico Recovery Solutions placed a priority on using brownfield land for its Resource Recovery Park,
reviewing dozens of sites previously used for industry. The site the team finally selected includes a decommissioned
paper mill which can be put back into operation manufacturing recycled paper products.

4.2.1 Applying the Environmental Performance Framework to Assess Sites

Selection of a piece of land for an EIP may engage your team in political and economic issues, ranging from “Not in
my backyard” to, “do it here on my 200 acres” (at an inflated price). The economic and environmental performance
objectives you have established will provide a framework for defining clear goals in site selection and assessing
competing locations. We describe the process of using this framework in the Appendix, under “applying the
environmental performance framework in site-selection”.

4.2.2 Reuse developed land when possible.

Planners recommend a central principle in locating industrial parks today: seek to redevelop an already developed
property rather than breaking virgin ground. Such properties could include an existing industrial site, a closed
military base, or a large public facility. Location on land owned by and/or near a power plant could open
opportunities for energy cascading, co-generation, and utilization of plant by-product materials.

This principle helps contain urban sprawl and avoids consuming valuable agricultural land. Communities that have
such vacant or underutilized properties are planning redevelopment of sites. They seek to recover investments in
existing buildings and infrastructure. However, in many cases, they must also deal with serious contamination of the
property from previous uses and associated liability problems.

The state of Minnesota has created model “recycling land” legislation that resolves state liability issues. This law has
opened the door for the cleanup and redevelopment of over two hundred contaminated sites, including industrial
sites. The California EPA and other states have created non-legislative voluntary cleanup programs to clear state
liabilities for developers of brownfield sites. The California Center for Land Recycling is an NGO that can work with
developers and government to clear title and encourage investment in such land.

Another strategy to encourage use of already developed sites is for the government to offer incentives to developers
and recruited companies. "Industrial tax exemptions could be offered to encourage companies to locate in and
develop existing industrial areas. The savings from exemptions could then be used in conjunction with public funds to clean up the brownfield site. To make this feasible, companies would require that the exemption be large enough to at least offset the cost of clean up and remediation.”

**Brownfields in Taiwan**

Taiwan has several cases of brownfield land clean up and redevelopment. However, most of these cases have been quite sensitive due to health risk and land speculation so they have been kept confidential. The one case discussed publicly was land in Taoyuan where soil was contaminated by cadmium for over a decade. After years of dispute and studies, the county (prefecture) government decided to engage a consultant to prepare plans for the clean up and reuse of the land.

In Taiwan, the Legislative Yuan passed the Soil and Groundwater Pollution Remediation Act in January 2000. The Act defines control standards for soil and groundwater contamination and regulates the clean-up and sale of contaminated land. The Construction and Development Administration in the Ministry of Interior is in charge of zoning and rezoning. The Administration amended the regulation to require land owners to clean up their land before selling or applying for rezoning, if evidence shows that the land was contaminated. (2000. Personal communication from Yue-Lang Feng, ADB Environment Department)

“Over 160 sites in Taiwan have been identified as contaminated to various degrees. These sites have all been scanned by non-destructive geophysical methods, of which selected sites have been further sampled and tested to examine the seriousness of their contamination in terms of the soil and groundwater. As a result, about 20 sites are classified as requiring immediate clean-up action. Removal of dumped wastes has been conducted on a few of these sites. Obviously, restoration and redevelopment of the contaminated sites are the final goal of all parties concerned.” (2000. Personal communication from Chih C. Chao ITRI, Taiwan.)

### 4.2.3 Greenfield Sites

If your team cannot make an existing industrial site feasible for your project, a backup planning principle is to apply the highest standards of ecological planning in your greenfield development. Regard the virgin land as a precious resource to be used with efficiency and minimal disturbance. Understand it as an ecosystem, not just a building site. Design to preserve its character as an ecosystem, in balance with its neighboring environment. If the land is in a farming area, consider the feasibility of using the agro-EIP model described in Chapter 6 so your development will benefit that agricultural economy rather than displace it.

### 4.3 EIP Recruitment Strategy

An eco-industrial park team strongly links recruitment of companies to the park design process and community economic development strategies. Your recruitment team will need to enlist major prospects into your vision of an EIP, helping them understand how they will benefit from its innovations. As they sign leases they will become your partners in implementing the vision. These predevelopment commitments will help investors see the bottom line value of your innovations in design.
A successful recruitment strategy depends upon achieving balance between:

- Traditional marketing strategies and selling the EIP’s unique advantages.
- Economic, social, and environmental goals.
- Filling the park and getting the ‘right’ mix of companies for by-product exchanges.
- Outside recruitment and local business development.

We cover each of these themes in detail below, but we want to emphasize that the third point of balance is particularly vital. We are still learning about the feasibility of deliberately creating a network of companies utilizing each others’ energy, water, and materials by-products. Our lead examples of by-product exchanges (BPX), Kalundborg (Denmark) and Styria (Austria), developed spontaneously, not as the result of industrial park recruitment. However, experience with industrial clusters indicates that there are strong precedents for companies locating to be near suppliers or customers. This makes the by-product strategy a variant of a familiar pattern rather than a total innovation. Testing the feasibility of recruiting a mix of companies exchanging energy and materials by-products is one important goal. But it must not overly constrain the basic task of filling the park. Chapter 12 on by-product exchanges explores alternative strategies for development exchanges, including the possible creation of a by-product utility.

### 4.3.1 An EIP’s Unique Advantages in Marketing

Conventional industrial park developers recruit companies on the basis of access to supplies and markets, workforce capabilities and costs, transportation access, economic incentives, and quality of life. More general features of the site plan such as an industry cluster focus, offer competitive advantage to potential tenants. Your project must have strengths in these areas to begin with.

An eco-industrial park adds a new level of benefits to participating companies—improved economic, social, and environmental performance through enhanced efficiency and synergistic relations among the park's companies. Your marketing strategy can feature these advantages as additional incentives. Many of them will contribute directly or indirectly to the tenants' bottom lines and to their public image. But, of course, you cannot ignore the more traditional benefits in marketing your park.

#### 4.3.1.1 Potential Benefits of EIPs to Companies

- Park environmental management infrastructure and services enable tenants to outsource major responsibilities in these areas.
  - Site-wide or umbrella permitting (when it is feasible in your jurisdiction).
  - Shared solid and liquid waste-management.
  - Shared training in new regulations and technologies.
  - Shared emergency management services.
- Sales of material and energy by-products increase revenues and reduce disposal costs.
- Membership in an EIP gives companies an authentic green image in the marketplace.
- Potential collaboration among some companies in marketing, training, or R & D may offer a new source of competitive advantage.
- Other possible shared services in the EIP reduce costs to companies.
• Cafeterias and day-care,
• Purchasing of non-product related supplies.
• Education/training facility.
• Transportation services.

4.3.2 **Balance Economic and Environmental Goals**

As your team moves through the steps of the development process you will be setting measurable environmental, social, and economic goals. These will be guided by the performance objectives you established in initial planning and that you continue to evolve with recruited companies. In your detailed design concept for the park, for instance, you will begin making choices about target industries, facility design guidelines, possible covenants, park infrastructure, landscaping, and other aspects of the project. In each area you will need to set goals for economic, social, and environmental performance.

Finding a creative balance among these goals is a high priority in an EIP. With care, your choices will result in a design that optimizes the whole system. You will achieve trade-offs among possibly conflicting goals that can enhance performance in all realms. For example, design guidelines that require comprehensive energy efficiency strategies in all EIP buildings (infrastructure and plants) could conflict with project financial goals by raising costs of construction above thresholds important in the feasibility analysis. A straight trade-off (lower efficiency goals for lower up-front costs) would reduce long-term savings from higher efficiency, thus optimizing only short-term project economics. It also would result in greater consumption of energy and use of resources over the life of the project. To the investor these are social goods, not corporate goods.

A more systemic solution would involve ways to manage up-front costs while maintaining high efficiency. Some form of public investment could be backed up by technical support services from local utilities, universities or colleges and the government's department of energy. This is a case where the benefits and the costs in a public/private partnership must be balanced across sectors. To secure a public good, arrange to reduce risk or increase return for the investor.

*See the discussion of public/private partnerships in Chapter 1, 3, 5 and the EIP Performance Framework Chapter 10.*
4.3.3 Balance Recruiting for a By-product Exchange Network with Filling the Park

"Many businesses benefit from the proximity or co-location of functions that are closely related to, or rely upon, the production process. This reduces production costs for goods and services by eliminating unnecessary transportation movements and, in the case of high-technology industries, by creating an intellectual and mutually reinforcing creative environment." (Urban Land Institute 1987)

The common sense value of companies exchanging energy, water, and material by-products, is appealing. The story of Kalundborg's network has captured the imagination of corporate innovators in many countries and inspired development projects in Europe and the US seeking to emulate this "industrial symbiosis" in Denmark.

Finding "matching" companies will always be a constraint, even with more traditional recruitment targeting. Recruiting to a by-product exchange may take more time and effort, but it is within a limit familiar to any developer. It is a matter of degree. Once you recruit a major anchor tenant, this plant's inputs and outputs will define a next tier of tenants that could be teamed with it. Then you ask, is there need for these companies in the local economy? Are there existing companies that could locate at this EIP to be near a major customer and supplier? Your recruitment team's analysis of the anchor will determine how feasible the BPX recruitment theme could be.

In the Financing and By-Product Exchange chapters we outline a number of strategies to support enlisting the right mix of companies for an EIP by-product resource network and for maintaining the exchange patterns as companies change. We also describe some of the possible community initiatives that can provide a larger system of by-product utilization.

4.3.4 Balance Attraction with Growing Your Own Firms

"Most economic development professionals spend most of their time chasing "deals" from other cities. Research consistently shows that local growth accounts for 90-99% of the jobs in any given area. We are more interested in growing jobs, than in shuffling them between various cities."

- Stephanie Neumann, Economic Intelligence Specialist for Littleton Colorado

You may fill your eco-industrial park most effectively by striking a balance between attracting businesses to move into your market and supporting local entrepreneurial development. A large anchor company is likely to be part of a national or transnational corporation. But it is equally likely to create niches for new or established local businesses as suppliers and as reprocessors or users of its by-product streams. With any industrial park, the developer recognizes the importance of the anchor plant's supply chain. So adding the by-product utilization firms is only an extension of a familiar model.

In the next chapter we project some of the implications of the transition to a sustainable economy for eco-industrial park development in Asian developing countries. We outline several possible “theme EIPs”, in which recruitment focuses on specific clusters that will grow rapidly as part of this transition. We believe these very strong development opportunities will enable recruitment teams to place more emphasis on local businesses. In some cases entrepreneurs will have developed their own technology or acquired it from domestic R & D. In others, they may license technology from a cutting-edge firm overseas or from national or international R & D centers.

There is one important drawback to new business development in EIP recruitment. Institutional investors seek to reduce the risk of financing industrial parks by focusing on projects with well-established, AAA credit rated tenants. We discuss some ways of dealing with this limitation in the Financing chapter.
4.3.4.1 Business Incubators for EIPs

“Every year more than 400,000 entrepreneurs start new businesses in the US and of those, 350,000 close before
the year’s end. However, the National Business Incubation Association (NBIA) estimates that over 80 percent of
firms cultivated in an incubator have kept their doors open after five years of operation.” – Alameda Center for
Environmental Technologies

An EIP development team can enhance the success rate of new businesses by setting up an incubator on-site
through public/private collaboration. This resource can play a vital role in developing suppliers to anchor tenants,
filling out a theme cluster such as renewable energy, or helping to fill niches in the by-product exchange network.

Business incubators typically help entrepreneurs in several areas:

- Support in venture financing, marketing, accounting, organization design and other business capabilities.
- Access to common legal, secretarial, and bookkeeping services and office and telecommunications
equipment.
- Collaboration among businesses in a shared facility.
- Access to timely information on markets and emerging technical opportunities.
- Access to training in business basics through local schools.
- Mentoring from entrepreneurs in the region.

“Such a system can nurture start-up and newly established firms by providing the above-mentioned services and office
space on a shared, affordable basis. However, at its core is the financial, marketing and design support and the
managerial training it gives to the emerging entrepreneur. Another by-product of a business incubator is the internal
dynamics that come from working together in a shared physical space: the joint and cross-disciplinary learning that
takes place and the opportunity to form the business networks and contacts are also critical to the launch of successful
ventures.” UNIDO incubator web site: http://www.unido.org/stdoc.cfm?did=300456

Potential investors see participation in an effective incubator as a factor that will increase the success rate of new
ventures. Research by the US-based National Business Incubator Association indicates a very high success rate for
incubator supported enterprises, compared to startups without this systematic support.

Incubators can range from profit-making entities allied with venture capital funds to public institutions with no
financial interest in the incubator businesses. In the US only a relatively small proportion of incubators are for-profit
and many have failed. The latter model is probably preferable in an EIP setting. Here the park developer, business,
government, and the community (especially environmental and labor interests) cooperate in incubator planning.

A mix of public and private sources may provide incubator startup funding. Local utilities and banks have significant
self-interest in seeing new businesses succeed and have helped seed the development of incubators in many areas.
The usual sources of public grants are industrial development agencies and international development banks. Costs
need to cover:

- Forming of strategic public/private partnerships;
- Strategic planning and design, giving a focus and timeline;
- Feasibility study and budgeting of the operating entity;
- Identification of candidates for initial incubation;
- Space and equipment;
Staffing.

EIP developers could seek support for incubators focused on any of the eco-industrial park recruitment themes we describe in the next chapter: resource recovery, agro-industrial, renewable energy, and green chemistry for petrochemical parks.

A Chinese Business Incubator

ChinaTechStart is an incubator in Fujian Province founded to help new Chinese high tech companies succeed and be globally competitive. It provides “the necessary infrastructure and services which are critical to success in today’s accelerated global marketplace...offices, state-of-the-art technology, human resources, business development, marketing and financial services...”

Partners in this incubator include the Xiamen High Tech Innovation Center, the Fuzhou Economic Technological Development Zone, and a US company, JW Group. In addition to space and the usual support services for startup firms, ChinaTechStart provides extensive technical design support and guidance in financing, debt restructuring, forecasting, financial management, and funding strategies.

For details see www.chinatechstart.com

Possibly the single most important service for startups is access to information. EIP management or incubator staff can work with the economic development agencies to provide an electronic research center that also serves the region’s other firms.

Littleton Colorado’s Business/Industry Affairs department, subscribes to seven commercial database services (including Dialog, Newsnet, Datatimes and others) covering nearly a thousand databases and hundreds of thousands of publications. Their initial information efforts were focused on strategic issues (industry trends, social and technological changes, etc.), and changed as the “market demand” evolved. They now use these on behalf of the smaller businesses to identify marketing lists, track industry trends, do competitor intelligence and run financial backgrounds on potential partners and customers.9 [to what do their, they, and these refer?]

In an EIP such a research center could track the market demand for, and commercial feasibility of, technologies in renewable energy, energy efficiency, resource recovery, environmental information systems, alternative transportation, green chemistry, pollution prevention, ecosystem restoration, and other environmental technologies. The center would also scan for non-environmental business opportunities that match other development goals of the EIP.

4.3.4.3 Value Adding Networks

An advanced concept of business networks called Value Adding Partnerships or Flexible Networks, offers important advantages for small-to-mid-size companies in an EIP. With this model, several businesses cluster (physically or “virtually”) around a broker/coordinator company in order to leverage resources. This collaboration enables the
cluster to compete more effectively with much larger companies in national and global markets. The network may also conduct joint R & D and product development or procure common goods and services for members. Flexible Manufacturing Networks have demonstrated success in Italy, Denmark, and some areas of the US.

This concept is very complementary to our definition of an EIP as a community of companies and to the strategy of developing by-product exchanges within that community. Flexible Networks suggest that it is possible to provide conditions that facilitate such inter-firm collaboration. Researchers such as Richard Hatch at New Jersey Institute of Technology have identified these conditions and supported formation of new networks in the US.

At least fifteen states have started programs to support network development. For instance, Oregon's Office of Economic Development has created a training program for Network brokers and offers grants supporting development of Flexible Networks. Several networks there function in environmentally related fields.

Local colleges or university extension programs could provide similar training. National or local economic development agencies could provide seed grants.

4.3.5 How a Company Looks at Site Selection

A company seeking new plant locations will consider the possible advantages of an EIP along with a host of traditional criteria. Each site-selection team will be screening locations to ensure that all of its priority criteria are met. Your own screening of candidates is likely to build a list of desired companies that will find EIP benefits attractive, so long as your park meets their other criteria.

We will first outline the traditional company site-selection criteria and then provide a check list that could be used by EIP candidates to explore the value of locating in an EIP.

4.3.5.1 What does a company seek in a site for a new facility?

An adequate labor supply is fundamental: Are there ample numbers of workers at a fair cost? Is local training, education, and the quality of all types of schools adequate?

Materials supply: For some firms, proximity to raw materials is a major requirement (for instance, ore and minerals processing and food processing). Are transportation facilities adequate (harbor, airports, highways, railroad, barge canals or rivers, pipelines)?

Parts and components supply: Are there businesses already in existence that can constitute the company’s supply chain or will they have to be recruited or created?

Energy and fuel supply: Are adequate energy and fuel available at a competitive cost? For some, this is paramount, i.e., for aluminum refining, electrochemical processing, and power plants.

Customers: Close proximity to customers is a major requirement for some industries, i.e., beverage can or bottle manufacturing, automobile assembly, or ready-mix concrete.

“A Good Place to Live, Work and Raise A Family”: A key question is whether the decision makers would want to live in the area, theoretically or in fact. This is a very personal decision which may not be articulated. Site-selection teams often include at least one person who will actually work at the new facility.

Capital Investment: For some firms, especially start-up companies, close proximity to investors may be important.

The Local Business Climate: This includes tax laws, labor laws, environmental regulations, financial rules affecting transfer of funds in and out, and types of ownership permitted.
A company site-selection team will be asking, "Do the locals 'have their act together'?" Is there a good working relationship between state and local government officials, the Chamber of Commerce, the local banks and real estate interests, labor unions, schools and colleges?

Another factor to be considered will be the availability of “special incentives”, such as governmental aid through tax reductions or “holidays”, subsidies on land and/or building purchase, infrastructure support (e.g., construction of new roadways to site, railroad siding, or expansion of airport facilities), industrial development bonds to support purchase of equipment, or employee training programs.

**Topics to be Considered by a Prospective Tenant in an EIP**

Your EIP plan will probably address many of the company concerns regarding site-selection we have just reviewed. Your potential recruitments can adapt the following questions to support their site-selection teams as they explore the implications of locating in your park.

**What EIP benefits will be available to us? How will they affect our profits?**

- Will we spend less management time and effort on environmental matters and permitting?
  - Will the EIP managers assist us in applying for operating permits, etc.? Are they experienced, have they done this for other tenants?
  - Will we also be able to learn from our neighbors? Is there a cooperative attitude among the various tenants, supporting the joint solution of common problems and sharing of experiences? Would their experience be pertinent to our business issues?

- Will we find a high quality, highly motivated labor force?
  - Will people prefer to work in this industrial park? Do they understand and share in the goals of the EIP and the tenant companies?
  - Will the employee oriented benefits and facilities of this EIP, such as day care centers, choice of cafeterias, and excellent public transportation, improve employee attendance and morale?
  - Will our training and skills improvement programs cost less, and be more effective, because of the shared facilities provided on the EIP campus?
- Will we achieve lower costs and gain new revenues for energy and materials?
  - Can we adapt our processes and methods to use the waste energy or materials streams available from other tenants?
  - Will our by-products, such as surplus energy or water, material by-products of our processes, used packaging, or other materials be attractive to our co-tenants?
  - Will we be comfortable working closely with our neighbors? We've learned a lot about strategic partnerships with our suppliers in recent years. Can we do something similar with our neighbors, helping some of them become our customers or suppliers?
  - Will our people, inspired by what they see around them at the EIP, discover new ideas to further lower our costs and improve our quality?
  - How much will the EIP’s recycling programs affect our operations and lower our trash disposal costs?
- Will we achieve lower costs for our other business needs?
  - We've always handled things like purchasing, building services, training, and staff functions such as health, safety & environment internally. Will it work for us to outsource many of these to the shared services provided by the EIP managers and service companies?
  - Will these shared services really lower our costs, including the burden on our management’s time? How will they respond when we have a rush or emergency situation?
- Can we benefit from cooperative marketing & sales?
  - We've heard that in EIPs smaller companies may develop cooperative or joint M&S programs. Will that work for us? Only certain kinds of products/services could be co-marketed with ours; are these available in this EIP?
- Will we gain an improved corporate image?
  - Will our customers care about us being part of EIP? Will an improved image increase sales?
  - What will our bankers and investors think? Will they view EIP tenants as better managed and, therefore, better risks? Will this result obtaining loans and letters of credit more easily?
  - Will being part of an EIP help us in recruiting senior management, engineers and other specialized workers?
- Various EIP services will cost us, in service charges and in our lease payments. Will they add enough value to our personnel and our company to offset these costs?
Industrial Parks:
The Tenant’s Position:
"The location is great; the price is right."

IP improves Corporate Image
("This is a good address; prestigious!")

Payments from Customers

Company ‘C’
@ Site ‘S’

Payments to:
- Landlord - lease
- Suppliers - goods & services
- Employees - salary & benefits
- Governments - fees & taxes
- Shareholders - dividends

Profits

Management
Time & Efforts

Labor
Energy
Materials
Capital

Payments to:
- Landlord - lease
- Suppliers - goods & services
- Employees - salary & benefits
- Governments - fees & taxes
- Shareholders - dividends

Profits

Does being in this IP improve Profits?

DBHolmes
9 Jan 1995
Eco-Industrial Parks: The Tenant’s Opportunity:
“Location is great; the price is right, and my costs are lower.”

Better quality labor force; more motivated!
Coop Training Facilities
Less Mgmt Time Req’d, for Permits, Compliance, etc.
Easier Access to Capital; the banks and Wall St. like what we’re doing here!
Lower Cost Sources, incl. neighbor’s waste materials
Lower Cost Sources, incl. neighbor’s waste energy

Payments from Customers
Capital
Material
Energy
Labor

Company “C” @ Site “S”

Payments to:
• Landlord - lease
• Suppliers - goods & services
• Employees - salary & benefits
• Governments - fees & taxes
• Shareholders - dividends

Improves Corporate Image (“Green”, etc.)
Better Access to Customers
Cooperative Marketing

Neighbors as customers for waste streams

Better Access to Customers
Cooperative Marketing

Payments to:
• Landlord - lease
• Suppliers - goods & services
• Employees - salary & benefits
• Governments - fees & taxes
• Shareholders - dividends

Easier Access to Capital; the banks and Wall St. like what we’re doing here!
Lower Cost Sources, incl. neighbor’s waste materials
Lower Cost Sources, incl. neighbor’s waste energy

Does being in this EIP Improve Profits?

Payments from Customers
Capital
Material
Energy
Labor

Better Access to Customers
Cooperative Marketing

Neighbors as customers for waste streams

Payments to:
• Landlord - lease
• Suppliers - goods & services
• Employees - salary & benefits
• Governments - fees & taxes
• Shareholders - dividends

DBHolmes
9 Jan. 1995
4.4 Project Organization

4.4.1 Management of the Design and Development Process

4.4.1.1 The Learning Organization

Your eco-industrial park development process can benefit from working as a learning organization at three levels: the core development team, the professional design team, and the larger body of community stakeholders. At each level, your project will be breaking new ground in a field with solidly established traditions and practices. You will continually apply new solutions within the financial and political constraints on your project.

The learning organization model will be especially important in early EIP projects, where rapid recovery from inevitable design errors will be imperative. This approach will also help your team discover the new responses demanded by the changing forces in the global, as well as national, economies. The openness, flexibility, and systems view of the learning organization embody the qualities needed for success in the EIP development process.

Some essential attributes of a learning organization include:

- Using the development team's successes and errors as opportunities to build the strength of its efforts as a group.
- A willingness to check its underlying assumptions and beliefs to break through apparent conflicts.
- Exploring how the pieces each member manages come together into a whole system.
- Observing its learning and communication processes to continually improve its collective ability to learn.

There are many management consultants experienced in helping businesses and other organizations achieve such apparently idealistic patterns of behavior. These ideals are embodied in practical methods well suited for the various levels of organization in your development process.

Barry Clemson, a management consultant and professor of engineering management offers this description of the value of learning organizations:

“We can consider organizations as focusing in knowing, thinking, valuing, or learning (McGill and Slocum). The knowing organization reduces everything to a standard procedure and operates “by the book.” The thinking organization excels at problem solving, and the organization is viewed as a series of problems which are to be solved as quickly as possible. The valuing organization emphasizes its culture, core values and foundational myth. Employees or members are often expected to exercise considerable discretion, but are always guided by the strong, clearly articulated corporate culture, values and myth.

“The learning organization, in contrast to all the others, must excel at observing and reflecting on itself, including not only its results but also its internal patterns of behavior. This observation and reflection on self must also consider the way in which the organization observes and reflects, i.e., the organization must be able to learn about and improve its learning.
“The learning organization must use the methods of the other three types. Certain things must be done “by the book,” problem solving is a critical skill, and a strong corporate culture is necessary for excellence. However, the learning organization puts these elements together in a distinctive pattern with learning at the center. The learning organization is able to sustain a rapid pace of change as necessary to adapt to changing conditions in the environment.”

4.4.1.2 Project and Community Communications

Communications within your immediate project design team and with the broader set of stakeholders will be vital to the planning and design process. You will want excellent two-way communication channels with your community, to keep citizens informed and to understand and incorporate their issues and creative ideas. Your development team will need to understand how the project is unfolding in different specialized areas. Continuing communications with economic development, planning, and regulatory agencies will be critical. New methods and technologies enable you to meet these needs effectively. Online networks and skilled design and facilitation of meetings complement traditional media.

4.4.1.2.1 The Project Online

A closed project web site for your development team will help your immediate design team and the network of specialists and stakeholders to interact effectively. A web site with citizen access will provide a channel for gathering community input and informing citizens on the value EIPs hold for them. You can design the web site with different levels of access and conference spaces for working groups. Industrial parks around the world are using the web as a basic tool for marketing and raising finance.

HYPERLINKHYPERLINKConferences, Workshops, and Charrettes

Your project will be holding meetings often, ranging from small team sessions to broad community conferences. Skilled design and facilitation methods enable groups to work together creatively, even when they are at odds with one another. These methods help diverse participants work effectively with complex initiatives. They include the Search Conference14 and Open Space meetings.15

You will want consultants with the following capabilities and experience. They should be accustomed to working with different cultural backgrounds; good at supporting decision-making processes and resolving conflicts; and strong in supporting design of whole systems change efforts. Look for someone who knows how to set the stage for teams to organize themselves successfully. Most important, your meeting designer/facilitator must know how to support people in moving forward with their action agenda. How do you find such talent? The person you need may be a management or organization developmental consultant. Perhaps he or she is trained in mediation or conflict resolution. Some architects are very imaginative in design of community meetings.

The phrase “design charrette” began as a strictly architectural term for very intensive design sessions to meet a project deadline. EIP planners in many US cities have used it to describe the variety of meetings needed to build project vision and integrate design ideas from various disciplines. Usually a charrette is a two-to-three day intensive session including the project’s core team and design consultants.
4.4.1.2.3 Other media

A project newsletter, columns in local newspapers, and radio and TV presentations (with call-ins) are all valuable for keeping your community informed on your project's progress.

4.4.2 Designing the Management of the Operating EIP

The management of eco-industrial parks will be responsible for more functions than traditional park management. In its recruitment function, management will support development and maintenance of energy and material resources exchange within the park (and with other industries in the area). Management will play a critical role in supporting and maintaining the community spirit among EIP companies. It will administer contracts for shared support services and facilities. Park management may also play an important role in relationships with regulatory agencies. Industrial park and estate managers in Asia are creating site-wide environmental management systems and seeking certification (EMS such as ISO 14001) so this planning process is also part of the design challenge.

As you develop your EIP concept, your team should start designing the management system for the park. What management structure will best support realizing your vision of how the park will operate? What sort of entity can best carry out the management functions required? How will management maintain the highest standards of quality control in all park operations? We cover these and other issues you need to consider in this management system design process in chapter 10.

4.4.3 Accessing professional services in tune with your vision

You will need a broad range of consultants at each stage of planning your eco-industrial park. These include developers, accountants, land-use planners, architects, attorneys, ecologists, economists, and engineers (civil, logistics, chemical, environmental, etc.)

Given the level of innovative thinking required in designing an EIP, you may benefit from using a Request for Qualifications rather than the usual Request for Proposals to solicit consulting assistance. With an RFQ, firms respond to a detailed set of questions about their training, specific professional capabilities, and their track record in applying them. Responses are used to narrow the field of candidates to two or three, or to make the final selection. Then the developer negotiates the terms of the project with the most qualified prospect(s). Through this process, the contractor can collaborate with the firm to develop an effective scope of work.

Your project needs architectural, engineering, and planning consultants experienced in applying new environmentally sensitive approaches. But, at the same time, it needs these specialists to be familiar with the planning codes, zoning, and regulations of your region. If your area lacks the former, you can build local capability by importing highly qualified outside consultants to work in concert with local firms and to provide training.

4.4.4 Integration Across the Different Systems of Planning

Developing an eco-industrial park is a challenging effort, demanding integration across many fields of design, businesses and organizations: the core EIP team; city economic development, planning, and public works departments; developers; potential tenants; professional firms; regulatory agencies; and community/environmental organizations.

- Your team will work closely with local and state economic development agencies to create recruitment and business incubation strategies featuring an EIP’s unique advantages and needs.
Companies considering location in the park will need two-way communication with your planning staff. (You will want to understand their needs and considerations. They will need to understand the evolving design of the EIP and how it will impact their operations.)

Key staff in regulatory and zoning agencies will explore with your EIP team how to best enable innovations such as site-wide permitting and regulation and new design options in water, energy, and materials infrastructure.

Your EIP design team will work closely with possible community initiatives to encourage local industries to exchange wastes as by-products and possibly absorb surplus by-products from the park.

For instance, an infrastructure feature, such as an integrated by-product management facility serving all firms in an EIP, requires coherence across business, engineering, regulatory, financial, and company recruitment systems. Its design must work economically, technically, legally, and organizationally. At another level, it may serve as a backup system for the set of companies engaged in trading by-products in the region. In turn, the broader trading network may absorb surplus by-products from firms in the EIP. So you will also need input from the economic development or public works agency managing creation of the community by-product exchange program.

Most developers could say, "So what's new about this? It's just the way this business works." However, developing an EIP does add new issues. Your project may benefit by a number of innovations in communications and processes. We discuss project communications in the preceding section. In the Design Options chapter we cover design processes and tools that enable greater integration across disciplines and organizations.

You might consider setting up a project operations center, a room with whiteboard and corkboard on all walls and a computer with a projector. In this facility, any working team would be able to reference a graphic model of the whole project and all of its sub-systems. It could also include a project timeline, budgets, geographic information system (GIS) displays, site-photos and renderings of the site-plan, and other conceptual maps of the work you are doing. This level of access to easily absorbed information would enable your project teams to better integrate their work. This operations center would continue to function through construction and commissioning of your EIP. It could then serve as the hub for management once the park is in operation. (We provide more detail on this in the Management chapter.)

1.4 Environmental Standards in Development

In this section we discuss those aspects of the development process relating to the setting of standards in environmental performance. These include environmental policy and regulations, the project environmental impact assessment, covenants, the environmental management system, and performance objectives and indicators. Attention to developments in environmental policy and regulations are essential throughout the development process.
For an eco-industrial park the writing of the project environmental impact assessment and the property covenants are essential part of the real estate development process, flowing from the work of the feasibility study. At the same time, first steps in design of the environmental management system must be coordinated with both the EIA and the covenants.

### 4.4.5 Policy and Regulations

The developer of a traditional industrial park needs to carefully watch emerging trends in regulation, permits, and zoning. EIP teams may go beyond this to help create the trends. From the earliest days your project will need to be in dialogue with policy-makers, regulators, your community’s planning departments, and your future tenants. The questions to discuss include:

- To what extent is it possible (and advisable) to establish the whole park as the regulated entity?
- What are the implications of tenant companies out-sourcing some environmental management functions to the park management company or third parties?
- What changes (or special permits) in water, waste water and solid waste regulations and ordinances will you need to permit by-product exchanges or shared treatment facilities in the park?
- Will you need changes in current zoning to allow the mix of industries needed for such exchanges?
- Can Federal and state agencies certify cleanup and clear liabilities to permit redevelopment of contaminated brownfield sites?
Developers of EIPs may need to lobby for amendments to policy and laws to enable innovative approaches to environmental protection. They also can work with associations of real estate developers and industrial park managers to support such changes. See Chapter 7 for some of the policy and regulatory issues important for EIPs beyond the umbrella permitting we discuss in the next section.

4.4.6 Innovations in Environmental Impact Assessment

The idea of site-wide or umbrella permitting could ease the burdens of environmental management for companies as well as regulators. However, it is a solution that raises a number of critical issues. Would each plant be liable for the noncompliance of any plant under the permit? Would it make sense to lump together large and small companies, or those with very different levels of potential exposure to liability?

Establishing an EIP regulatory “association” would be one effective way to manage regulatory permitting and compliance matters. Through the association, each EIP tenant would pay a weighted up-front cost and monthly fee based on its level of regulated releases. Some of the regulatory association’s funds could be leveraged against future environmental liabilities. When considering joint liability, the association could exercise the authority to fine or remove tenants if they remain in noncompliance.

Another way of resolving the issues with site-wide permitting is to design umbrella permits as administrative structures that leave potential liabilities in the hands of each member. The companies would establish limits for the group as a whole, with distribution of these limits negotiated within those under the permit.

The EIP management could be the administrator, monitoring environmental performance, handling regulatory reporting, and providing feedback to company personnel. A goal of this system would be to reduce time devoted to regulatory issues by companies and regulators. So long as the environmental performance for the EIP as a whole was within targets (both regulatory and self-imposed), companies would have more flexibility in managing individual performance. At the same time, peer pressure rather than external policing would create the sanctions needed to regulate plants that are outside of limits.

Another useful variation is to create different umbrella permits for different groups of companies, depending on their size and potential exposure to liability.

In Asia the Philippine Department of Environment and Natural Resources is piloting Programmatic Environmental Impact Assessments (PEIA) as a way to prepare a site-wide EIA. We discuss this and other environmental policy issues in Chapter 7.

4.4.7 Convenants, Conditions, and Restrictions

Restrictive covenants typically set limits on design of individual facilities to protect the park’s investors, other tenants, and the community. They cover aesthetics, potential nuisances, maintenance assessments, design guidelines, and review processes. They also refer directly to environmental compliance issues such as protection of natural landscape, air and water emissions, and toxic materials. They may also prohibit certain types of industry or indicate the range of industries that are welcome. CC&Rs usually require membership in an organization for handling common issues, such as a tenants’ association or plant managers club.

Design of EIP covenants will require creative collaboration among your development team, potential tenants, and zoning and regulatory agencies. CC&Rs may place stronger limits than local zoning or national regulations allow but can not be weaker. At times you may seek to implement a strategy that is less restrictive on each plant’s performance but generates higher performance for the park as a whole. For example, some industrial parks in Asia include a site-wide waste water pretreatment plant or solid waste management facility that lowers the total effluents of the park, by absorbing wastes from tenants. (See Chapter 8 for a Thai industrial estate’s closed-loop water system.) Such common infrastructure may require zoning variances as well as covenants or incentives for the tenants to use the common systems.
Shared infrastructure for waste water treatment, hazardous waste management, or by-product collection and storage also requires covenants specifying conditions for outputs from each plant and monitoring of quality. Tenants will save on the costs of separate systems and personnel but they should be accountable for a system to control quality of their outputs.

You should not put CC&Rs into effect until the planning agency has granted project zoning (or rezoning). Covenants typically include a time period, means of revising them, and provisions for enforcement and mediation.

You may want to synthesize covenants into comprehensive facility design guidelines. The result is an independent document that the local planning agency records as a separate ordinance. This defines criteria for site planning, architectural design, and a review process to evaluate each development in the park. In an EIP, this approach offers a way of better integrating facility design into the overall industrial ecology approach to site-wide planning. Through the review process your EIP design team can support individual plant design teams. They need to understand how to apply your broad performance objectives and guidelines in harmony with their business and technical design goals.

4.4.7.1 Some principles for defining covenants in an eco-industrial park

- Coordinate your drafting of environmental management system performance objectives and your design of covenants, incentives, and guidelines in several stages.
- Encourage performance objectives that go beyond compliance to regulations.
- Seek a balance between covenants and incentives to create acceptance of shared environmental management activities; emphasize voluntary solutions and incentives wherever possible.
- Focus on desired outcomes in performance, not specific means for achieving them.
- Reflect the understanding that performance of the EIP is based on a balance between economic and environmental objectives and goals.
- Protect the rights and uses of all parties.

How you apply these principles will be very specific to your site, community, and local environmental conditions. Generally, begin with your broad objectives, such as increasing efficiency and reducing the environmental impacts of energy systems in the park. Since energy efficient and passive solar building design are well-developed fields, you could specify performance goals and suggest guidelines to support designers in meeting them.

Plant designers will need flexibility, as they must balance savings from lower building operating costs, costs of design, and costs of construction and equipment. You might consider offering a useful incentive like technical support in design and budgeting, especially for smaller tenants. This could include referrals to experienced designers and perhaps a conference for tenant design teams. Utilities in your region may also offer incentives and technical assistance for energy efficiency.

Your covenants are an important leverage point in meeting your environmental objectives as well as your business objectives. Some US EIPs have emphasized environmental values over business values and alienated possible tenants. It is important to test your draft covenants with candidate companies. Ask their input on how to design the covenants in a way that gets the performance you want without appearing too much of a burden on the companies interested in your site.

4.4.7.2 Some typical covenants set by US EIPs

*From Ecological Guidelines and Recommended Practices for The Londonderry Eco-Industrial Park, New Hampshire*
General criteria for construction: “Establish and maintain procedures for communication between design and construction professionals, and the Eco-Development Team and the organization’s ecological coordinator or representative.”

“Develop criteria and specifications to design-in water, energy and building material conservation; ease of recyclability; and the utilization of low maintenance and low embodied energy building materials and non-toxic materials in construction.”

Energy use suggestions: “Optimize natural day lighting, passive solar gain and natural cooling.”

Building material suggestions: “Choose wood products from salvage operations and/or certified as sustainably managed.” “Prioritize building materials that are non-toxic, made from recycled materials, manufactured with low embodied energy.”

“Implement an incentive-based program to minimize both the environmental impacts, and the cost associated with employee’s commute to work and the transportation of materials to and products from the site.”

“Provide priority parking to those employees that car pool.”

“Develop, implement and maintain an environmental management system (EMS) appropriate to the nature, scale and ecological impacts of the organization’s activities, products, or services. The EMS will include, at a minimum, an ecological policy, defined roles and responsibilities, a documented “Plan, Do, Check, Act” program and written objectives and targets consistent with the Eco-Park vision statement.”

From Cape Charles Sustainable Technologies Park, Virginia

Air Monitoring suggestions: “Occupant has installed a permanent air monitoring system with the capability to monitor supply and return air for carbon monoxide, carbon dioxide, total volatile organic compounds and particulates.”

“Provide annually to the Eco-Park Governing Board an environmental performance summary including, but not limited to, performance against Park objectives and targets, performance against organizational objectives and targets, regulatory compliance and Environmental Management System review data and a self-certification statement, signed by the CEO or President, attesting to the accuracy and truthfulness of the report.”

Cornell University’s Work and Environment Initiative has created a Handbook on Codes, Covenants, Conditions, and Restrictions for Eco-Industrial Parks. This very useful resource includes guidelines and CC&Rs from a number of EIP sites in the US. It is available on the web at http://www.cfe.cornell.edu/wei/papers/codes_files/codes_home.htm

4.4.8 Setting Performance Objectives for an EIP

Setting performance objectives is one of many aspects of the development process that are done repeatedly, each time in greater depth. These measures are fundamental to the creation and operation of an environmental management system (EMS). As the chart above indicates, a development team needs to start planning the EMS in parallel with the writing of the EIA and covenants for the project. The commitments made to regulators, the requirements placed on tenants, and the objectives and indicators need to support each other quite well. Our full discussion of EIP performance objectives and indicators is in Chapter 10, EIP Management.

In the following chapters we discuss several major EIP design themes. In the next chapter we discuss design of your EIP financing strategy. Then we move on to chapters on the transition to a sustainable economy and the special recruitment clusters for theme eco-parks this is creating; issues in EIP policy and regulation; and the design of EIP infrastructure and buildings.
4.5 Resources


Bosworth, Brian, Broun, and Williams. 1999. The Network Tool Kit: Volume One —Manufacturing Networks and Competitive Manufacturing. Regional Technology Strategies Inc. This manual catalogs and describes the most useful tools, practices, documents, and materials that have been developed over the past few years to aid the formation and management of inter-firm collaboratives. The tool kit's material is drawn from successful practice in the US and in many other nations. http://www.rtsinc.org/index.html

California Center for Land Recycling “Redeveloping Land for Sustainable Communities.” www.cclr.org See CCLR’s Brownfield Redevelopment Case Studies. California Center for Land Recycling


The Incubator Center for the UN Industrial Development Organization (UNIDO) includes a Handbook for creation of incubators in developing countries, comprehensive guidelines, case studies, and links to operating incubators. http://www.unido.org/stdoc.cfm?did=300456


The National Business Incubator Association (US) http://www.nbia.org.html also includes links to international incubation associations and organizations http://www.nbia.org/intl.html

A Chinese high tech incubator: www.chinatechstart.com

Oregon Economic Development Department. April, 1993. Flexible Networks for Oregon Businesses, Progress Report. 775 Summer St NE, Salem, OR 97310.


Value Adding Networks: Regional Technology Strategies Inc. This site offers an extensive list of publications on inter-firm collaboration: http://www.rtsinc.org/index.html


Financing Eco-Industrial Parks

5.1 Introduction

Large, sophisticated development companies are now responsible for most conventional industrial park development and management in Asia. They understand quite well the basics of financing major real estate projects in their own countries and often in other Asian countries. In this chapter we will attempt to offer some insights to complement what such companies already know, not to duplicate it. Financing an eco-industrial park may add some new potential sources of support and it may require some innovative strategies to realize the added benefits of this form of development.

In addition, as Asian countries explore the implications of the financial crisis that began in 1997, they are raising serious questions about the traditional approaches to investment and industrial development. Simultaneously, a global movement is challenging the assumptions of globalization and its negative social, economic, and environmental impacts. Agenda 21 programs in each country have enlisted all sectors in creating programs for achieving the balance between these three factors in programs for sustainable development. The international development banks, including Asian Development Bank, are themselves seeking to understand how their grants and loans can contribute to sustainable development in each client country.

A specific source of sustainable investment is emerging around the need for reductions in greenhouse gas emissions. This and other environmentally related funds could support aspects of the development of eco-industrial parks. We offer an extensive set of resources in this area.

For all of these reasons the developers of industrial parks and estates in Asia will need to explore new opportunities and be aware of new challenges, as they learn to create and finance eco-industrial parks.

5.2 Levels of EIP financing

Your design team has formed a whole system vision for a sustainable development project—an eco-industrial park, probably anchored by a major company committed to your development concept. Realizing this vision will provide a powerful model for the sustainability and self-reliance of your community and of your country. It is important to maintain the integrity of the vision by designing the short-term financial strategy to be the basis for implementing the full system. This may be achieved by creating an infrastructure of public private partnerships to support the longer-term actions as well as the next steps in development of the EIP.

There are at least four levels of the project's development that require financing and management:

- Completion of predevelopment feasibility and engineering studies;
- Development of the EIP's physical infrastructure and marketing program;
- Construction of possible speculative plants and the financing of tenant facilities;
- Development of supporting institutions like the business incubator and training center;
- Broader sustainable community initiatives that may provide benefits to the EIP development, such as a community green house gas reductions program.

These four interrelated projects are a model for sustainable local development. They support meeting the business and financial objectives of the property development and at the same time increase the self-reliance of your community and country. At each level they provide a mix of private and public benefits, suggesting that project financing and other support should come from a mix of private, public, and civic (e.g. foundations and other non-governmental funds) sources. The balance between the two will vary by project.
- You EIP project may benefit from finance from public and civic sources in its pre-development and design phase. The park can probably fully qualify for private sector funding in the actual development of the eco-park, however public sources such as industrial development agencies should also be evaluated.
- The financing of tenant enterprises and their facilities will generally come from private equity and debt capital sources, though the public sector may provide industrial development bonds or other forms of public support.
- Support structures like the incubator and training center will probably qualify for funding from government or international and/or bilateral development banks. Since they will benefit recruitment to the property, it is appropriate that the EIP’s private investors should also contribute to their success.
- Community development initiatives may also be largely financed from public and civil sector sources, with contributions from the EIP development budget (as part of its investment in mitigating the impacts of development).

This blending of different public, private, and civil sources of support at different levels suggests that the EIP developer should form a number of overlapping public private partnerships (PPP) with members appropriate to each level of the project. These partnerships will seek timely development for the elements they are managing. Through their coordination, the project will derive the mutual benefits stemming from their interaction.

For instance, the developer could seek support for feasibility planning of the EIP from development banks, bilateral banks and aid organizations, and national industrial development or economic development agencies. Where the development includes employee housing, national housing authorities may also help. Generally international funds have to go through a government entity, which then joint ventures with the development company. The public benefits of the EIP in economic development, job creation, and superior environmental performance would repay this public investment. The completed feasibility study then becomes the basis for private investment to develop the infrastructure for the park.

If the land is owned by the government, another sort of public private partnership would work through a phased timetable for acquiring the property. So long as the option for all future parcels is firmly binding, this arrangement would reduce the carrying costs and taxes on the land in each stage of eco-park development. An alternative would be to explore the possibility of the government continuing as owner, providing a long-term lease to secure tenure. The patterns of industrial land tenure are quite different from country to country. In China the government still owns most industrial parks. Thailand is going through a transition from ownership by the Industrial Estate Authority to joint venturing with private development companies.

One of the primary purposes for forming PPPs is to use public funding to offset risks and to compensate for public benefits that projects offer. Thus, using public funds for the more speculative but critical elements—like the land development feasibility study for the EIP—builds the basis for more risk-averse private investors to come in at the implementation stage. For associated projects that will benefit public and private interests alike—like the business incubator—it is appropriate for costs to be shared. On the other hand, large development companies may have the capital available to fully fund all predevelopment activities.

The public-private partnership model may appear to increase the number of decision-makers who can impact the course of the financing process. Even when a partner is bringing capital, the conditions on that investment may create costs and risks that are not worth the potential return. This means that developers have to proceed carefully in forming PPPs, define the roles clearly, and limit the range of decisions any partner participates in.

On the other hand, partnering with the community is really another form of efficiency, not an add-on. Having a good place to live for one’s employees, a happy and skilled workforce, a peaceful community, and excellent local suppliers all add to the competitive advantage of the development.
At the end of this document there is a matrix of possible partners and project levels or components. This can be used to identify and evaluate members of the different PPPs that may be required.

5.3 Basic steps in forming Public Private Partnerships (PPP)

Discuss financing strategy with the individuals who are already playing a core role in the EIP development process. Map the networks of close contacts and other resources for each of them. Determine who is the best lead person in opening discussion about participation with each possible partner.

Define the role members of this initial core group could play in forming specific PPPs for different projects within the overall development.

Keep the partnerships as small as required to do the job. Establish a clear sense of the value added by each proposed partner.

For the EIP, nearly all decision-making obviously remains with the development company, with guidance and high level decisions by the investors. For the most part, other partners in the EIP are responsible for delivering resources and their decisions concern specific areas they are supporting. In becoming a partner they will have evaluated the developers qualifications.

Determine the appropriate and feasible timing for creating each partnership. Develop an organizing structure and channels of communication for coordinating the activities of the partnerships. Distinguish between sources of finance and sources of in-kind support.

Corruption-proof public monies by keeping each aspect of the project highly visible. Develop sound fiscal management and reporting procedures in any entities party to the PPP. Make anti-corruption a facet of sustainability. (In Chapter 7, Policy we discuss anti-corruption initiatives in developing countries.)

Though the partnerships themselves take time to develop, they should support streamlining of public financing processes, helping to overcome some of the inertia implicit in bureaucracies. PPPs often become networks of education and influence, with key members able to help break log jams.

Public agencies involved may request some profit sharing or recapture provisions which are contingent on exceeding assumed performance levels (unless the current tax structure already provides for such sharing).

In some countries national agencies make grants, loan guarantees, and other support available only to a public entity which maintains fiduciary responsibility. The funds may then be used by a private business for feasibility studies, program development, capacity development, construction, and other purposes that serve a combined private and community benefit. An alternative pattern may be for the funding to go to an organization, such as a development district, established by a public private partnership.

The developer may find creation of an allied nonprofit organization useful. For instance, Recovery Solutions in Puerto Rico set up Conserva el Encanto as an educational NGO focused on resource recovery and environmental protection. Such an advocacy organization or an action and research foundation could provide a channel for public and civil sector money that can not go to a private business. This, of course, requires full disclosure of the relationship between the NGO and the for-profit firm and careful legal guidance. See discussion of an action foundation below.

5.4 The Community Capital Investment Initiative

Northern California investment sources are creating a model for public-private investment infrastructure that could be adapted for developing countries. The San Francisco Bay Area Alliance for Sustainable Development is creating a Community Capital Investment Initiative (CCII) that aims to integrate investment from public, private, and civil sector sources in supporting “keystone” sustainable community projects. (Eco-industrial parks in Northern California are likely candidates to demonstrate this CCII.) The initiative’s designers recognized that fragmentation of funding often threatens the integrity of projects working to
integrate many elements into a more complex system—like EIP development. This CCII is setting up a financing infrastructure designed to work with such projects in a more holistic way.

“There is a need for an organizational structure that both: (a) brings together the business community leadership to work collectively as joint investors; and (b) provides an interface between the business leadership and other potential partners in the venture. Other potential partners include the community capital infrastructure, community-based organizations and social equity advocates, and government agencies.” (Sustainable Systems 1999) Sustainable Systems. 1999. A White Paper on the Community Capital Investment Initiative. Oakland, CA.

The proposed organizational structure for the CCII includes

- **Private sector:** the Community Capital Investment Council will be a CEO-led incorporated subsidiary of the Bay Area Council which will govern allocation of dedicated investment funds from the private sector.
- **Civil sector:** the Community Capital Investment Network, comprised of the community capital infrastructure organizations and equity champions including foundations, community based organizations, and other groups that can supply capacity development, bridge financing, and other support.
- **Public Sector:** The Government Community Investment Panel, comprised of state and federal agencies which can provide financial and technical assistance to the specific projects.
- Together, the three groups will constitute the Community Capital Investment Roundtable responsible for integrating the financial support of the three sectors.

This organizational structure is an appropriate starting point to ensure both business entrepreneurship and community collaboration.

### 5.5 Partnership Between the Developer and the Tenants

This traditional investment model for industrial parks assumes relatively little community of interest among the companies resident at a site and so provides no incentives or financial structures for their forming the business community characteristic of EIPs. A potential alternative model for financing could provide that cohesive force. A real estate development company would finance the park through a holding company that takes equity stakes in the individual enterprises, which in turn invest in the park.

A successful example of this is the Brazilian petrochemical enterprise, PetroQuisa, formed by the oil company PetroBras when it wanted to generate downstream businesses in the 60s. Ownership of this new entity shared half by PetroBras and half by private investors. Petro Quisa developed the land with a master plan for a petrochemical complex. It built the ethylene cracker to provide feedstocks, the main power station, utilities, and the materials handling infrastructure (docks, pipelines, storage, etc.) The financing for the basic complex (the cracker and infrastructure) established cross ownership between PetroBras, the downstream chemical manufacturers recruited (such as a polyethylene plant), and private investors. PQ took one third ownership of each enterprise, the owner one third, and private investors one third. In turn each plant owner had a proportion share of ownership in the basic complex. As a holding company PQ used its own capital and that of outside investors. The cross ownership created a financial interdependency reflecting the technical and business interdependency of the complex and its chemical plants. (Dehejia 2000)

Perhaps this model could be applied to financing of eco-industrial parks in developing countries for quite a range of industries, not just petrochemical. For instance, the Puerto Rican EIP is anchored by a major, high capital waste-to-energy plant. The business plan calls for cross investment between the development of this central facility and the development of the EIP infrastructure. Other resource recovery companies being recruited to the park will utilize energy, water, and material outputs of the WTE facility and have the opportunity of becoming investors in it and in the property development. By following the holding company
model, the primary development entity would own and manage the anchor facility and the park and invest in the facility of each tenant that comes in. The tenants would benefit from this investment and would share in the ownership of the complex.

5.6 An Investment Fund

Another part of the investment package could be a channel for smaller investors to participate in the EIP development. This could take the form of an investment fund or funds. There could be a fund designed on the model of a real estate investment trust (but with small investors able to qualify) for the property development, an enterprise fund to finance companies located at the EIP or serving its tenants, and a joint fund including both types of investment. The fund(s) might be set up with a focus on sustainable development projects in your country or region, with your project as the first enterprise.

Creation of such funds would enable residents of your community and country, as well as overseas social venture investors to participate in the project. The fund's management would play a role in decision-making, possibly on the project's board, and would serve as the interface between the individual investors and the project's management.

5.7 An Action Foundation

The development company or EIP management could create an action foundation, with funding from the developer, from EIP tenants, and from public sector funders. The core purpose of the foundation would be furthering the self-reliance and sustainability of your local and national environment, economy, and society. It would fund development of policy, programs and projects relating to sustainable development; research on specific technologies in your park’s industrial clusters; and graduate fellowships.

The foundation would also manage projects without a direct economic return, such as ecosystem restoration projects, public education programs, and sustainability research and fellowships. It could negotiate cooperative research agreements with universities in your country and overseas, agencies, and environmental non-governmental organizations.

The foundation would function as a non-profit, acting under the guidance of an independent board of directors. To leverage grants from EIP companies and investors, the foundation would seek external funding from government agencies, foundations, and international sources.

An important facet of the foundation’s mission could be to research and evaluate emerging technologies that would further sustainable development while it supported the tenants at the EIP. It would work through a network of independent technology evaluation resources, not allied with any particular country's exporters.\footnote{Many sources in Asian countries complain that environmental technology companies are often quite aggressive in their marketing and extravagant in their claims. Unfortunately some overseas aid organizations do not provide the independent evaluation required by buyers.}

At the end of this chapter is a master table with the five levels of the project laid out against possible sources of finance or other support. The EIP team can use this to test possible mixes of partners for the different levels of the project and its support institutions. The second table is for the EIP with potential sources of investment laid out against the primary phases of development.
5.8 Positioning Your EIP for Investment

Consider marketing your project to investors by linking it to established development categories rather than emphasizing its eco-industrial aspects. You may describe it as a niche approach to land-use and business clustering, much like high-tech industrial parks. We discuss several themes for EIP recruitment based on this industrial cluster approach in the next chapter. Help investors understand that the EIP niche offers to potential tenants a green public image closely linked to bottom line advantages. You may also present your park as a variation on a familiar recruitment strategy: seeking companies in the supply chain of an anchor tenant.

Emphasize to investors the demonstrated economic and environmental benefits of design strategies like energy efficient facility design or a park water recycling system. Cutting costs for tenants through higher efficiency and shared services will add to the value of the park. Your feasibility study will evaluate a whole system of design options like these and determine how many you can incorporate and still maintain the financial viability of the project. Many of them may add significantly to its competitiveness.

In reviewing the EIP concept with developers and development finance people, we found one potential stumbling block: the strategy of materials, water, and energy exchange among park plants (by-product exchange or BPX). Some people we have interviewed have suggested that a strategy that targets companies that can use each other's by-products could make it difficult to gain investment. They say this method of targeting is too unconventional and could dramatically increase the risk of an empty park. If the exchanges create too much interdependency among the companies, the failure of one or two critical links could damage the performance of the whole network in an EIP. This perception could be an obstacle to recruitment as well as investment.

However, developer John Clark argued strongly that the resource exchange strategy is actually quite conventional.

“To me, the most interesting piece of economics is economic geography. In this field they are looking at the benefits of geographic focus and co-location in places like Silicon Valley, the Route 128 corridor in Boston, Austin and its high tech-industry, or Hollywood and the film industry. These ideas from economic geography are the normative condition in industrial real estate development, not the abnormal. The idea that this strategy sets up a ‘dependency’ is just part of the existing natural order. Companies are inter-dependent by nature.”

Financiers will ask: “Is it really possible to recruit a set of companies within a reasonable time to function in this way? Will too great a dependence on this strategy add an unacceptable level of risk to the project?” The answer has to be, we will test how far we can implement this exchange of resources in the recruitment process and not push it to the point where it blocks attracting quality tenants. It may add to the marketing appeal of the park. It may be neutral. If it becomes a liability we will not pursue it. Fortunately the BPX strategy is one that can play out on a regional basis, if it does not fit with your eco-park recruitment strategy. See Chapter 12.

5.9 Reducing the Risks

Investors in real estate tend to be risk averse so it is important to reduce their exposure to risk through the structuring of the total investment package. We have emphasized that an eco-park is a public/private partnership. This collaboration is itself, a means of reducing the risk of investment. Each side can work for trade-offs that assure the public benefits of an EIP are earned by compensating private sector players who risk their capital. This idea is a foundation to the often-used strategies we describe in this section for

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2 Project interview with John Clark, April 27, 1995. Mr. Clark is currently developing 1700 acres near Fredericksburg, Virginia as a mixed use residential, commercial, farming, and light industry community. It will include ca 200 acres for industrial parks.
reducing the risk of industrial real estate investments. Drawing upon these wherever possible will indicate to investors that you are effectively safeguarding their investment in your EIP. They include:

*Investment of public land:* As a public investment in the project, this puts value on the table that reduces the risk of equity or debt capital invested in the project. The land provides collateral to secure later rounds of investments for feasibility and engineering studies, recruitment, site-preparation, and development of infrastructure.

*Municipal bond financing:* Low-interest, tax-free bonds can create a block of debt financing that makes it easier for lenders or equity investors to take a position in the development. An EIP’s combination of economic and environmental benefits to the whole community makes it a good candidate for municipal bonds.

*Commitment by an anchor tenant:* A contract with a major corporation (with AAA credit rating) demonstrates that your innovative concept has market appeal. The anchor’s manufacturing processes will also suggest other companies to target as suppliers and customers for its energy and material by-products. This will make the resource exchange aspect of EIPs more concrete to investors.

*Commitments by utilities:* In addition to possible investment of land, companies may contribute planning time, demand-side management programs, and discounts to recruited companies. (Some utilities also make grants to support economic development planning.) Investors see such in-kind investment as an indication that projects have strong community support.

*Partial site development:* You may do a master plan for a larger parcel of land and in the first phase develop an EIP on one parcel. The rest may be developed as a conventional industrial park or housing, or held in reserve.

*Reducing risk of new ventures as tenants:* Institutional investors (pension funds and insurance companies) prefer investing in parks with established and proven companies (AAA ratings). If seeking capital from these sources, you may have to limit the number of new local ventures in your park or create an adjoining incubator park as a separately financed property.

*Support to startup companies:* New companies may be important to your development plan. You can enhance their odds for success by including in your plan a business incubator, a strong entrepreneurs’ coaching network, and training from local educational institutions.

*A liability-free site:* Investors and lenders are very suspicious of any site where they might incur liabilities for environmental contamination. (This can include remediated sites that might later prove to be still polluted.) On the other hand, reuse of industrial land is environmentally preferable to opening virgin land. Developers can back up application of high quality remediation technology by negotiating with regulatory agencies for clearance of past liabilities.

### 5.10 Funding Dedicated to Sustainable Development

Some aspects of eco-industrial park development qualify for investments, loans, grants, and in-kind contributions that are available to address issues of sustainable development. The sources include:

- Development Bank programs like World Bank’s Global Environmental Fund;
- International aid programs of European, US, and Japanese governments;
- Re-insurance companies like Gerling Re Swiss Re.
- Pension funds concerned with a healthful environment for their beneficiaries;
- Social investment funds operating internationally;
- International foundations like Ford and MacArthur.
Funders are beginning to accept responsibility for the environmental and social costs of many of their earlier development projects. At the same time increasing awareness of the complex environmental crisis is causing them to create new financing instruments. We provide an extensive list of investment programs for greenhouse gas emission reductions, cleaner production, biodiversity, and environmental infrastructure. EIP developers may be able to fund aspects of their project through sources like this.

To take one major instance, investment funds and programs to credit reductions of greenhouse gas emissions are now emerging. The Kyoto Treaty on Climate Change established mechanisms for firms with excess greenhouse gas emissions to purchase emissions credits or finance emission reduction projects elsewhere. A large beneficiary of these programs will be firms or organizations achieving reductions in GHGs in developing countries. There are three Kyoto mechanisms. International Emission Trading (IET) enables companies with excess GHG emissions to meet part of its commitment to reduce emissions by buying credits from another firm or organization that has reduced emissions to below target levels. Joint Implementation (JI) and the Clean Development Mechanism (CDM) enable firms to offset their GHG emissions by investing in projects to cut emissions elsewhere and receive credits for those reductions.

Many companies such as British Petroleum are seizing the initiative while controversy on the details of ratifying the Kyoto Treaty continues. Their strategy is to act early to help create the structures through which industry will reduce emissions. At the end of Chapter 3 we summarize a strategy through which an EIP could make a significant contribution to such reductions, thus gaining valuable investments or credits. While most EIPs may be able to benefit from this strategy, its greatest return would be for parks with a renewable energy or resource recovery cluster.

Individual countries are also creating investment initiatives for alternative energy and other environmental industries. For instance, Thailand has a national Energy Conservation and Renewable Energy Programme that is a possible model for a domestic investment fund that other developing countries could follow. This program makes direct investments in many industries to encourage conservation and implementation of renewable energy programs. A report on this is available in a larger UN document on financing for energy efficiency at http://www.unescap.org/enrd/energy/finance/index.html

5.11 References
In writing this chapter I have been assisted by a number of colleagues expert in real estate finance. I am deeply indebted to Dr. Thomas Black, real estate economist and former research director for Urban Land Institute, Dan Sloan, attorney with McGuire Woods, who has structured financing for EIPs and New Urbanist communities; Mark Smith, real estate finance expert with Pario Research, who has also worked with EIP and New Urbanist projects, and Pat Mahony, CEO of Recovery Solutions, a developer of EIPs.


The Kyoto Protocol and Beyond: Potential Implications for the Insurance Industry. this is a report from the UNEP initiative with the insurance industry. It includes a major section on possible insurance products and services the industry could provide to support reduction of greenhouse gas emissions. http://www.unep.ch/eteu/insura/KYOTO-HPT-FINAL1.html

Kozlowski, David, 2000. Can Green be Gold? Proponents say green buildings are worth more than conventional ones. Now there are signs that the market is starting to agree. Building Operating Management Nov 2000  http://www.facilitiesnet.com/fn/bom This article describes the income-capitalization method of evaluating buildings.


5.12 Resources for Financing

We list a number of the major sources of information on environmental and sustainable development funding. However, your development team can ask the appropriate national agencies or ministries to help you identify the sources that will be most cost-efficient to pursue. There are many layers of bureaucracy wrapped around many of these sources. In some cases requests for assistance must come from a government, not the private sector. The major exception will be the trading of emissions credits.

Overview

Indigo Development, RPP International will include updates to this list of resources at www.indigodev.com/financingSD.html

International Institute for Sustainable Development. UN Bodies, The Banks, and Overseas Development Assistance Agencies http://iisd1.iisd.ca/ic/sb/direct/sdun.htm


The Global Environment Facility provides financing for actions reducing or mitigating greenhouse gas and ozone depleting emissions, preserving biodiversity, and preserving the health of international waters. GEF grants cover the difference or “increment” between a less costly, more polluting option and a costlier, more environmentally friendly option. GEF project ideas may be proposed directly to UNDP, UNEP, or the World Bank. www.gefweb.org

Alternative Energy


Solar Century is creating a Global Community Trust to support installation of solar technology in developing countries. http://www.solarcentury.co.uk/


The World Bank has a number of web sites relating to climate and energy issues:


Prototype Carbon Fund: [www.prototypecarbonfund.org/](http://www.prototypecarbonfund.org/)

**Climate Change and Green House Gas Reductions**

The United Nations Framework Convention on Climate Change for basic documents and overview of joint implementation, emissions trading, and other instruments. [http://www.unep.ch/iucc.html](http://www.unep.ch/iucc.html)

Joint Implementation On-Line (http://www.ji.org/) Joint Implementation Online contains information on a wide range of possible arrangements between interests in two or more countries, leading to the implementation of cooperative development projects that seek to reduce or sequester greenhouse gas emissions. Joint Implementation On-Line includes information on the International Climate Change Project Fund (ICCPF). Site is sponsored by United States Energy Association (USEA) and United States Agency for International Development (USAID) and managed by International Utility Efficiency Partnerships, Inc. [http://www.ji.org/](http://www.ji.org/)


The Netherlands Pilot Phase Programme on Activities Implemented Jointly [http://www.ji.org/wn/nether.htm](http://www.ji.org/wn/nether.htm)


**Emissions Trading**

The UNEP GHG Indicator: Guidelines for Calculating Greenhouse Gas Emissions for Businesses. The guidelines provide a methodology whereby information fuel and energy use readily obtainable by companies is converted and aggregated to compute GHG emissions. Provides a set of worksheets with clear instructions. The tool is applicable at all levels of a company regardless of size or location, and can also be used by governments, NGOs, and other entities. (Source GreenBiz.com) GHG Indicator [http://www.unep.ch/etu/flu/insura/CO2-Main-Page.htm](http://www.unep.ch/etu/flu/insura/CO2-Main-Page.htm)

Carbonmarket.com is a weekly carbon trading newsletter subscription service that provides up-to-date information on progress in the development of carbon emission trading systems to fight climate change, including initiatives taken by both governments and corporations. [http://www.carbonmarket.com/FAQs.html](http://www.carbonmarket.com/FAQs.html)

Prebon Environmental Consulting Services (PECS) provides advisory services to companies and institutions dealing with the financing mechanisms related to greenhouse gas emissions. It offers risk management products and project development and claims expertise in the energy sector, energy markets, capital markets and environmental policy. [http://www.prebon.com/pecs.html](http://www.prebon.com/pecs.html)

*Note: a growing number of consulting companies will offer services such as the one just cited. Evaluate contractors in this area carefully.*

**Cleaner Production**

Financing Cleaner Production Programs: an extensive page of links [http://www.cleanerproduction.com/finance.htm](http://www.cleanerproduction.com/finance.htm)

Biodiversity

Financing biodiversity conservation, Innovative funding mechanisms at World Resources Institute web:
http://www.wri.org/wri/biodiv/cwb-viii.html

Foundations

The Foundation Center http://www.fdncenter.org/index.html Includes a grantmaker directory, with foundations, corporate foundations, and public grantmakers.
http://fdncenter.org/funders/grantmaker/index.html
This site also has links to corporate foundation sites
http://fdncenter.org/funders/grantmaker/qws_corp/corp.html


The Energy Foundation focuses its grant making on energy efficiency, renewable energy, and climate change issues. The general web site is www.ef.org and its China Sustainable Energy Program is at:
http://www.efchina.org/ch/aboutus/index.cfm

The Ford Foundation has offices in Beijing, New Delhi, Jakarta, Manila, and Hanoi with many programs for energy, environment, and economic development. http://www.fordfound.org/

Rockefeller Brothers Fund Sustainable Resoure Use Program fund programs in East Asia.
http://www.rbf.org/sustainprog.html

The Shell Foundation makes sustainable energy and other social investments worldwide. Its Sustainable Energy Programme will support projects that either encourage environmentally cleaner energy use or help tackle poverty by providing sustainable energy to poorer communities in developing countries.
www.shellfoundation.org

The MacArthur Foundation Program on Global Security and Sustainability is at http://www.macfdn.org

Socially Responsible Investment (SRI)

The field of socially responsible investment is starting to create international funds and venture development funds. We include general resources for researching this field as it develops. Investors in your country may have already started creating similar funds.


Green Money Journal is comprehensive source on socially responsible investment
http://www.greenmoney.comGlobal/
It has a Global Socially Responsible Investment special issue
http://www.greenmoney.com/gmj/fall00/newartic.htm

Information on Environmental and Energy Venture Funds can also be found through these SRI sites. There are many specializing in renewable energy such as:

RAM Capital Management recently announced the creation of an investment vehicle designed to assist companies involved in hydrogen energy technology and the emerging fuel cell infrastructure. The fuel cell venture capital fund will offer a complete package of financial, sales and marketing solutions to the rapidly emerging fuel cell technology sector. http://www.FuelCellVentureCapitalGroup.com

Gaia Kapital (A solar venture fund established by Gerling Global Reinsurance http://www.gerling.com/ggpe/)
### Table to identify possible partners for each level of the project

*For each level, score the possible partners for strategic & financial importance 1 low-5 high*

<table>
<thead>
<tr>
<th>Partner</th>
<th>EIP pre-development</th>
<th>EIP development</th>
<th>Support institutions</th>
<th>Community initiatives</th>
<th>Links to national sustainability</th>
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Civil sector institutions may be recipients of grants for environmental, social, or economic projects associated with the EIP. They may also make in-kind contributions to such projects because of the shared benefits, assuming financial contributions from the development company or tenants.
## Financing Options for the EIP

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<tr>
<th>Source</th>
<th>Pre-feasibility studies</th>
<th>Feasibility analysis</th>
<th>Land acquisition</th>
<th>Land development</th>
<th>Construction</th>
<th>Management &amp; recruitment</th>
<th>Permanent financing</th>
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<td>Detailed architecture &amp; engineering studies, cost estimates, pro formas</td>
<td>Evaluate alternatives for financial and ownership structures</td>
<td>Site cleanup, infrastructure for roads, water, waste water, power, steam, flood proofing</td>
<td>A commons building, speculative buildings, tenant construction, and park offices.</td>
<td>Traditional soft costs are in the development pro formas. Unique EIP benefits may be shared.</td>
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6 The Emerging Sustainable Economy and EIP Recruitment

6.1 Introduction

Developing a competitive eco-industrial estate or park requires awareness of fundamental trends in the global economy as well as within one's national and local economy. An EIP must attract and retain profitable tenants serving both emerging and established market sectors at these different economic levels. Eco-industrial parks themselves are one example of the sort of real estate development indicated by this emerging economy.

There are many signs that the global economy in its present form is unsustainable. Recent decades have demonstrated increasingly unequal sharing of wealth and income between and within both developed and developing countries. If income gaps continue to increase, who will be the customers in an increasingly productive industrial system? Climate change, local air pollution, loss of biodiversity and ecosystems, degradation of farm land, and massive depletion and waste of natural resources are some of the environmental signs of the system's failure to respect the natural constraints upon human activity.

In addition, major challenges to the present practices of the global economy are coming from within its establishment as well as from the streets. The World Bank has been host to two of the most notable economists of sustainable development: Herman Daly and Amartya Sen, the 1998 Nobel economist. Both Daly and Sen offer powerful arguments for development as a means, not as an end in itself that takes precedence over environmental and human values. The activists who protested the World Trade Organization in Seattle and the World Bank in Washington are continuing to organize resistance to the negative aspects of globalization. They are themselves empowered by the World Wide Web, which provides both them and the corporations with global channels of communication. At the same time, some advanced corporate leaders are charting their companies path into the sustainable economy.

Sir Robert Browne, CEO of British Petroleum/Amoco, Ray Anderson, Chairman of Interface, and Gordon Forward, CEO of Chaparral Steel, are three pioneering corporate leaders redefining the way corporations operate in the global economy and biosphere.

- Brown was the first oil and petrochemical executive to accept the likelihood that greenhouse gas emissions are contributing to climate change and that his company must act to limit these releases. He is investing over a billion dollars in developing the world's largest solar manufacturing capability.
- Anderson has led the creation of a company-wide sustainable development initiative that seeks to improve his company's social, economic, and environmental performance. Interface has created one of the most comprehensive and far-reaching agendas for corporate sustainability.
- Forward has created an eco-industrial park around his recycled steel mini-mill in Texas and has championed more efficient resource use throughout North America.

None of these three have abandoned their commitment to financial success but instead see their initiatives as sources of sustained competitiveness, which also protect environmental and human values. Companies like BP, Interface, and Chaparral Steel are models for the corporate transition to a sustainable economy and we believe this transition is beginning to accelerate.

While BP and Interface are multinationals, Chaparral is a mid-size corporation. The emerging sustainable economy offers many opportunities for start up ventures and expansion of small to medium enterprises. When a venture is in a hot area, such as hydrogen fuel cell technology, it may suddenly find its has support from major players. Ballard Power in British Columbia, Canada is in a joint venture with Daimler-Benz-Chrysler for commercialization of its fuel cell transportation innovations. Metals recycling companies have been targets of mergers and acquisitions across the US.
There is growing evidence that the variety of niches in a sustainable economy deserve attention from industrial park developers in Asia's developing countries. This is particularly important given the over-capacity in production facilities for many sectors of the electronics and telecommunications economy. While computer and electronics companies will continue to seek plant locations, it is now time for industrial parks to diversify their recruitment targeting.

One of the particular strengths of the sustainable economy will be an increasing emphasis on production for local as well as export markets. Later in this chapter we discuss EIPs focused on renewable energy, resource recovery, and support industries for sustainable agriculture. Such developments need not be dependent upon winning the difficult competition with other sites for a limited number of multinational candidates. Their recruitment focus can be local companies and entrepreneurial startups, supported by business incubators and public sector support.

6.1.1 Key Trends

We can describe the major trends in this transition toward a sustainable economy in terms of four potential business strategies: 1) Increasing efficiency and use of renewable energy and material resources; 2) Designing of communities and the built environment using ecologically-aware methods; 3) Sustaining and renewing natural systems; and 4) Redesigning of public and private sector organizations. An overarching goal will be the redefinition of development in terms of quality rather than quantity of life and, as Nobel economist Amartya Sen proposes, realizing the concept of “development as freedom.” (Sen 1999, Hawken, Lovens, & Lovens 1999, Lowe 2000)

1) Increasing efficiency and use of renewable resource flows, reducing pollution
   - Highly efficient use and reuse of all material, water, and energy resources;
   - Generation of energy and materials from renewable sources;
   - Replacement of non-renewable and toxic materials by biomaterials and benign manufactured substances (green chemistry).

2) Ecologically-aware design, planning, and development of the built environment
   - Renewing obsolescent infrastructure, industrial stock, and residential stock through reclamation or redevelopment rather than new construction;
   - Designing and building new communities, buildings, infrastructure, and industrial areas with minimal environmental burden and with attention to their ecological settings;
   - Developing integrated transportation systems that move people and goods efficiently while sharply reducing the environmental impacts of this sector.

3) Sustaining natural systems and the ecological niche for humans
   - Renewal and restoration of natural systems as the foundation for biodiversity;
   - Growing of food and materials through ecologically-based, sustainable farming practices;
   - Continued development of traditional biotechnology while placing strong precautionary limits on the testing of new genetically engineered organisms for farming;
   - Preserving human health through an ecological and systems approach.
4) Re-design of private and public sector organizations

- Changing corporate organizational systems to align operations with environmental constraints and sustainable development;
- Shifting business missions from selling obsolete products to delivering durable products and services to end-users;
- Shifting government policy, R & D, and regulation to support these corporate changes;
- Ending the many forms of corruption that undercut the sustainability of developed and developing economies alike;
- Applying information and telecommunications technologies to the challenges of sustainability.

A redefinition of development will underlie these inter-related changes, one phrased in terms of quality of life and richness of individual, family, and community experience. This redefinition will require institutional change to insure equitable sharing of the benefits of technical innovation and to avoid the environmental costs of poverty. Advanced companies around the world are starting to understand their role in increasing quality of life as the foundation for their future viability.

We believe that understanding the emerging sustainable economy will be strategically important to the developers of eco-industrial parks in Asia. This awareness will give development companies a context for creating long-term marketing strategies and for designing the eco-parks themselves. The “theme parks” we describe below detail some of the clusters of businesses that will constitute new recruitment opportunities for your developments. In the resources section for this chapter you will find books and web sites to give you more information.

**HP Global Partnership Program**

Hewlett-Packard’s E-Inclusion initiative seeks to help close the “digital divide” by bringing computer and telecommunications technologies to the underprivileged populations of developing countries. “This is fundamentally a business initiative, not a philanthropic venture, but it's also a chance to make a social contribution,” said Lyle Hurst, director of world E-Inclusion at HP. “This is not about exporting Western values or culture in a neocolonial sort of way,” he said. “We have as much to learn from these new markets as we have to offer.”

In its first year the E-Inclusion program seeks to establish partnerships that will sell, lease or donate $1 billion worth of products and services from HP and associated companies. The goal is to bring “measurable social and economic benefits” to 1,000 villages around the world. E-Inclusion programs will have to preserve or enhance the environment, Hurst said, warning that “economic growth could do more harm than good if it exacerbates environmental degradation.” (Norr 2000)
Themes for EIP recruitment

Developers of conventional industrial parks often set recruitment strategies focused on clusters of companies that benefit from co-location. High tech and biotech companies are the obvious examples, where proximity enables the service and product supply chain to function more efficiently. The emerging sustainable economy suggests a number of similar clusters formed around major environmental and energy industries. The possibilities include:

- Agro-Eco-Industrial Parks
- Resource Recovery Parks
- Renewable Energy EIPs
- EIPs anchored by a power plant
- Green Petrochemical Parks

With these clusters inter-company flows of both ideas and by-products add to the usual business advantages of co-location.

Developers are planning eco-parks formed around each of these themes. The proposed Resource Recovery Park at Arecibo, Puerto Rico illustrates how several recruitment themes may support each other in both business and environmental terms. In this project, three clusters have potentially high synergy: resource recovery, generation of renewable energy, and support to sustainable agriculture. In fact, some tenants may serve all three functions, as with a company generating renewable energy and compost from farm by-products. So developers should recognize the possible benefits of setting several complementary themes for EIP recruitment.
6.2 Agro-Eco-Industrial Parks

The agro-eco-industrial park or estate is strategically very important to sustainable development. Conventional agribusiness depends upon unsustainable, polluting, and costly petrochemical inputs and is destructive of soil and water resources. Its industrialized nature and emphasis upon export crops undermines rural communities and their livelihood from indigenous crops. Conventional agriculture violates all principles of sustainable development.

Farmers in many Asian countries, including Japan, Thailand, China, India, and the Philippines have been developing sustainable agricultural practices appropriate to their regions, often with the support of organizations such as the International Institute for Rural Reconstruction (near Manila) and the Food and Fertilizer Technology Center (Taipei). Often the “innovations” of sustainable farming simply entail the relearning of traditional practices. A recent large scale field test in China demonstrated that increasing the diversity of rice strains almost doubled productivity compared with growing only one strain as a monocrop. The diversely planted fields also showed little crop destruction from fungal diseases and chemical inputs (Youyong Zhu et al. 2000).

Government policy in Thailand is aimed at regaining, through sustainable agriculture practices, the productivity lost through exhaustion of soil by industrialized farming on former forest land (Buch-Hansen 2000; Setboonsarng and Gilman 1999). On the demand side, the market for organically produced grains, fruit, and vegetables is growing rapidly in Europe, the US, and Japan and beginning to open in some developing countries (Kortbech-Olesen 2000). In the US, organic produce sells at premium prices, and many leading supermarkets now feature organic foods. There is growing evidence of a trend toward sustainable agriculture, driven by the need to conserve soil, water, and energy in food production and by consumer demand for a healthful, non-polluted food supply.

The transition to sustainable farming requires the support of a unique cluster of companies that developers of agro-eco-parks can target for recruitment. We will build the model for this theme EIP and outline the likely tenants from proposals for agro-industrial parks in the Philippines, Thailand, Puerto Rico, and the US.

6.2.1 The Generic Model

Developing an agro-EIP begins by using the basic strategies of eco-industrial parks regarding site selection and development, building standards, infrastructure, and management. The opportunity for profitable by-product flows between tenants is particularly high with the biomass, energy, and water intensive companies in food processing. The recruitment for an agro-park focuses on the cluster of companies that support sustainable farming, helping farmers and agribusiness realize several basic objectives:

- Preserve and restore traditional farming practices that are ecologically sound.
- Support the transition from petrochemical-based industrialized farming to an ecologically-based model.
- Preserve and restore rural lands and water systems, avoiding further degradation.
- Preserve and renew the economies and societies of rural communities.

Achieving these objectives of sustainable agriculture calls for a very different support system than the present agribusiness suppliers of petrochemically-derived fertilizers and pesticides, heavy farm equipment, and international commodity marketing. This support system includes several basic types of firms and agencies which may be recruited as tenants of an agro-eco-industrial estate: Suppliers of equipment, energy, materials, and services to farmers;

- Suppliers of equipment, energy, materials and services;
- Food processing and distribution firms;
Firms utilizing by-products from any part of the system.
- Intensive food production located in or near an agro-estate, particularly as greenhouses and aquaculture ponds.

We will describe some of the specific recruitment targets in each of these categories.

6.2.2 Suppliers of equipment, energy, materials, and services

Field equipment for sustainable farming is generally lighter weight, more energy efficient, and often seeks to optimize the continued use of human labor. In arid and semi-arid regions water conserving irrigation technologies are especially important, such as drip systems and soil monitoring systems. Equipment for monitoring of nutrients as well as moisture in soil enables farmers to apply various organic fertilizers and water in an efficient manner. The equipment needs of small-scale farmers may be defined primarily as devices of appropriate technology, relatively simple tools to support productive farming.

Energy needs in food processing are intensive, so an agro-park will seek ways to use co-generation energy and renewable sources. Location near a conventional power plant could yield steam and hot water for heating and cooling processes. A potential provider of renewable energy is a firm utilizing biomass by-products of farming and food production. It might operate as a distributed energy firm generating electricity and fertilizer from animal manure (with anaerobic digestors and generators it owns located on farms and dairies). An alternative would be an ethanol fermentation plant using crop and food wastes or specific bioenergy crops such as cassava as input. Fuel cell technology is evolving rapidly and methane from biomass processing could be a good source of hydrogen.

Suppliers of integrated pest management (IPM) services and products are critical to reducing the toxic outputs of farming and maintaining high productivity. These companies provide training, consulting, and beneficial predator insects and other organisms that serve as the natural enemies of common pests, without themselves becoming pests. IPM strategies need to be carefully tailored to local climates and ecosystems.

Consulting and training firms and agricultural extension agencies play an especially important role in helping farmers to learn or relearn ecologically-sound farming practices. This is especially true for employees of industrialized farms and for small to mid-scale farmers who have become dependent upon petrochemical fertilizers and pesticides. An agro-park would include office and classroom space for programs which could be funded by processing and distribution firms, agricultural agencies, and development aid grants.

6.2.3 Food processing and distribution firms

A marketing co-op, direct marketing, or distribution center for fruits and vegetables emphasizing delivery of organic produce to market is an essential tenant of an agro-park. The co-op and direct marketing approaches increase farm revenues, as community supported agriculture (CSA) has demonstrated in Japan, Europe, and the US. (See sidebar on Full Belly Farm.) There are relatively few organic tropical fruits in the US market and the US, Europe, and Japan all show growing demand for all forms of organic produce.

Food processing EIP tenants fall into three major categories: fruit and vegetable; dairy; and meat, fish, and poultry. A Yale University industrial ecology study for the Arecibo, Puerto Rico EIP details the processes involved, emphasizing the potential by-product usage.

“The processing of vegetables has two major components. The first is the fresh pack segment, during which produce is sorted, trimmed, washed, graded, and packed. The second processing segment involves peeling, stemming, pitting, trimming, chopping, and blanching. Depending on how the produce is to be preserved, this step may also include dehydration, brining, freezing, or cooking.
Community Supported Agriculture in Japan and the US

**Full Belly Farm**

Four partners operate an organic farm in Copay Valley, northwest of Sacramento, California. Soil fertility is maintained through cover crops, composting and pasturing of farm animals. The farm hires 15-20 full-time farm workers and 5 apprentices year round. Full Belly supplies a wide variety of fruit, herbs, flowers, vegetables and animal products to 600 families each week (through drop-sites in urban neighborhoods) as well as to three farmers markets and a half-way house for low-income women with cancer. At the height of a season, costs for the organic produce can rival the cost of conventionally produced items.

The environmental benefits from Full Belly Farm’s mode of operation include reduction of demand on non-renewable petrochemical resources; elimination of pollution from chemical pesticides and herbicides; recycling of nearly all farm “wastes”; preservation of biodiversity in farm plants and animals, regeneration and preservation of soil; preservation of wildlife habitats through hedgerows and native plantings; and enhanced healthfulness of diet for consumers.

Fully Belly offers many social and economic benefits for the local and regional community. Its style of farming and marketing strengthens the connections between food, land and people. It provides higher productivity and steady employment to a much larger group of employees than industrialized farming on a similar acreage would offer.

Organic farmers in many states are working in the model of Community Supported Agriculture Full Belly reflects, demonstrating the business and ecological value of organic farming. (Full Belly Farm 1996-98)

**The Tekei System**

The Japanese organic movements have a consumer support and agriculture system, called the Tekei system: They have producer groups in villages and consumer groups in the cities. The producer groups regularly pack up what they produce, and this is collected by the consumer groups. This is an organised, long-term relationship. There is a very good understanding between the two [groups]: if the producers have produced cucumber in excess they inform the consumers to consume more of that kind and they also invite the consumers to come and visit their farms and work with them during their times of vacation. This is a beautiful innovation of the whole marketing structure. So Asian people are going to take this as the model for the future, for domestic marketing structures (DeSilva 1999)

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Fruit follows a similar path to the marketplace, with a few additional steps, like pitting and slicing. Fruit is most commonly preserved by canning, freezing, or fermenting. Most of these steps require water to help transport the produce and wash the equipment. Due to its heavy load of organic material, fruit processing results in a liquid waste with about ten times the BOD (biological oxygen demand) of domestic sewage as well as elevated TSS (total suspended solids). Other significant residues of fruit and vegetable processing are the solids consisting of peels, pits, cores, and trimmings. These easily biodegradable organic materials are frequently used as animal feeds. They could also be digested anaerobically, fermented for ethanol production, or composted.

“Dairy processing involves the pasteurization and homogenization of milk, and production of other products like butter, ice cream, and cheese. Wastewater from this type of processing carries large amounts of lactose, proteins, and fat. This means elevated BOD and also fats, oil, and grease. This content causes problems for conventional wastewater treatment systems that don’t deal well with oily wastes. Here again anaerobic digestion would provide the best option for breaking down
these more complex organic materials.

“Finally, the meat, fish, and poultry processing industry slaughters and processes into a variety of products. The first steps of slaughtering, segregating the carcass portions, and packing the meat are shared for both fresh and prepared meat products. However, canned cooked products, dried products, luncheon meats, hot dogs, bacons, stews, and other ready-to-eat meat products require additional processing steps. Most solid residues are recovered by the industry. Meat scraps, blood, feathers, and bone are transformed into animal and pet foods. Wastewater requires extensive treatment to reduce its organic loads). Anerobic digestion or ethanol fermentation are two alternative means to reclaim value from many meat and poultry by-products.

“In general the processors add substantial value to food products. A close relationship with this industry would be beneficial to both the food processors and the farms in the EIP’s region. The farms could provide the processors with a steady supply of organically grown and raised fruits, vegetables, and livestock, while the processors could provide the farms with animal feeds and organic fertilizer or compost, rather than disposing of this material as process wastes.” (Abuyuan et al 1999)

The Puerto Rican project as well as a proposed agro-EIP in the Philippines emphasize the value to food processors of using by-product steam and hot water from other EIP tenants and in turn having their material and water by-products used by other processors or farms (Meganomics 2000). State-of-the-art facility design is important to avoid one historic by-product of animal and fish processing – the smell which makes such plants undesirable neighbors to communities.

6.2.4 Firms utilize by-products from any part of the system.

We have indicated the major opportunities for recruitment for this category in our discussion of food processors – energy generators, manufacturers using biomass by-products, animal feed processors, greenhouses and aquaculture ponds, and composting yards.

Renewable energy generation companies, using the farm and food processing by-products mentioned above, are important possible tenants in an agro-EIP. They include ethanol fermentation plants and systems for anerobic digestion of farm and food processing by-products, which could use distributed systems as well as a site at the park. Both businesses make important contributions to closed-loop production and cost reductions for other tenants.

The Yale report for the Puerto Rican EIP (Abuyuan et al. 1999) summarizes possible ethanol feedstocks: “Recent technological developments have enabled the production of ethanol from much cheaper sources, called ‘lignocellulosic biomass.’ This refers to the leafy or woody portions of a plant that are inedible for humans. Such breakthroughs have vastly expanded the range of suitable feedstocks for ethanol production and reduced production costs (Shleser 1994). Today, ethanol can be generated from grass crops such as napier grass, switchgrass, and sugarcane, tree crops including leucaena and eucalyptus, sweet sorghum, crop residues like corn stover, bagasse, potato waste, and citrus waste, and intriguing new sources like municipal solid waste, newspaper, yard and wood waste, and cellulosic fiber fines from recycled paper mills (Jeffries 1995).” One such technology has even produced ethanol successfully from junk mail discarded by the US Postal Service. In Brazil ethanol is a significant fuel for vehicles and in some US states it is the preferred fuel additive.
A US company, Parallel Products, has the motto: “In the past we harvested resources and managed wastes. Now, and in the future, we must manage resources and harvest wastes.” This firm installs an on-site system for the isolation, collection, and concentration of high strength waste directly from food processing operations. Concentrates are then used for the production of ethanol at one of Parallel's regional processing plants. Its customers include breweries, wineries, distilleries, soft drink and juice companies, candy, pharmaceutical, and cosmetics plants. The products created include fuel and industrial grade ethyl alcohol, food flavor enhancers, and liquid protein animal feed concentrates. (Source  http://www.parallelproducts.com/ August 2000.)

Arkenol markets a competing technology; “Building a chemical company that is looking to the sugar barrel instead of the oil barrel for our feedstocks.” www.arkenol.com.

Firms utilizing anaerobic digestion to reclaim organic by-products are another major renewable energy recruitment target. These include manufacturers and suppliers of digestor and generator systems, and firms using food, farm, and residential/commercial organic discards to produce methane, electric power, and benign liquid and solid fertilizer. Anaerobic digestors utilize bacteria specific to the input mix for the conversion of organic material into methane and nutrients. (For some feedstocks aerobic digestion may be superior.) The system is completed by gen sets with energy efficiency improvement systems enabling recovery of heat usually wasted.

Dairy, poultry, pork, and fish farming, cattle feedlots, and processing plants generate high levels of wastes, which are economically and environmentally costly. Since this technology can be efficiently operated at a small to medium scale, a business could operate a network of distributed systems installed at the site of production of farm or landfill organic wastes as well as a central facility in an appropriate location. Such a company would offer efficient discard management solutions to the food producers and processors along with a renewable source of energy. (Based on US EPA AgStar program material. www.epa.gov…)

Other organic by-product processors include: a composting yard which would directly process farm and food processing discards as well as the solid by-products of energy plants; a specialty paper mini-mill using rice straw and other farm fiber by-products; a bioplastics or other biomaterials plant using some components of the by-product stream as well as crops grown for this purpose such as bamboo, kenaf, or industrial hemp.

Living Machines is an ecological water treatment system that complements the functions of the technologies just described. It has been used in major food industry applications in the US and Brazil. See Chapter 8, water infrastructure, for details.

6.2.5 Intensive food production locates in or near an agro-estate.

Greenhouses and aquaculture ponds are another way to utilize by-product water, energy, and biomass from other tenants of an agro-park. These operations could be tenants on the site or in neighboring agricultural land. When operated within agro-ecological guidelines they offer high productivity, high value products, and low environmental impact. The brewery case study in the case profile appendix indicates a few of the potential linkages. The Integrated Bio-systems Network web site provides many field reports on similar projects in developing countries. http://www.ias.unu.edu/proceedings/icibs/lbs/lbsnet/

Other potential recruitment targets

The agro-EIP’s close linkage to farming suggests other tenants that are particularly suitable for this type of development. Manufacturers using primary biomaterials such as kenaf, hemp, or bamboo could find
business synergies with other manufacturing tenants as well as their nearby suppliers. Resource recovery tenants serving the broader community could collaborate with those only functioning within the site.

6.2.7 Cases

6.2.7.1 BUHAI Agro-Industrial Estate Project, Philippines

Meganomics, a Manila-based planning and consulting firm, has proposed a master plan for development of eco-agri-industrial parks as a livelihood base for families dislocated by rail construction in Luzon and Batangas. The facilities for the estate would include:

- Cattle fattening and possible grow-out or feed contract growing operations
- Free-range chicken raising
- A feed mill facility
- Abattoir and slaughterhouses
- Ice plant and cold storage facilities
- Technology development, learning and transfer centers and facilities
- Agri-tourism, techno-tourism and eco-tourism facilities
- Integrated resource recovery systems (for the agri-business sub-projects)
- Waste water treatment facility
- Water impounding, irrigation and aquaculture

An Integrated Agri-Aqua™ Support Project would connect water impounding, irrigation, agricultural and aquaculture projects into a system for site-wide water management. This will help recycle supplies to meet the complex’s large water requirements, preserve and maintain the site’s ecological balance, add sources of livelihood, and serve as training venue and continuing education center for the relocated households. The project site could also become a techno-tourism and agro-technology center.

Meganomics also proposes an Integrated Resource Recovery System (IRRS) for the estate, to achieve closed-loop production linkages among the facilities to be located within the estate. By converting the wastes of one facility into the feedstock of others, estate tenants can gain higher productivity and income through optimum resource utilization and lower pollution levels.

If approved by the Department of Environment and Natural Resources, a programmatic environmental impact assessment would enable the developer to permit the estate and its tenants as a whole. This PEIA would assess the total reduction of environmental burdens in the development through utilization of by-product materials and water. See our EIP controls, policy and regulations, for detail on this regulatory innovation. (Meganomics 2000)

6.2.7.2 An agro industrial estate in Thailand

The Industrial Estate Authority of Thailand is seeking investors in agro-industrial estates, though as of Fall 2000 the proposals do not include the sort of by-product utilization and other environmental strategies projected in the Philippine Buhay project. The Authority’s web site carries information on this project as it evolves: www.ieat.go.th or contact Tel. 253-0561 ext. 3343, 3306; or 253-2874 Fax. 253-2874.

See also the information on the sustainable agriculture cluster proposed in the Integrated Resource Recovery Park at Arecibo, Puerto Rico.
6.3 Integrated Resource Recovery Parks

Recruiting firms that recover a society's wasted resources are clearly a major marketing opportunity for industrial park developers. A 1999 study by the US Northeast Recycling Council reported that resource recovery is a “$44 billion industry ... with 13,000 recycling and re-use business establishments employing over 206,000 and paying wages in excess of $6.8 billion.” These figures refer only to the northeastern United States, and are much higher when revenues are calculated for the entire country. (NERC 2000)

However, it is often difficult for cities in developing countries to benefit effectively from opportunities in resource recovery. Two noted researchers state that “... modern, efficient, economically, environmentally and socially sustainable waste management systems are frequently beyond the reach of developing country municipal governments acting alone” (de Lundert & Lardinois 1995). The result is often mountains of waste, such as Manila’s famous Smoky Mountain, that burned for years, causing extensive air and water pollution.

In July 2000, tragic slides at landfills in Bombay and in Metro Manila's Quezon City demonstrated how poor management of landfills can inflict a major human cost. Several hundred scavengers and their families were killed in the Philippine disaster, which resulted from heavy rainfall on steep mountains of garbage. Thousands of scavengers, living in shanties below the mountain of garbage, flock to the area to collect reusable items such as plastic containers and bottles, which they sell to junk shops. The slides buried the shanty villages with the very resource that provides their residents' source of livelihood.

In developing countries around the world such micro-entrepreneurs inhabit landfills, seeking to recover value out of every product and material possible. They are the pioneer recyclers and reusers. However, they need a clean and safe context for their activity, one that provides an opportunity to become respectable business people in a local resource recovery economy. At the same time, there are many larger, established ventures to provide the stable tenant base required by an industrial park developer. The Resource Recovery Park (RRP) provides an opportunity to profit by ending the concept of waste while cleaning up urban environments. We draw upon cases in the US, Manila, Egypt, Mexico City, and India in building the general concept of the RRP.

Our discussion of the agro-EIP concept has already outlined several major resource recovery businesses, focused primarily on biomass by-products. Many of these firms would fit well into an Integrated Resource Recovery Park (IRRP) focused on this theme. Such an EIP would be home to the full variety of businesses that profit by collecting, processing, and manufacturing products from an economy's discarded resources, not just the food and farm related materials. Since resource recovery businesses and parks help solve major problems of pollution and the waste of society's resources, many countries and development banks offer investment programs and incentives to support their development.

An IRRP seeks to realize the value of managing discard streams from industry, commerce, residential, and public sources as a whole system. The local municipality needs to incorporate a broader resource policy to reduce waste at the source and assure separation of materials to maintain value. See discussion of this below. We propose that EIPs, with resource recovery facilities as their hub or anchor, can become an organizing force for this integrative strategy.

EIP site location and size will determine the nature of tenants that can be accommodated beyond the core resource recovery companies. The following outlines general business categories for RRP recruitment and development.

6.3.1 Recruitment targets for a Resource Recovery EIP

The resource recovery industry includes reuse, recycling, remanufacturing and composting, as well as the marketing and end-use of reclaimed discarded materials. As a vertical industry it involves a wide range of
business activities including collection, sorting, and processing of industrial, commercial, government, and household materials; repair, refurbishing, or dismantling of equipment; manufacturing and energy generation from recycled feedstocks; and wholesale or retail sales. The unifying concept is that discarded materials, goods, and by-products are turned into salable materials and products.

### 6.3.1.1 The Core Resource Recovery Cluster
Dropoff, buyback, and distributed collection strategies may be operated by an IRRP, by plants in each category below, or by collection companies.

- Reuse firms buy, often refurbish, and sell reusable goods and materials;
- Recycling firms process paper, plastic, chemicals, glass, tires, biomaterials, textiles, and metals into usable feedstocks;
- Niche collection companies serve particular types of businesses by gathering and delivering unused materials to other firms. Examples include office discards, food and paper discarded by restaurants, solvents and other chemicals.
- Composting and soil mixing firms target soils, ceramics, plant debris, putrescibles, and scrap wood (organic and mineral materials with no higher value use);
- Construction and demolition (C&D) businesses collect and process debris from deconstruction or dismantling, used building materials (e.g., scrap lumber, doors, windows, plumbing fixtures, and ceramics), concrete and asphalt recycling, and processors of roofing materials, bricks, and mixed demolition debris.
- Energy firms use a) selected organic materials for ethanol, methane, or methanol production and b) shredded rubber from tires to produce fuel or electricity generation
- Dismantlers reduce goods, such as older electronics and household equipment, that cannot be repaired or reused to usable components.

### 6.3.1.2 Manufacturing Firms
- Firms that use the feedstocks created by the processors to manufacture recycled products. Those that can use other outputs of park tenants (surplus heat, water, or other by-products);
- Plants that remanufacture capital and consumer goods (electronics, construction, transportation, and medical equipment are major niches for remanufacturing);
- Producers of equipment for resource recovery, renewable energy, and energy efficiency;
- Repair shops for household and office equipment;

### 6.3.1.3 Other firms that link to any of the above:
- Greenhouses and intensive agriculture, with specialty food processing;
- Fish farms;
- Micro-enterprises making products or crafts from recycled materials or offering repair services;
- Environmental consulting and service companies;
- Investment recovery firms.

### 6.3.1.4 Wholesale and retail businesses
- Reused household and office equipment, clothing, furniture, etc.;
- Remanufactured equipment;
- Outlets for finished goods from other firms at the site;
- Recycled commodity brokers.

6.3.1.5  **Infrastructure and businesses providing services**

- A commons with meeting space, training and education center, dining hall, and day-care;
- Telecommunications/Information systems;
- Business incubators and entrepreneurial support networks;
- Coordination with financing, research, and training resources;
- Shared business services including environmental management, purchasing, logistics, and accounting;
- Bubble permitting for the site, or clusters of firms within it.
- A crafts production and sales mall, with shared equipment, e.g., a metals or glass foundry for a collection of artists and craftspeople.

6.3.1.6  **A waste-to-energy plant as an anchor?**

The RRP proposed by Recovery Solutions for a site at Arecibo, Puerto Rico will be anchored by a state-of-the-art, low emissions waste-to-energy facility (WTE). This plant will consume up to 2 tons per day of selected portions of the municipal solid waste (MSW) stream. Target tenants include a recommissioned recycled paper mill, a tire shredding plant, a compost yard, a concrete construction products yard, a steel mini-mill, and additional firms using portions of the MSW stream, or energy and material outputs of the WTE facility. See Arecibo RRP Case Study in appendix for more detail on this planned resource recovery, renewable energy, and sustainable agriculture oriented EIP.

In the US and other countries a history with older, heavily polluting WTE plants has created opposition to this technology. Zero waste advocates also charge that it diverts materials that recyclers could use to create higher value outputs. In the case of Puerto Rico and many other developing economies, this competition appears to be unlikely, given the present magnitude of the waste disposal challenges they face. The Arecibo plan calls for separation of the MSW stream, community drop off sites, incentives for elimination of toxic materials from the feedstock, capture of recyclable and reusable materials, and recruitment of tenants that recover value from them. It appears to be a realistic approach to managing the materials and goods society continues to discard in such massive quantities.

IRRP developers may want to explore anchoring their parks with advanced WTE plants. They would need to work closely with environmental and solid waste agencies and NGOs to ensure that the technologies are evaluated according to the strictest air, water, and solid emissions standards. Such partnering will be important because of the opposition that could emerge due to the history of earlier versions of this technology.

6.3.1.7  **Toxic discards management**

An IRRP can work with regulatory and development agencies, trade associations, and NGOs to create a collection system and treatment facility that makes it safe, easy, and cost-effective for businesses, government operations, and households to dispose of toxic substances. Used oils and solvents, for instance, can be re-refined and returned to use. This toxics option may be feasible depending on the park location, the other tenants, and the technologies chosen for treatment. See discussions of toxic discards management issues in Chapters 2, 7, and 8.
6.3.1.8 The Drop-off and Sales Center

An IRRP should have excellent transportation access for moving materials in and out (rail, highway, and local). Proximity to industrial users or suppliers of discarded materials, water, or energy is important. It should also be accessible to individuals and small businesses wishing to buy and sell or discard goods. The optimum size would be between 100 and 200 acres, although the property could be two or three non-contiguous parcels relatively near each other. Contamination levels from previous use should be low enough to allow cleanup and clearance of liability in a timely fashion, with the previous owner covering costs.

Site design must optimize logistics for three functions: 1) easy access for industrial or individual users and collectors to drop-off materials and product discards; 2) access for customers purchasing reused or recycled products; 3) easy management of materials and product flows between the reception point and companies in the park. Dan Knapp, President of Urban Ore in Berkeley, California, has designed effective resource recovery centers for sites in Australia and New Zealand and in California, Tennessee, and Hawaii. Since there is a relatively high volume of material passing through such centers the physical layout must enable ready movement of visitors and efficient processing of inputs. Dr. Knapp's designs create a flow pattern separating different types of users and distinct areas for each class of material.

Employees and haulers receive both training and incentives to maintain the value of resources by keeping different classes of materials separate. For instance, building contractors and haulers receive good prices for reusable building components and materials recovered from deconstructed buildings. But they pay a tipping fee if they bring in the low value waste from a demolished building.

Landscaping of an eco-industrial park can include natural ponds for treatment of storm water run-off and lightly contaminated process water from tenants. It should reflect and contribute to the ecology of the region.

6.3.2 The Context

6.3.2.1 A Transition for Scavengers

The disastrous trash slides we mentioned earlier highlight the role of scavengers in the traditional resource recovery economy. In developing countries around the world such microentrepreneurs inhabit landfills, seeking to recover value out of every product and material possible. They and the small scale collectors and haulers of business and industrial discards are the pioneer recyclers and reusers. In the Philippines industrial estate managers emphasized the need to preserve scavengers' livelihoods as they planned a feasibility study for by-product management of a resource recovery estate. These managers realized that their community responsibility included maintaining a niche for the scavengers and small collectors in any RRP they developed. (Lowe 1999)

Celebrated programs in several developing countries have demonstrated that these workers at the bottom of an economy can organize formal businesses and coops and thus improve their social condition significantly. (See sidebar on the Zabbaleen in Egypt.) For the developer of a Resource Recovery EIP this means working with economic development, waste management, and training resources to survey this sector of the economy and determine how they can participate in the EIP. Partnering with the right agencies and NGOs would build both the tenant base and services for the resource recovery tenants. If the development team determines that a business incubator in the park is feasible it should include a micro-entrepreneurial level of membership. Training should include courses in small business management skills as well as technical skills.
The Zabbaleen Organize in Cairo

The Zabbaleen Environment and Development program, a product of local, national and international organizational assistance, collects nearly 50% of Cairo’s 6,000 tonnes of daily household waste. In the 20 years of this program’s operation, the Zabbaleen—a historically poor and marginalized group—have drastically improved their quality of life, largely through the creation of thousands of jobs and government investments in infrastructure.

Two decades ago this was a disempowered community characterized by environmental devastation, few economic or educational opportunities, poor sanitation and health, high infant mortality and other problems typical of urban slums. Now the Zabbaleen now operate integrated waste collection, recycling, and composting businesses for greater Cairo. Through this efficient program, Cairo now enjoys a much reduced environmental burden, and other cities have used this model of community development and cooperation to address the increasingly pressing issues of population and burgeoning municipal waste. (Perlman 2000).

6.3.2.2 The Integrated Resource Recovery System

The development of Resource Recovery EIPs needs to be integrated into a community or region-wide resource recovery system. By viewing the goal as resource recovery, rather than simply handling and storage of ‘wastes’, the resulting system can recover value and generate business opportunities, jobs, and new tax revenues, while benefiting the environment and human health.

Such an integrated system would embody proven technologies and business structures that enable society to recovery value from the highest possible proportion of what we now call waste. It would include both physical sites and action programs in industrial parks and with stand alone companies in a region.

The action programs—conducted by environmental, solid waste, and development agencies, schools, and private consultants—could include training in waste minimization, provision for separation of by-product materials to maintain reuse value, accreditation of and incentives for haulers, and an overall awareness program for industry ("If you pay to generate a by-product, either find a market for it or stop making it.

A research network could identify uses for by-products and discards with no reuse or recycling value. Municipalities can create many incentives to encourage households, commerce and industry to practice waste minimization, segregation of discards, and other resource recovery strategies. (Liss 2000B)

Creation of a by-product exchange is a broader resource recovery strategy that can link very closely to the operations of an IRRP. The PRIME Project in the Philippines began with the intention of creating a BPX at one industrial estate, grew to include five estates in Luzon and Batangas, and then moved to studying the feasibility of creating an RR-EIP to increase the opportunities for reusing the by-products the estate locators generate. See Chapter 12 for full discussion of creating BPXs and the Appendix for the PRIME case study.

An integrated resource recovery system should also cover options for handling residual products for which no use is found through landfills or other technologies.

Creation of a resource recovery business incubator would support small and medium recycling businesses, haulers, and scavengers in developing their operations to be more efficient and to observe good environmental standards. See Chapter 4 under business incubators.

The whole resource recovery system for a region is likely to occupy a number of collection points and processing and production sites. The system needs local input points distributed throughout the community as well as one or more central RRPs. Some processes need to be insulated from both business and residential neighbors because of odors and noise.
**Action steps toward an integrated resource recovery system**

One or more eco-industrial parks as outlined here could serve as agents to integrate planning and management of the total stream of resources that we now call waste. Essential elements and issues in this process of integration include:

1. Over time, integrate management of industrial, commercial, civic, residential, and agricultural discard streams.
2. Create the process and institutional structures needed to coordinate this diverse, self-organizing set of activities.
3. Identify which elements of this stream are already reused and recycled. Determine the level of value of recovery and the companies or agencies responsible.
4. Identify the "service voids", the resources no one is now utilizing, and the technologies and business models needed to put them to work.
5. Be aware of any environmental or health hazards that may be opened by using some present discards. Stay abreast of emerging research in this area.
6. Identify any institutional, business, or household values that support continued wasting of resources.

This chart models how a resource recovery-based eco-industrial park can serve industry, commerce, government, households, and agriculture in regaining the value of what we now call waste. The integrated resource recovery system functions as a whole, with all community sources feeding discards into an eco-industrial park anchored by a resource recovery facility. Finance, communications, education, and government agencies support development of the system.

### 6.3.3 Case Studies

**Experiences In Innovative Solid Waste Management In The Philippines**

The Mayor of Bustos, Bulacan (a medical doctor) mobilized the Local Health Board to conduct a comprehensive campaign to raise the people's awareness on the importance of and the interaction between health and the environment. The aim was to adopt an ecologically-sound waste management system which includes waste reduction, segregation at source, composting, recycling and re-use, more efficient collection and finally, more environmentally sound disposal. Community assemblies, zonal dialogues and household teach-ins were conducted. Women's organizations, the youth, NGOs and other civic and religious groups were tapped. Residents were organized into small groups to carry out:

- the construction of backyard compost pits;
- the construction of storage bins where recyclable and reusable materials are stored by each household;
- the construction of storage centers where recyclable and reusable materials collected by the ecology aide (street sweepers) are stored prior to selling same to junk dealers;
- maintenance of cleanliness in yards and the streets;
- the greening of their respective areas; and,
- motivating others to join.

An ecology training center was set up for the production of organic fertilizer and to train people on livelihood projects using waste materials. Regular monitoring and evaluation was facilitated by mobilizing the existing
structure of the barangay health workers (volunteers). Started in 1993 in just one barangay and some schools, this program has now beautified and improved the sanitation of the entire municipality. (Gozun undated)

HYPERLINKCase Study: Cabazon Resource Recovery Park

Recognizing the need for well-conceived, environmentally sound industry to diversify their economy, the Cabazon Band of Mission Indians in Southern California has set aside a 590-acre portion of their reservation for a Resource Recovery Park. Proposed tenants will implement practical solutions to environmental and waste management problems.

The first two operating industries are:

Colmac Energy, Inc. (a biomass-fueled power generation plant), anchor for the overall concept of the Park. Colmac Energy is a $148 million, 48-megawatt biomass-fueled power generation plant that provides power to Southern California Edison under a long-term contract. The facility uses 700 to 900 tons per day of biomass fuels. Colmac obtains wood, woody wastes and agricultural residues from throughout southern California, combined with limited amounts of natural gas and petroleum coke, to fuel this plant. This has provided one of the most stable markets for many municipal yard waste and wood waste recycling programs in the region.

First Nation Recovery Inc. (a crumb rubber manufacturer recycling used tires). This plant is a wholly owned $10 million venture of the Cabazons. Through state-of-the-art recycling processes, First Nation can turn millions of scrap tires a year into useful products. The facility has been shipping close to 1.5 million pounds of crumb rubber a month since it opened in June 1999. The facility obtains its tires from permitted and licensed scrap tire haulers who collect from tire shops; public works departments; and other scrap tire generators. First Nation currently processes 6,000 pounds of tires per hour.

Cabazon is seeking to recruit the following additional industries:

- Metals reclamation and recycling;
- Energy companies including a biomass (tires, organics, plastics) gasification plant, a used oil refinery, and an ethanol or methanol plant;
- Green and food waste composting and soil blending and bagging;
- Construction & demolition recycling;
- Plastics and rubber molding;
- An organic prawn farm;

Streamlined permitting

The Cabazons’ Planning Department handles approvals, plan checks, building permits, zoning and inspections. While the Cabazon tribe chooses to maintain high standards for environmental quality, a project proponent need not go through lengthy and costly approval processes typical in other areas.

Of particular benefit was the recent approval by the US-EPA of a programmatic Environmental Impact Statement (EIS). This EIS included about 50 potential projects in the project description. Any projects that are consistent with those named in the EIS would be easiest to get started. Larger or different projects would require a modification of the EIS, but the bulk of the environmental review will be still have been completed. See Chapter 4, policy and regulations, for discussion of programmatic EIS in the Philippines. (Liss 2000A and interview with Gary Liss.)
6.4 A Renewable Energy EIP

Insert more Asian examples

6.4.1 The Drivers for Acceleration of Renewable Energy Technologies

A powerful set of economic and environmental forces are opening a path to major increases in the use of renewable energy and the more efficient use of energy. These drivers make the creation of a renewable energy EIP a promising opportunity for development companies in Asia. The forces supporting alternative energy include,

- The political and economic costs of a country being dependent upon imported fuels will play an increasing role in national policy.
- Demand for petroleum is likely to exceed supplies, resulting in long-term continuing increases in the costs.
- Higher value uses for petroleum in manufacture of petrochemical products will eventually compete with use of it as fuel for transport and energy;
- Pressure will increase to reduce the greenhouse gas (GHG) emissions that contribute to climate change and local emissions that damage health and environment.
- Many financing programs seeking GHG reductions are available for projects in developing countries. See Chapter 5 for a comprehensive directory of these incentives for alternative energy technologies.
- Investments are already growing in renewable energy from major companies, investors, and financial institutions.
- Society will realize the payoffs from three decades of R & D in renewable energy.
- There is broadening recognition of the financial benefits of investing in high efficiency of energy use.
- More industries require high quality, reliable energy supplies.
- Growing public and private markets seek to use green energy.

The interaction between changes in the cost of fossil fuels, growing willingness to act to reduce greenhouse gas emissions, and breakthroughs in renewable technologies are opening markets for these technologies, perhaps sooner than most analysts have expected. Alternative energy investments are growing rapidly, as venture funds multiply with diversified portfolios of renewable energy firms or that target specific sub-sectors like hydrogen technologies. Daimler-Chrysler is investing over one billion dollars in fuel cell technologies for both transportation and energy. British Petroleum-Solarex is investing one billion dollars to increase its photovoltaic manufacturing and marketing capacity. (It is already the largest PV producer in the world.) World Bank, re-insurance companies like Gerling Re, and other international financial institutions are creating a variety of global investment vehicles to fund technologies that cut greenhouse gas emissions. See Chapter 5, Financing.

On the demand side, the energy crisis in California beginning in Summer of 2000 demonstrated that a comprehensive mix of energy resources is required to maintain business viability. Some city-owned utilities like Sacramento Municipal Utility District and the Los Angeles Department of Power and Water contained prices, partially through their aggressive programs in utilizing renewable energy. The former won the Energy Globe 2001 company award for its installation of 8 MW photovoltaics and plan to install another 7, making it...
the largest utility use of this technology. The Los Angeles utility plans to buy alternative sources for 50% of its new capacity. *(See discussion in Chapter 7, Policy.)*

Some Asian countries have large areas and populations without access to reliable electricity. There are many pilot programs using renewable sources such as photovoltaic arrays to serve schools and clinics distant from the existing grid. Aggressive development of the full variety of renewable energy sources could enable more rapid rural electrification (often in a cost-competitive way given the avoided costs of grid development) and also delay major capital expenditures of fossil fuel power plants.

Capital for renewable energy and energy efficiency is available at an unprecedented high level to take advantage of technological innovations from the universities and laboratories. In financial terms, renewable energy is a rapidly emerging sector of the sustainable economy. Developers of renewable energy EIPs in the next decade are likely to find well-financed tenants seeking sites for their operations. Some earmarked funds, such as the greenhouse gas mitigation investments of the re-insurance industry, may be available directly for industrial park developments or for the financing of tenants.

### 6.4.1.1 The Potential Competitive Advantage of Developing Countries

Many factors may make it easier for entrepreneurs in developing nations to profit from renewable energy and energy efficiency opportunities. In energy importing countries and those with an underdeveloped grid, distributed renewable sources may be cost competitive with fossil fuel sources. In addition, in most developing countries these alternative sources will yield the higher quality and more reliable energy many industrial tenants demand. While new multinational facilities are usually designed with highly efficient systems, operators of older facilities can cut costs significantly by upgrading to more efficient buildings, equipment, and processes. Through emissions trading schemes it is possible for a company in a developed country to invest in a major improvement in efficiency in a facility located in a developing country instead of using the same investment to gain only a small improvement at home. There are funds, such as the Global Environment Facility at World Bank, that invest in use of renewable energy equipment in developing countries. A growing number of resources are available for reduction of greenhouse gas emissions, including ones financing new renewable energy ventures. *(See resources section below.)*

There is a synergy among these different factors that may enable Asia’s developing countries to take a lead in renewable energy.\(^1\) The increasing demand for energy can be met, in many cases, through distributed renewable systems more effectively than through traditional solutions. The building of energy capacity in a modular fashion enables developing countries to avoid the very high sunk costs of fossil fuel power plants. Financing is available in increasing quantities.

### 6.4.2 Energy Efficiency

The market for energy efficiency products and services in Asian developing countries is large because higher efficiency cuts the costs of energy and the environmental impacts of its production. Companies seeking to tap this market will find support from environmental finance structures, including those seeking to mitigate greenhouse gas emissions. Investments in energy efficiency are generally paid back within three to five years through the cost savings. The world market for energy-saving and energy-efficient equipment is $82 billion per year, according to one source. *(Serchuk and Singh 1999)*

Manufacturers of energy efficiency equipment include those producing more efficient lighting, heating, ventilation and air conditioning systems, appliances, insulation, windows, industrial and office equipment, and energy use sensors.

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\(^1\) Just as the Asian Tigers benefited greatly from the explosion of demand for high tech equipment.
Energy service companies conduct energy audits, design more efficient energy systems for new and existing buildings, and play a key role in design of systems for co-generation and cascading of energy from one quality of use to another. See the Design Options chapter for more detail on these technologies and services.
A Scenario of a Developing Country’s Electrification

This is the energy section of a future scenario of how a hypothetical developing country could use industrial ecology to chart its path to sustainability, written looking backward from the year 2005. The full scenario can be found at www.indigodev.com/Qwanin.html

Qwanin’s power grid was poorly developed so the strategy emphasized a decentralized energy system based on a combination of relatively small and clean fossil fuel plants and renewable sources. The diversity and scale of technologies was essential to creating a reliable and resilient system.

The Economic Development and Energy Ministries put out a request for qualifications (RFQ) defining this strategy and inviting energy companies to prove their capability to help implement it. The winning proposal came from an international consortium of small to mid-size companies at the cutting edge of energy planning and technology. This group projected targets for building energy capacity with efficiency higher and emissions of greenhouse gases far lower than Qwanin’s performance objectives demanded.

Working with the Energy Ministry, this consortium developed a whole systems plan avoiding investment in large power installations and older technologies.

The strategy emphasized phased development of smaller energy generating modules, as needed. Such modular systems are more flexible and resilient and require a much smaller initial investment. It called for modest improvements to the power grid rather than the massive grid proposed by a large Asian engineering company.

The relatively small fossil fuel plants needed use advanced technologies to insure low emissions. They were sited near industrial plants that could use their waste heat. Industrial plants with large waste heat output used co-generation to create electricity for themselves and their neighbors.

The strategy’s renewable energy sources included photovoltaics; passive solar design in new buildings and homes; small to medium hydro projects; wind power; geothermal, and ethanol production and other biomass technologies.

The consortium’s plan eliminated the major costs of a traditional solution: large centralized power plants and a heavy power grid. Without these large investments in the project budget the energy system could make cost-effective use of photovoltaic cells (which would not be competitive with fossil fuels in a developed country). This plan also reduced significantly Qwanin’s dependence on costly imported oil to fuel its energy system.

As an additional benefit, the phased development will allow installation of newer renewable technologies, particularly hydrogen fuel cells, when they become cost-competitive.

Qwanin’s energy strategy also called for the government and utilities to issue RFPs for 15 year contracts to acquire photovoltaics for all new government buildings and for new utility installations. With these guaranteed domestic markets, a photovoltaic plant broke ground in 2001 to make PV modules, roof tiles, and film for windows (Lowe, Warren, Moran. 1997)
6.4.3 Manufacturing of Equipment for Renewable Energy

Integration of a variety of technologies will provide the energy of the future. Some analysts emphasize the hydrogen fuel cell and provision of the infrastructure for production and distribution of hydrogen as the foundation. Wind energy is presently a cost-competitive alternative to fossil fuel sources where local climate enables its deployment. In many applications direct and indirect solar technologies are the preferred choice now and will undoubtedly play a role in the energy system of the future. Entrepreneurs and large companies alike are very active in all renewable energy technologies, recognizing that there are many markets now, particularly in locations where distributed sources of energy are less expensive than centralized fossil fuel sources. Each of the technologies we describe will have a growing niche, even though one may dominate.

6.4.3.1 Fuel Cells and Supply Chain

Fuel cells can be used for a variety of energy uses: powering vehicles, centralized energy generation, home energy systems, and other distributed uses. Large corporations such as DaimlerChrysler and United Technologies work in team with a host of smaller companies in developing the wide variety of specific technologies needed for the cells themselves and for the hydrogen infrastructure. This industrial cluster includes:

- Fuel cell manufacturers produce complete cells, configured for the different markets.
- Specialized manufacturers provide commodities such as electrolytes and components such as carbon graphite plates and membranes, ceramic plates, hydrogen purification devices and storage tanks, and inverters.
- Fuel companies provide the feedstock for generating hydrogen (natural gas, gasoline, plant material, methanol, etc.) and may be the direct suppliers of hydrogen to the users of fuel cells.
- Reformer companies make equipment to separate hydrogen from carbon.
- Distributors and energy service companies design and install integrated fuel cell systems.

Many utilities around the world are installing pilot facilities to train their staff and research the business and technical implications of fuel cell technology. Fuel cell technology may eventually be cost-effective deployed in a distributed fashion. Units are now on the market suitable for home or commercial usage. EIPs might consider installation of fuel cells for backup power.

The longer term transition from a carbon to a hydrogen economy will open large opportunities for the companies listed above as well as for engineering and consulting firms that install the new infrastructure required. Given the huge investments in hydrogen technology, this transition may begin in the next decade.

6.4.3.2 Wind Energy

Wind energy is the fastest growing source of renewable energy, with major wind farms operating in California and several other US states in Japan and in the Netherlands, Denmark, Germany. Turbines are manufactured in sizes ranging from a few dozen kilowatts to over a megawatt. Large arrays of machines are used in high wind areas to supply power to the grid but the technology is well suited to smaller scale distributed generation, so long as the wind is sufficient. Advanced aerodynamic design of the machines has significantly reduced the numbers of birds being killed by flying into them.

The industry includes these segments:

- Large and small wind turbine manufacturers assemble the machines and support systems.
- Suppliers manufacture blades, electronics, gearboxes, towers, brakes, generators and other components.
Windfarm developers and operators manage large arrays of turbines, selling power to utilities. Consulting companies identify promising sites and assess environmental impacts.

The American Wind Energy Association estimates that the global wind power industry had annual sales of US$2 million and generated over 10,000 MW of power per year by the late 90s. The industry grew at an annual rate of 27% from 1992 to 1999. Manufacturers in Denmark lead the industry, producing over half of the generators used around the world.

In Asia, Tomen Corporation, a leading Japanese trading house, built a 20,000-kW wind farm in Japan's most northerly main island of Hokkaido. Built in 1999 it is Japan's largest wind power installation. The company has announced plans to build an additional 32,500-kilowatt (kW) wind farm at a cost of about US$64.11 million. Total electricity generated by wind power in Japan amounted to 70,000 kW at the end of 1999. Other Asian countries have many smaller wind power projects.

6.4.3.3 Photovoltaic Cells and Systems

Photovoltaic (PV) cells generate electricity from sunlight (even with light cloud cover) through silicon-based semiconductors. Clusters of cells are integrated with inverters, transformers, and storage devices. In some applications they are integrated into building materials such as roof tiles, building facades, or windows, capturing the economies of multiple use for one cost. While utilities sometimes create large arrays of PVs mounted on sun-tracking devices, the technology is ideal for distributed energy systems located close to energy consumers. BP-Solarex, for instance, is installing local PV systems at 500 off-the-grid villages in the Philippines to provide power for educational and health facilities.

Some firms in the PV cluster include:

- Suppliers of primary metals and glass provide commodity materials for PV cell production. Semiconductor manufacturers can supply silicon for PV production.
- Manufacturers of PV manufacturing equipment.
- Suppliers of silicon, often firms in the computer industry, provide raw silicon.
- Manufacturers of PV cells may be vertically integrated from manufacture to distribution and installation, or they may serve as PV cell or module wholesalers.
- "Balance-of-system" suppliers make batteries, inverters, and wiring.
- System integrators assemble PV products for specific uses. Some also distribute systems, install them, and assist with servicing.
- PV system installers and servicers can overlap with integrators as well as manufacturers.

The major consolidation of the PV industry accomplished by the BP Amoco merger made BP-Solarex the primary player with a very strong technological and market base. However, German and Japanese firms such as Siemens, Kyocera and others remain players. Any one of them could discover the breakthroughs in the basic technology or the innovations needed to reduce the cost of manufacturing. Relatively few PV plants are likely to be needed in any one region of the world so you may need to target other parts of the supply chain.

An energy EIP developer could work with industrial development agencies to create a major incentive for a PV company to locate a primary manufacturing plant in the eco-park. This would be by assuring demand through use of PVs in the park, other developments by the same company, and in public buildings. A guaranteed market for a share of the plant’s first years of production would be a major attraction.
6.4.3.4 Solar Water Heaters

Solar water heaters use the sun’s heat directly to heat water for industrial, household, or commercial use. Depending upon climate and season, they may yield the temperature required or they may be used to pre-heat water for standard heaters. Solar units are competitive with gas or electric heaters in many situations. Simpler than for other renewables, this industry segment includes manufacturers, distributors, installers, and repair services. The market is potentially quite large if units are integrated into new home design and if industrial facility designers recognize the energy savings to be gained through pre-heating of water for boilers.

6.4.3.5 Biomass

We have already covered generation of energy and fuels from biomass in the agro-EIP section of this chapter. Manufacturers supplying biomass generators would include firms making fermentation equipment for ethanol, anaerobic digestors to produce methane, generators to burn methane, and bulk materials transport and handling equipment.

6.4.3.6 Microturbines and Microhydro Equipment

Microturbines are 25 to 500 kilowatt generators akin to jet engines and the larger gas-fired turbines used in new power plants. They can use either natural gas, a relatively clean fossil fuel, or fuels from biomass, such as landfill methane emissions. The technology is simple to maintain and can be used readily for industrial purposes, including co-generation, or for distributed uses like powering villages that are off the grid. Estimates for the microturbine global market range from $2 to 10 billion in the first decade of the new century.

Low-head hydro systems are effective sources of power for rural communities so manufacturing and installation of the small power mills for streams and ditches are another promising renewable energy niche. A project in Sri Lanka won the Energy Globe 2001 award in the category of “Building & Housing” for providing electricity supply to 75 villages with micro hydro power.

6.4.3.7 Design, Installation, and Maintenance of Integrated Systems

In the next decade the feasibility of using renewable energy will be enhanced by integrating two or more of the technologies needed in order to best meet a specific site’s needs. A company serving as energy systems integrator will assess the customer’s energy requirements and budgets, determine energy efficiency strategies that can reduce the demand, select the optimum combination of sources, and coordinate installation of the system. It may also negotiate financing and sales of excess energy to utilities. Depending upon the host country’s tax structure and incentives, such a company could conceivably operate as a distributed utility, owning the equipment and selling the energy services.

6.4.4 Renewable Energy Generation Cluster

We summarized opportunities for ethanol fermentation and methane and methanol production in the agro-EIP section and waste-to-energy plants under resource recovery parks. Any of these could play a role in a renewable energy EIP, though the WTE plant would need to also link to companies using its outputs and other resource recovery firms. Photovoltaic systems could be mounted on the extensive roof space in an industrial park to supply the energy needs of tenants and to feed power to the grid. Recovery Solutions in Puerto Rico estimates that this application could use half the output of a PV manufacturing plant, providing guaranteed sales as an incentive for locating at its resource recovery and renewable energy park. Fuel cells The by-product utility we describe in Chapter 12 By-Product Exchange could also serve as an energy utility, managing opportunities for energy cascading between facilities, co-generation, and generation from renewable sources. It could supply all or most of the tenants’ needs in the park and provide energy to the
community and region. If the property management company chose to set up such a utility as a subsidiary, it would add significantly to the EIP’s revenues. The variety of sources would guarantee tenants that they would have access to the high quality and reliable energy most of them need. The cost of power interruptions is very high for most industries.

6.4.5 Conclusion

This focus of EIP recruitment on renewable energy and energy efficiency could be the sole target for an EIP or it could be part of a broader recruitment strategy. The Arecibo Resource Recovery Park in Puerto Rico aims to integrate renewable energy with resource recovery and support to sustainable agriculture, with strong synergy between the three clusters. With either choice there are many drivers toward a renewable energy economy, many potential businesses to recruit or incubate, and funding to support establishment of these technologies. An industrial park developer who chooses to use this recruitment theme will have the added recruitment attractions offered by business synergy among the energy companies and reliable power for all tenants.

6.5 Power Plant Eco-Industrial Parks

China has large coal reserves and moderate oil reserves, Indonesia has some oil and natural gas reserves, and Thailand and the Philippines natural gas reserves. Even without domestic sources of fuel, Asian countries will continue building new fossil fuel power plants, often with development bank loans. This suggests the strategic importance of developing eco-industrial parks anchored by such plants. The EIP’s community of companies could generate significant sustainable development benefits, helping offset the environmental burden of the power plant itself.

At Kalundborg in Denmark, the world’s most celebrated industrial ecology case, is a coal-fired plant that is the center of a network of companies utilizing its water, heat, and material by-products. (See the detailed description in the Appendix.) While not an industrial park, the network at Kalundborg suggests that a power plant makes an effective hub for an EIP.

We will outline a generic model for such an EIP anchored by a fossil fuel plant and then summarize one US case under development in Mississippi. One US expert on energy facility developments, Dan Sloan, reported to us that some of his clients gave up projects in China because their power plants were so automated they were not able to create the numbers of jobs the government required. He sees that an industrial park around a power plant could generate many 100s of employment opportunities and at the same time use the outputs of the plants efficiently. (Sloan 2001 personal communication.)

Recruitment for an EIP anchored by a power plant would focus on creation and attraction of firms that help meet the plant’s procurement and output requirements as well as other long-term business interests. Development strategy could create several industrial clusters as the foundation filling the site.

Since the power plant is likely to be owned by a utility or energy authority, as the projects prove-out, the owner could implement variations upon the basic model at other power plants it manages. Possible clusters to be considered include:

1. Supplier Cluster: Companies providing services and products to the plant’s operations;
2. By-Products Cluster: Plants utilizing energy and materials by-products of the plant;
3. Energy Efficiency Cluster: Firms providing consulting services and products to promote energy efficiency in industry, municipal operations, and residences;
4. Renewable Energy Cluster: Renewable energy products and services, especially firms offering integrated energy solutions.
5. Farming and Food Processing Cluster;

6. Telecommunications cluster

Several of these clusters could export products and energy planning services to other Asian countries. The EIP development team will need to conduct a market analysis to determine which clusters appear most viable and what the best sequence of development will be. We will detail those clusters not discussed earlier in this chapter.

1. Supplier Cluster: Companies providing services and products to the power plant's operations

A strategic analysis of the plant's pattern of procurement should focus first on high volume and high cost goods and services; those presently imported from outside the country; and those where new suppliers could have a positive environmental and social impact. The analysis would be done in terms of equipment, supplies, and services for generation, transmission, construction, offices and consumer education. The next step would be scanning for domestic companies that could become key suppliers (with economic development support) and entrepreneurs capable of setting up new businesses to fill the company's needs. In parallel with this internal search the team should scan for likely overseas joint venture and technical transfer partners. The basic value sought here is to optimize domestic sourcing of the plant's material and service requirements.

Chemical procurement might be outsourced to a company or partnership based on the model of the US Strategic Chemical Management Group, which handles this function for major utilities like Southern California Edison and Florida Light and Power. Internal service functions such as landscaping and security could be outsourced to firms in the EIP.

2. By-Products Cluster: Plants utilizing energy and materials by-products of the power plant’s operations;

A large variety of firms are potential users of the steam, hot water, water, fly ash, gypsum, CO₂, solvents, and other chemical outputs of power plants, distribution system, and offices. The first step here would be an industrial metabolism analysis tracing material and energy flows of power plant operations, offices, the electricity distribution system, and internal service units.

Some of the candidates include:

- Manufacturers of building materials and products using gypsum and fly-ash by-products (wallboard, building blocks, roof and paving tiles, road aggregate, etc.)
- Manufacturing of ashalloys—metal matrix composites with aluminum and lead that incorporate coal fly ash. Markets for such lightweight composite materials include automotive, aerospace, and other manufacturing industries.
- Greenhouses, heated fields, and aquaculture ponds using heated water and steam from power plants.
- Steam from the plant could heat all EIP facilities and provide energy for industrial processes, as needed.
- Solvent and oil re-refiners; (Trichlorethane, Methy Ethyl Ketone, and various hydrocarbon solvents such as kerosene, stoddards's solvent, etc are commonly used in utilities and could be supplied back to the plant for cleaning and maintenance applications.)
- Firms packaging CO₂ to replace chemical solvents in cleaning processes.
- A center researching and prototyping technologies for sequestering CO₂ in concrete products, plastics, and other materials.
- Remanufacturing companies to renew power generation and distribution equipment.

This cluster would have a strong linkage to the farming and food processing cluster.
3. Energy Efficiency Cluster: Firms providing consulting services and products to promote energy efficiency in industry, commercial and municipal operations, and homes;

The experience of other major utilities in Japan, the US, and Europe has demonstrated the benefits of demand side management programs by the utilities. Achieving significant increases in efficiency will delay the need to construct new power plants, conserve imported fuels, and make the country's economy more competitive in world markets.

The demand side management function may be more effectively provided by independent companies working in partnership the utility that uses the plant’s power. There are opportunities in industrial and municipal markets for E-efficiency service providers, and energy management services. This cluster would enable smaller companies to partner in offering integrated packages of services and products.

Some of the specific members of the cluster might include companies offering:

- Industrial process energy audits and design of retrofitting of facilities and equipment;
- Energy management analysis, design, and budgeting software;
- Re-manufacturing of more efficient equipment – motors, controls, drivetrains, etc.;
- Analysis and improvement of municipal building systems;
- Design of district heating and cooling utilizing waste industrial heat.
- High efficiency home lighting equipment and appliances. (Including design of integrated home heating, cooling, lighting, and cooking systems, particularly for multi-family housing.)

4. Renewable Energy Cluster: Renewable energy products and services, especially firms offering integrated energy solutions.

A renewable energy cluster, as described in the previous section, has a strong potential for synergy with a fossil fuel plant. The benefits include:

- Renewable technologies are the future of energy generation and every company needs to be investing in its future.
- A utility that provides cost-effective and reliable back up systems for industries gains new revenues and potential sources of renewable energy and peaking power for its grid.
- Investments in renewable sources can offset greenhouse gas emissions for the fossil fuel power plant, helping it to meet Climate Change Treaty obligations.

5. Farming and Food Processing Cluster:

Since power plants and utilities often have extensive tracts of land the various industries and farming operation see describe above for an agro-EIP can play a significant role in the recruitment strategy. Power plant by-products that would support this cluster include steam, hot water, cooled water, compost, fly-ash and gypsum for soil amendments) This cluster could include providers of food services to power station personnel as well as to the market;

6. Telecommunications Cluster

A utility’s transmission line right-of-ways offer an underutilized resource for telecommunications. A cluster of companies dedicated to generating transmission line telecommunications products and services would help realize new revenues from this asset.

Complementing this could be companies serving telecommunications needs of off-grid rural communities. An example would be a developer of integrated telecom modules for rural communities (to meet administrative needs as well as distance learning for schools, libraries, and clinics).
The Redhills Ecoplex

The Danish industrial symbiosis at Kalundborg has inspired the state of Mississippi to develop the Red Hills Ecoplex around a strip coal mine in the northeastern region of the state. Marian Chertow, a professor of industrial ecology at Yale University, describes this project:

“The core of this project, which broke ground in October, 1998, is the construction of a new, $450 million power plant by Belgium-based Tractebel at the site of a lignite mine in rural Mississippi. Using circulating fluidized bed technology to reduce sulfur emissions, the 440 MW plant will burn approximately 1.5 million tons of lignite per year. The project, supported by the Energy Division of the Mississippi Department of Economic and Community Development, has a 30-year power purchase agreement with the Tennessee Valley Authority. State officials are recruiting additional tenants to participate in a large-scale industrial symbiosis using by-products of the power facilities as feedstocks for new businesses. (Chertow 2000)

The state of Mississippi plans to invest $20 million for the Red Hills Ecoplex infrastructure, including improvements of water supplies, access roads, natural gas, and rail service. The power plant will occupy ca 150 acres of a 300 acre construction site (with the mine and water treatment ponds the total site is 5,000 acres). Recruitment targets include food, agriculture, aquaculture, wood products, paper, and clay products industries. Tenants would have access to steam, hot water, fly ash, and gypsum from the power plant, as well as low cost electricity. A coal subsidiary of Phillips Petroleum will be responsible for the mining and land restoration process, with a commercial forest cover as the ultimate land use.

Cornell's Work and Environment Initiative organized an Eco-Industrial Development Roundtable at Red Hills in February, 2000. The minutes of this event with details on this project are online at http://www.cfe.cornell.edu/wei/.
6.6 Petrochemical Eco-Industrial Parks

An eco-industrial park anchored by petrochemical plants seeks to achieve the basic EIP objective of sustainable development. This may be a refinery and/or a complex with facilities processing basic building blocks like ethylene, propylene, butadiene, butenes, and the BTX aromatics. Although it is dependent upon inherently unsustainable resources, such an EIP will seek relative sustainability through a number of strategies. The field of green chemistry constitutes R & D and advanced practices seeking to increase efficiency, reduce toxicity, and replace inputs in both chemical processes and products. Another long-term goal of a PCEIP is to increase the value of oil's downstream products. Perhaps we could reach the point where we can no longer afford to burn the fossil fuels whose emissions threaten to fundamentally alter our global climate.

A petrochemical EIP also seeks to create local sources of specialty chemicals by better integrating the production of commodity and downstream products. This creates new domestic businesses and reduces imports that burden developing economies.

This industry's expertise in chemical processing gives it an advantage in recovering value from discarded materials and managing hazardous materials safely. Through its two hundred-year history the chemical industry's normal business practice has been to turn wastes into by-products, whenever this is economically feasible.

In addition, managers of PCEIPs will seek to design and manage their facilities with the best practices for resource efficiency, cleaner production, and pollution prevention. They work closely with neighboring communities to insure low risk of environmental and health impacts and high benefit to the local economy. The chemical industry's Responsible Care Program has created significant improvement in these areas.

Projects in Asia and Africa illustrate aspects of this petrochemical EIP model. See the cases in the appendix for the Thailand's Map Ta Phut, Philippine National Oil Company's PetroChem Park, and South Africa's ChemCity.
6.6.1  Green chemistry: a foundation for petrochemical estate development

For a petrochemical park to fully qualify as an eco-industrial estate, its facilities should go beyond incremental improvement in efficiency and emissions. The innovators of green chemistry are seeking to create a sustainable future for chemical producers and users. This work provides a solid foundation for operation and development of petrochemical EIPs. During the last decade the field of green chemistry has evolved rapidly, with strong support from major chemical companies, entrepreneurs, trade and professional associations, and the U.S.-Environmental Protection Agency. The central goals of this work are reduction of pollution from chemical production and end use and reduction of energy used in production.

Some drivers for development of Green Chemistry include:

- Increasing liability for health and environmental impacts of chemical products;
- The phasing out of some substances and classes of substances because of high toxicity or global environmental impacts (for example, ozone depleting substances, persistent organic compounds, and high impact greenhouse gases);
- Extension of the trend toward chemical product stewardship, takeback and recycling by chemical companies;
- New discoveries in toxicological research relating to disruption of endocrine systems, synergistic interactions among toxins, and heightened vulnerability during childhood and pregnancy;
- Technical breakthroughs in substituting industrial enzymes, biomaterials, and liquefied air products for some chemicals.

Companies in a PC-EIP Green Chemistry cluster would support changes in synthesis processes and new product development for major petrochemical facilities. They would also create their own new products from petrochemical feedstocks and renewable materials for the broader market. The park anchor tenants and the developer could encourage the cluster members by creating a business incubator providing space, assistance in financing, and administrative support for startups. The presence of this cluster would enhance the long-term success of the major petrochemical tenants, developing new products and services for their internal use as well as for their customers.

Green Chemistry R & D searches for new solutions in several basic areas:

Changes in chemical process design:
- Alternative pathways for synthesis that reduce pollution and energy consumed;
- Alternative catalysts and reagents for chemical production processes;
- Software tools for multi-value complex process design;
- Analytic tools for monitoring and controlling processes.

Changes in manufacturing processes using chemicals:
- Process intensification, getting more output per unit of chemical input;
- Alternative catalysts, reagents, enzymes, and feedstocks;

New products that serve functions of undesirable chemicals:

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2 This trend is leading some companies to move to a service model, in which they sell the function performed rather than the chemical product itself. See Reiskin, White, Kauffman Johnson, and Votta. 1999. “Servicizing the Chemical Supply Chain. Journal of Industrial Ecology, 3:2-3, pp 19-32. Cambridge, MA. Paper may be downloaded from http://mitpress.mit.edu/journal-home.tcl?issn=10881980
Benign petrochemical products;
- Liquefied and supercritical CO2;
- Biomaterials such as bioplastics;
- Biofuels such as ethanol and methanol for direct use or as feedstock to provide hydrogen for fuel cells.

Green chemists ask, how can we best perform the function the customer requires while lowering the pollution and the energy intensity of our processes and products? Their answers are rapidly entering the marketplace because of the broad acceptance of this field. As with any field of rapid innovation, it is important to assess new products and processes carefully to be sure that they are really better than the old ones and do not add new problems. Researchers at Battelle Institute found that new processes for creating commodity chemicals from food wastes produced energy and environmental impacts from these renewable materials that were just as high as for petroleum derived chemicals. (Butner 2000)

The Office of the US President has created a Presidential Green Chemistry Challenge Award, whose recipients have included industry leaders like Dow, Monsanto, duPont, Rohm & Haas, Bayer, Hoechst Celanese, and Hughes Environmental Systems, as well as smaller companies like Molten Metals, Imation, and the Henkel Corporation. The European parent corporations of some of these companies are actively pursuing green chemistry research in Europe. The Green Chemistry Institute has encouraged development of international affiliates, with South Africa, India, and Taiwan as early adopters. The Indian chapter organized an international conference on Green Chemistry in January 2001.

Developers and managers of petrochemical EIPs in Asia are likely to find that a Green Chemistry Cluster will strengthen the overall business and environmental performance of companies operating at their site.

### 6.6.2 Development of Higher Value Downstream Production

In South Africa the ChemCity design team was assigned to create an EIP that would transform commodity chemicals from Sasol Chemical's coal gassification process into specialty chemicals. The country, like many in Asia, exports commodity chemicals and imports the higher value specialty products. This development strategy promised to make South African more independent, improve its balance of trade, and increase Sasol’s profits. The design concept here also included creation of a Green Chemistry Cluster. Unfortunately, a new managing director chose to focus instead on acquiring downstream companies on a decentralized basis rather than continue with a development project he had not initiated.

This shift in strategy does not indicate any basic business or technical weakness in the overall PC-EIP concept the ChemCity team had created. Co-location of the source petrochemical facility with downstream customers creates excellent logistics of material, water, and energy flows. The community of companies would enjoy the advantages of a common skilled and semi-skilled labor pool, training programs, environmental management services, and emergency preparedness, prevention, and management resources.

See the ChemCity case in the appendix.

### 6.6.3 Improvement of Environmental Management

**By-Product Exchange**

Projects around the world are seeking to further develop the utilization of by-products in petrochemical complexes. These include initiatives in Alberta, Canada, Tampico, Mexico, Rotterdam Harbour, Netherlands, and the Thai and Philippine projects described below. While the industry has a long tradition of turning wastes into products, it appears there are still opportunities to do more. What is new in recent years is that companies are taking a more systematic approach rather than depending upon piece-meal
innovations. They are partnering to analyze their materials, energy, and water flows as a whole system, searching for what one company calls “by-product synergy.” In some cases they are working in the broader context of eco-industrial networks, seeking to identify benefits they can gain from inter-firm collaboration in areas of environmental management beyond the trading by-products.

<table>
<thead>
<tr>
<th>Petrochemical By-Product Exchange in Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>A project in Tampico, Mexico demonstrates the value of forming by-product exchanges including petrochemical operations. In October 1997, the Business Council for Sustainable Development – Gulf of Mexico (BCSD-GM) launched a demonstration By-Product Synergy project in the Tampico – Altimira – Cuidad Madero region of Mexico with a group of 21 local industries. In all, the participants identified 63 potential synergies. Of those, 13 with immediate commercial potential were pursued. Examples are detailed below:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>▪ Grupo Tampico has taken Tampico’s 134 tons per year polyethylene/polypropylene waste to use in the manufacture of its plastic cargo palettes.</td>
</tr>
<tr>
<td>▪ Two facilities are negotiating the financial aspects of a deal in which one company’s 51,000 tons per year spent butadiene will replace natural gas fuel in another facility. The cost of burner modifications will be shared by the two.</td>
</tr>
<tr>
<td>▪ Industria Ecologia del Golfo, of Matamoros has invested approximately $200,000 USD in the recovery and reused of the reported 6,500 empty chemical drums and barrels from Tampico industries.</td>
</tr>
<tr>
<td>▪ Two companies are reusing HCl streams. One company recovers the chemical on demand. The other, with a smaller quantity, is bottling the spent acid on small scale, and selling it as muratic acid for domestic and semi-industrial uses.</td>
</tr>
<tr>
<td>Potential</td>
</tr>
<tr>
<td>▪ Johns Manville is conducting tests on polymer residuals from GE-Plastics, PRIMEX, POLICYD and INDELPRO to determine if they meet standards for their impermeable membranes used on exterior roofing.</td>
</tr>
<tr>
<td>▪ Cryoinfra has demonstrated an innovative plastics recovery technology which uses liquid nitrogen to pulverize oily, resin, and plastic residues, and homogenizes them into a high-quality primary material. The technology offers a manufacturing opportunity for a small-to-medium size enterprise that wants to market a value-added product.</td>
</tr>
<tr>
<td>▪ DUPONT has a 70,000 tons per year stream of ferric chloride by-product. There is a significant demand for this product in Mexico City in wastewater treatment. The economics of recovery will determine this project. (Applied Sustainability 2000)</td>
</tr>
</tbody>
</table>

Petrochemical operations are finding there are benefits from participation in by-product exchanges, however there are clearly significant limits to this strategy. Overall efficiency of fossil fuel resource utilization is already high, economic barriers often prevent improved by-product utilization, and some outputs are true wastes. Scott Butner, an industrial ecologist at Pacific Northwest Laboratories says,

“If one only considers the strategy of using “wastes as feedstocks” then most refinery complexes are at least partial realizations of the EIP concept. I believe that the utilization of the crude oil feedstock in modern refineries is as high as 95% by mass, with everything from sulfur to light gases (propane, butane, etc) and hydrogen all finding markets that are secondary. These
secondary products are often handled by third-party firms, not the "anchor" corporation. Actually, I use the example of the petrochemicals industry as counter-example to the "wastes are just products without a market" dogma. In petrochemical and other industries there are some wastes that should not be allowed to become products, from an environmental perspective. (Butner 2000)

On the other hand, a facility may create by-products that it cannot economically turn into products. Petrochemical production is generally a linear process and adding each new step in the chain requires adequate volumes of outputs from the step before, investment in the facilities required, and access to markets. For instance, the secondary outputs of an ethylene plant can be utilized only if they are available in sufficient quantity to produce polyethylene, if there is effective market demand for the polyethylene, and if investment is available for the polyethylene facility. This economic dilemma may be met through a broader regional development strategy such as the Alberta Industrial Heartland project.

For general guidance on the creation of by-products exchanges, see the BPX chapter.

Integration with Resource Efficiency Initiatives Across the Region

Developers and managers of PC-EIPs may find that the limitations in utilizing by-products we have just described can be overcome by working in a regional context. A useful model is the Alberta Industrial Heartland project—located in a major petroleum, coal, and petrochemical region of Canada. Here the managers of petrochemical complexes, other industrial leaders, and public agencies are seeking to build an extended eco-industrial network across all chemical industries, as well as forestry, agriculture, and others in the petro-industry supply chain. The project has researched all available chemical feedstocks including primary products imported and exported and by-products presently unutilized.

The study has identified basic strategies for improving resource utilization, including:

- Displace feedstocks or products now imported in the region (through local production);
- Process ethylene by-products now exported to other regions (a major gap in this region's petrochemical economy);
- Use new plant development to promote co-generation or by-product utilization;
- Use the analysis of feedstock flows to guide new business development;
- Identify opportunities in transport, support and service firms and infrastructure. (Environment Canada 1999)

With the support of such an initiative, PC-EIP managers could increase the competitiveness and productivity of their facilities and attract the investments needed to enhance downstream production. By working in team with other industries and the public sector they could conduct the analysis of regional resource flows and identify the major business opportunities that also increase the efficiency of resource utilization on a regional basis. These opportunities may result in new tenants for the petrochemical EIP’s land.

Energy Management

Since the energy demand of petrochemical facilities is high, design teams can cut operating costs and reduce environmental burdens by seeking high energy efficiency in every aspect of the facility. Managers of existing facilities should conduct a comprehensive energy audit and determine investments required for retrofitting. Savings from such investments often pay back the investment in as little as a year or two.

PC-EIP energy management should insure the recruitment and co-location of customers for low-grade process heat, usually not utilized in normal operations. It is not cost effective to recover for main processes. Finding a user for such heat could be a primary focus of the EIP design. Hot water or low-grade steam may be used in many other industrial processes or for warming workspace or greenhouses. Heated water can be channeled to aquaculture. Some food processors use heat at low-to-moderate temperatures for functions such as heating water before it goes to boilers.
Given the ease of access to hydrogen in a petrochemical facility, energy infrastructure should include hydrogen fuel cells, at least in pilot installations. Then staff can learn the basics of working with this emerging renewable technology. Potentially the generation of hydrogen could be a means of storing excess energy at times of reduced demand.

PC-EIP engineers should remain alert to chemical process changes that reduce energy consumption at every point along the production stream. For instance, green chemistry researchers are developing catalysts requiring lower operating temperatures to function.

**Water Management**

Petrochemical complexes are large consumers of water, so they can benefit from substantial closing of water loops within the facility. Water and wastewater management should include cascading and recycling of process water. Ideally it would incorporate some degree of restorative recovery -- e.g., constructed wetlands for final stages of clean-up for discharge or reuse. Such wetlands could replace open static ponds for settling and equalization with functional wetlands that serve as tertiary treatment ponds. Remediation biotechnology now includes many organisms that can play a highly effective role in treatment. Features to discourage wildlife would be required in more contaminated wetlands of this nature.

**Site-wide EIA and EMS**

In our chapter on EIP Policy we describe an innovation known as umbrella permitting, site-wide environmental impact assessment, or programmatic EIA. The Philippine National Oil Company is piloting this structure at its site in Bataan. Under the Programmatic Environmental Impact Assessment the entire site will operate under a permit to the Philippine Petrochemical Development Corporation. (PPDC) See Chapter 7.

A logical companion to this regulatory structure would be a site-wide environmental management system. A number of Asian petrochemical parks have applied for ISO 14000 certification. For more detail on the advantages and limitations of EMS see Chapter 10.

PC-EIP management requires a significant information system maintaining collaboration among firms at the site. This would support facility wide inventory planning and optimization and control software to insure that scheduling of product runs is optimized across company and business boundaries.

### 6.6.4 Community Involvement

Excellent relations with local communities is a particularly important aspect of petrochemical EIP planning, development, and operation. Pollution and accidents are major risks to the health of local residents, who can become sources of political opposition. Emissions from facilities at Map Ta Phut in Thailand and their health impacts generated strong citizen initiatives demanding serious change. One company paid for the relocation of a school because of student pulmonary health problems. Ultimately these problems contributed to the eco-industrial park initiative the Thai Government has undertaken.

A PC-EIP will benefit from close partnership with the local community. This can assure collaboration in regional cleaner production, waste reduction, and emergency prevention and management programs. In addition community involvement supports building the skilled workforce the petro-park requires and the creation of supplier and service firms required by the site and its tenants.

The Map Ta Phut EIP initiative places strong emphasis on building strong community relations. The Philippines PNOC development has created a model community involvement program which we cover in Chapter 3.

*There are very few, if any, aspects of a chemical plant's intended and unintended operation that cannot be properly planned for in the design stage. If we carefully consider each operational scenario, knowing the properties of the materials involved, we can today design adequate features
to protect the environment and the employees, while making "in spec" product. There is nothing
intrinsic to a chemical plant that makes it impossible to handle all the materials within the plant in a
safe and responsible manner. But doing this properly is non-trivial; it requires highly skilled
designers, and careful attention to detail at every step of the design and construction process, and
then forever, 24/7, during operation." (Holmes 2000)

6.7.1 Resources on a Sustainable Economy

China-U.S. Center for Sustainable Development. The mission of the Center is to accelerate the
understanding and use of sustainable design and development practices in China and the United States.


London.

The International Sustainable Development Foundation includes the China-US Center for Sustainable
Development, the Zero Waste Alliance, and the Asia Pacific Economic Cooperation Sustainable

Lowe, Ernest. 2000. The Sustainable Economy and Themes for Eco-Industrial Parks. Indigo Development

12, 2000 ©2000 San Francisco Chronicle


6.7.2 Resources on Agro-EIP

6.7.2.1 References

Abuyuan, Alethea, Hawken, Iona, Williams, Roger. and Newkirk, Michael. 1999. Waste Equals Food:
Developing a Sustainable Agriculture Support Cluster for Renova Resource Recovery Park Arecibo, Puerto
Rico. Report from a graduate industrial ecology project by students at Yale University, School of Forestry.
New Haven, CT.

Meganomics Specialists International. 2000. Sustainable Agro-Industrial Development - A Proposal for the
Bulacan Housing and Agro-Industrial (BUHAI) Project. Manila, Philippines.

This site describes many examples of integrated systems for managing farm and food processing by-
products in developing countries.

Institute of Technology http://www.solutions-site.org/cat11_sol85.htm

University, Denmark. http://www.globasia.dk/papers/MBH(01-00)2.htm

Rudy Kortbech-Olesen. 2000, Export Opportunities of Organic Food from Developing Countries.
International Trade Centre. 1999. Organic Food and Beverages: World Supply and Major European Markets. “One of the major conclusions of this study was that demand is growing rapidly in most markets, and that insufficient supply of organic products is the main problem rather than lack of supply. It is on this background that we believe developing countries are going to play a very important role in the global trade in organic foodstuff.”


6.7.2.2 Institutional Resources

Biomass energy web sites: http://www.arkenol.com/links00.html
Centre for Learning, Agriculture; and Appropriate Technology http://www.nttindia.com/sholai_school
Food and Fertilizer Technology Center -- An international information center for small-scale farmers in the Asia Pacific Region http://www.fftc.agnet.org/
P.O. BOX 22-149 Taipei City, Taiwan R.O.C.
Tel: (886 2) 2362 6239 • Fax: (886 2) 2362 0478
E-mail: fftc@agnet.org

International Federation of Organic Agriculture Movements http://www.ifoam.org
In 1992 IFOAM elected members to become regional coordinators in Asia and in 1993 it held its first Asian meeting in Japan hosted by the Japanese Organic Agricultural Association (JOAA), with people from India, Pakistan, Bangladesh, Nepal, Japan, Philippines, China, Cambodia, Korea, and Sri Lanka.

International Institute of Rural Reconstruction offers training and support in integrated, sustainable, people-centered development known as rural reconstruction. Its program areas include regenerative agriculture, environment, and natural resources as well as rural enterprise development. Email: iirr@phil.gn.apc.org

International Trade Centre UNCTAD/WTO is developing an ITC website on organic trade. It will give information on ITC activities in this area and provide linkages to other relevant websites, including those of our partner organizations. Preparation of websites for producers/exporters in DCs may also become an important ITC activity in the future. http://www.intracen.org/itc/welcomef.htm

Integrated Biosystems Network: http://www.ias.unu.edu/proceedings/icibs/lbs/lbsnet/
offers access to current and past internet conferences on ecological farming and food processing, including Internet Conference on Material Flow Analysis of Integrated Bio-Systems (March-October 2000) http://www.ias.unu.edu/proceedings/icibs/ic-mfa

Journal of Sustainable Agriculture http://www.bubl.ac.uk/journals/agr/jsusagr/v14n0499.htm

HYPERTLINKOrganic World directory of organizations world wide supporting organic agriculture, set up by GTZ, a German overseas aid agency: http://www.agrarboerse.de/bioherb/ow/index.htm

The sub-directory of organizations supporting organic farming in Asian countries: http://www.agrarboerse.de/bioherb/ow/asia.htm
6.7.3 Resources for Integrated Resource Recovery Park

6.7.3.1 References

Collaboration with Dan Knapp and Mary Lou VanDevender in proposing a California resource recovery EIP contributed many of the key ideas developed in this section of the Handbook. They are among the key strategists of resource recovery and zero waste. Their company, Urban Ore in Berkeley, California is an outstanding example of putting these ideas into action.


Gozon, Bebet. undated. Experiences In Innovative Solid Waste Management In The Philippines. From a CSIS forum: Mayors’ Asia Pacific Environmental Summit, Summit Proceedings http://www.csis.org/e4e/Mayor41Gozun.html


van de Klundert, Arnold and Lardinois, Inge. 1995. Community and Private (Formal And Informal) Sector Involvement in Municipal Solid Waste Management in Developing Countries. prepared for discussion at the "Ittingen Workshop" jointly organized by the Swiss Development Cooperation (SDC) and Urban Management Programme (UMP) in Ittingen, Switzerland, for 10-12 April 1995. getwww.

United Nations Centre for Human Settlements (Habitat) The City Agency
6.7.3.2 Institutions and web sites

Many of the US sites listed here may offer strategies useful in developing countries of Asia: investment funds to finance resource recovery firms, policies and incentives, and market analysis.

Cabazon Resource Recovery Park: Ted Newman, Planning Director or Janice Kleinschmidt, Public Information Officer, Cabazon Band of Mission Indians, 760-342-2593, Ext. 3009 Theon214@gt.net


Grassroots Resource Recovery Network aims for a zero waste goal. zerowaste@grrn.org http://www.grrn.org


Northeast Recycling Council (US) www.nerc.org

NERC's Recycling Economic Impact Study RFP (scoping document lists recycling and reuse business categories and includes SIC codes. This gives a broader view of the industry.

Sustainable Jobs Fund, a community development venture capital fund, focuses on job creation in economically distressed areas, including recycling & environmental industries. Raising a $15M fund initially.

6.7.4 Resources for Renewable Energy EIP


ASTAE: The World Bank's Asia Alternative Energy Program (ASTAE) was established in 1992 to mainstream alternative energy (renewable energy and energy efficiency) in the World Bank's power sector lending operations in Asia. Since its inception, ASTAE has and continues to support a broad portfolio of alternative energy projects and activities throughout Asia. While lending operations are funded primarily by the World Bank and the Global Environment Facility (GEF), ASTAE has relied on a number of donors and partners to support its work program. http://www.worldbank.org/astae/


BP-Solarex, the world's largest manufacturer of solar photovoltaic systems. www.bpsolarex.com


The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies provides links to tools for energy efficiency calculations in different sectors: http://www.caddet-ee.org/ee_tools.htm


Cleaner and Greener is a website operated by the Madison, Wisconsin, USA based Leonardo Academy, Inc., a nonprofit organization dedicated to reducing pollution. The Academy works to harness both competitive market and public policy mechanisms as engines for environmental improvement and increased energy efficiency and renewable energy. It reports reductions in GHG emissions, and promotes the development of markets for the emission reductions that result from energy efficiency, renewable energy, and other emission reduction actions. (http://www.cleanerandgreener.org/environmentprogram/moreinfo.htm)

The Climate Change Knowledge Network offers many papers and tools to support stakeholders in developing countries to act strategically in climate change negotiations and using the various renewable energy financing instruments and emissions trading. http://cckn.net/default.htm

The Climate Technology Initiative (CTI) is a multilateral initiative of 23 IEA/OECD countries and the European Commission with the mission to promote the objectives of the United Nations Framework Convention on Climate Control (UNFCCC) by fostering international cooperation for accelerated development and diffusion of climate friendly technologies and practices for all activities and greenhouse gases. http://www.climatetech.net

CTI offers comprehensive links on alternative energy sources in various categories, including financing institutions and strategies. http://www.climatetech.net/links/index.shtml


Electric Power Research Institute (EPRI) research center funded by US utilities. www.epri.com


Energy Ideas Clearinghouse www.energy.wsu.edu/eic/

Environmental Technology Network for Asia (ETNA) http://www.usgtn.org


Greenstar Corporation and Foundation invests in installing in selected villages integrated systems for solar energy, telecommunications, and e-commerce. www.e-greenstar.com


REPP supports the advancement of renewable energy technology through policy research, including Reports and Initiatives. REPP seeks to define growth strategies for renewables that respond to competitive energy markets and environmental needs. http://www.repp.org/

Rocky Mountain Institute www.rmi.org one of the world’s leading private think tanks on sustainable energy and construction.
The Shell Foundation funds renewable energy project globally. [www.shellfoundation.org](http://www.shellfoundation.org)**


Solar Century is creating a Global Community Trust to support installation of solar technology in developing countries. [http://www.solarcentury.co.uk/](http://www.solarcentury.co.uk/)

The Source for Renewable Energy, a buyers guide and business directory to more than 4700 renewable energy businesses and organizations around the world. [http://www.energy.sourceguides.com/index.shtml](http://www.energy.sourceguides.com/index.shtml)

Tata Energy Research Institute, India. “TERI’s firm belief is that efficient utilization of energy, sustainable use of natural resources, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.” [http://www.teriin.org/](http://www.teriin.org/)

TERI. *Participatory rural energy planning: a handbook*. [http://www.teriin.org/pub/books/phe.htm](http://www.teriin.org/pub/books/phe.htm)

TERI: *Rural and renewable energy: perspectives from developing countries*. [http://www.teriin.org/pub/books/re.htm](http://www.teriin.org/pub/books/re.htm)

The UCCEE (UNEP Collaborating Centre on Energy and Environment) website aimed at promoting investments in energy efficiency and renewable energy projects in developing countries and countries with economies in transition. [http://www.uccee.org/PromoteInvestments/index.htm](http://www.uccee.org/PromoteInvestments/index.htm)


WIRE - An initiative of the International Solar Energy Society (ISES). Includes an extensive data base of renewable energy research reports [http://wire0.ises.org/wire/Publications/research.nsf dbs](http://wire0.ises.org/wire/Publications/research.nsf dbs)

Working Group on Environment in U.S.-China Relations bibliography. [http://ecsp.si.edu/china-biblio.htm](http://ecsp.si.edu/china-biblio.htm)

HYPERLINKInternational Institute for Sustainable Energy www.inforse.dk


Renewable Energy In China “China has five million square metres of solar heaters, six million m2 of fixed solar panels, 40,000 m2 of solar-heated greenhouses and 140,000 solar-heated stoves. There are 160,000 small wind turbines with capacity of 50,000 kW, as well as 15 power plants with large turbines from Denmark, the Netherlands, and the U-S, with total generating capacity of 30,000 kW. Ten tidal power stations have been built, with capacity of 20,000 kW.” sunreal/newscom016.html

6.7.5 **Resources for Power Plant EIP**


Cornell University, Work and Environment Initiative. The Eco-Industrial Roundtable minutes for February 2000 gives extensive information on Kalundborg and on the Redhills Ecoplex project. Click on EIPD updates at [http://www.cfe.cornell.edu/wei/](http://www.cfe.cornell.edu/wei/)
HYPERLINKThe Kalundborg, Denmark industrial symbiosis (BPX) is anchored by a fossil fuel power plant. The Symbiosis Institute web site contains an overview of this site: www.symbiosis.dk
See the Kalundborg case study in the Appendix for other references.
RPP International. 1998. A Sustainable New Town, A Concept Paper for ESKOM. Emeryville, CA. (ESKOM is the state-owned power utility of South Africa. This paper included a summary of a potential power plant anchored EIP.)

6.7.6 Resources for Petrochemical EIP
Several colleagues contributed a great deal to this section of the chapter, including Douglas B. Holmes, Scott Butner, Colin Francis, and Stephen Moran.
Butner, Scott. 2000. Personal communication on petrochemical industry. Mr. Butner is a chemical engineer at Pacific Northwest Laboratories.
Environment Canada. 1999. Summary of Eco-Industrial Networking Projects. Oil, Gas and Energy Branch, Quebec, Canada. Contact Manfred Klein manfred.klein@ec.gc.ca
Green Chemistry Institute http://ext.lanl.gov/projects/green/index.html
Indian Chapter, Green Chemistry Institute, Department of Chemistry, University of Delhi Delhi-110007 (India) Fax: 91-11-7256605/7256250 E-Mail: mkidwai@mantraonline.com
Green Chemistry Links http://ext.lanl.gov/projects/green/info.html
Green Chemistry Journal is published by the Royal Society of Chemistry, UK http://www.rsc.org/is/journals/current/green/greenpub.htm
Green Chemistry Network http://www.chemsoc.org/networks/gcn/
Holmes, Douglas B. 2000. Personal communication on petrochemical facilities. Dr. Holmes is a chemical engineer and co-author of the original edition of this Handbook


US-EPA Green Chemistry Site http://www.epa.gov/greenchemistry includes comprehensive lists of organizations and conferences in this field, as well as tools such as: The U.S. EPA Green Chemistry Expert system http://www.epa.gov/greenchemistry/tools.htm


7 Eco-Industrial Policy

7.1 Introduction

An eco-industrial park developer or manager needs to stay in close touch with the changing field of policy and regulations since it contains both opportunities and constraints to their development process. In turn, policy-makers need to be aware of the unique policy requirements of eco-industrial developments. EIPs and eco-industrial networks offer site-based opportunities for testing new policy approaches in areas like Cleaner Production. EIPs seek environmental performance better than simple compliance to regulations. This alone makes support for the innovations they request a priority in regulatory agencies.

In this chapter we discuss the challenges and benefits of developing a more integrated policy framework for industrial development. We explore the value of place-based policy as a complement to national and sector-based policy. We describe the options for linking environmental protection more strongly to policy based in resource efficiency, especially through by-product utilization. We list some of the incentives and research programs needed to support eco-industrial development. In a closely related area of policy, we also summarize some of the pitfalls of energy deregulation and privatization, based on the alarming energy crisis that began in California after a far-reaching de-regulation program there. The costs of energy are high for many industries, so it is important for industrial park developers to understand policies that can help contain them.

Since each country is at a different stage of environmental policy and regulatory development we will cover general principles and some cases to guide this process. Real estate developers may need to work with their government directly or through their trade associations to achieve a policy framework that protects both the environment and enables the innovations that seek cleaner, more resource-efficient development. We believe that the goals of policy makers in environment and industrial development will be very well supported by meeting the needs of industrial park developers and managers who wish to create eco-industrial parks.

“The Asian Development Bank has observed in its work that . . . Most programs to promote cleaner production have failed to address either the underlying policy framework that could provide critical incentives for change or the integrated national planning needed to use resources efficiently to achieve the rapid spread of cleaner production. Both donor and national programs consist of collections of intuitively useful actions to build capacity and awareness. But they have been selected episodically without reference to any holistic perspective of national goals, the conditions required to achieve widespread voluntary change, the public policies required to pursue and support those goals and conditions, and the set of actions strategically selected to best achieve those goals with the available resources.” (Stevenson 2001)

7.2 Integration of Policy and Policy Organizations

A central requirement for more effective environmental protection and industrial development is integration of policy and its implementation. More cohesiveness among the many agencies for environment and for economic development would end the fragmentation and conflicting goals that industry now faces.

Many developing countries in Asia have created a fragmented regulatory structure, following the earlier model set by U.S. environmental policy. The U.S. system has focused on regulation of individual point sources (factories and facilities), looking for ways to improve their performance, minimizing toxic releases by environmental medium (air, water, soil). Separate laws cover air, water, and land and separate offices administer these laws. Often the solutions in one medium generate new problems in another, such as transferring pollution from air release to landfills.
Countries following the U.S. model have also experienced fragmentation between the functions of environmental protection and economic development. Recycling has largely been left to the whims of a marketplace distorted by large subsidies to extraction industries. Environmental and development agencies have often appeared to be in conflict, failing to recognize that resource efficiency serves the interests of both. Similarly both types of agency have often failed to recognize the many financial and market advantages business gains from improved environmental performance. A more integrative approach views industry as a proactive participant in the improvement of environmental performance, not simply a "regulated entity".

In the last decade the costs of this fragmentation have become acutely apparent to U.S. agencies, partly due to leadership from the European Union countries and Japan. Leadership has also emerged in Asian countries, as many of our cases throughout this Handbook demonstrate. The Philippine Board of Investments created an Environmental Department and a unique initiative to encourage eco-industrial development and participation by industry in sustainable development. (See PRIME Project in Appendix.) The Programmatic Environmental Impact Assessment is another Philippine innovation in environmental permitting that also reflects a more integrative approach. (See below.)

This Handbook illustrates dramatically the many diverse issues a real estate developer must deal with in creating industrial parks or estates. Developers need from policy-makers a more integrated set of policies and regulations and a more coherent organizational face to work with. Closer integration among policies and among organizations will reduce the developer's costs and risks at the same time that it will enable each agency to serve its function better.

An earthy example from the U.S. illustrates this point well. Animal feedlots are an alarming source of ground water pollution in many parts of the US and in nearly all Asian developing countries. The US-EPA water office is the responsible agent by law and defines the problem as one of compliance, though it also has a program to encourage feedlot operators and farmers to install anaerobic digestors. The Department of Energy researches biogas systems as a renewable energy source. The Department of Commerce gives loans for small business development. The Department of Agriculture appears more concerned with increasing meat production than addressing issues like this.

With an integrative approach, these different agencies could create a task force to support application of available technologies through entrepreneurial firms. Distributed energy generation and fertilizer companies would install and operate anaerobic digestors and generators in rural areas. The pollution would become power and fertilizer to use or sell. The farms would have a reliable and affordable energy source. The local economy would grow and the energy supply would become more diversified. Environmentally, the result would be improved health of farm land and water systems and reduced greenhouse gas emissions.

Chapter 6 describes this business solution to an environmental problem in the section on agro-EIPs. The Industrial Estate Authority of Thailand and a private development company in the Philippines have proposed eco-parks with this theme that could be home to such a venture. In either case, the overall development would benefit greatly from integration among the many different policy-making bodies.

Education in industrial ecology and the dynamics of eco-industrial development would help achieve this objective of integration among policies and among agencies. Industrial ecology proposes that organizations learn from the functioning of ecosystems and other natural systems. Regulatory processes in nature are distributed, not centralized; they are information driven; and overall balance depends upon self-regulating processes in the diverse elements of an ecosystem. Better understanding of ecological regulatory processes would improve the design of policy and regulations, the functioning of regulatory agencies, and their collaboration with industry.

"The new approach to environmental regulation . . . recognizes that attempts to micromanage a complex system from a single, centralized node are doomed to failure; dispersed control mechanisms and feedback loops are required." (Graedel & Allenby 1995)
7.3 Place-Based Policy

“An approach that focuses on “places” is particularly intriguing because it can include the concept of island economies and industrial estates—“cordoned-off” areas where regulatory and policy practices are able to incubate, mature, and provide data to other places and their policymakers as well. In such cases, the significance of ‘the fence’ becomes more apparent; those physical boundaries make it easier for developers, manufacturers, and local government officials to ensure compliance with safety, environment, and security regulations. A fence line also makes it easier to direct and implement programs more efficiently and keeps out unplanned residential and commercial growth, sprawl, and squatter communities.” (Bateman 1999)

Place-based policy complements national and sector-based policy and provides a coordinated framework for implementation with effective channels of communication. Cleaner Production programs often encounter resistance because they lack this grounding in the local business community. Eco-industrial parks (EIP) and networks (EIN) offer high leverage opportunities for testing and disseminating policy initiatives regionally. Developers or managers of EIPs and the organizers of EINs can act as the champions needed to enlist participation of industrial facility managers. In this way, policy-makers can gain essential feedback in the design and testing of voluntary programs that help to achieve their national goals in environmental protection and industrial development. At another level, “This process is increasingly empowering communities to deal directly with industry that is impacting the economic base or quality of life in the community.” (Stevenson 1999)

In exchange, policy-makers work through the concrete issues that a park manager or developer must address to create a welcoming home for industry. How can they overcome the regulatory obstacles to more efficient use of resources by industry? How can they streamline permitting processes? Is site-wide permitting feasible? What incentives can they provide to encourage environmental excellence in the operations of industrial parks and their tenants? We explore possible answer to these questions in the following sections.

A valuable document on this topic is the US-Asian Environmental Partnership report prepared by Brenda Bateman, *Place-Based Public Policy in Southeast Asia*. This paper covers several cases illustrating application of place-based policy:

- **An innovative market-based incentive.** Using one type of market-based incentive, policymakers in the Philippines’ Laguna Lake Development Authority have implemented a successful environmental user fee system for the economic and domestic activities around this large and heavily polluted lake.
- **Industrial estates in a leadership role.** This is the most universal of the four topics, with the most available documentation and debate throughout the region.
- **The potential for sustainable development through growth triangles.** This is an idea in development. Growth triangles first began in Southeast Asia in the early 1990s and provide unique opportunities to local economies, as well as historic ties to the past.
- **Industrial symbiosis.** Primarily Europe, Japan, North America, and international organizations such as the United Nations Development Programme lead these industrial cooperation efforts, which are now garnering attention in Southeast Asia too.” (Bateman 1999)

7.4 Resource-Based Policy

Environmental policy developed from end-of-pipe controls with the cutting of pollution to the environment as the primary objective. Although policy-makers have gradually added concern with resource issues, the result
is a patchwork of policies, regulations, and voluntary programs. There is no overall framework of policy that seeks to optimize utilization of resources in our economies while preventing pollution.

One of the reasons for the increasing popularity of industrial ecology in the world of business is that it seeks whole systems responses to this need for resource efficiency linked to pollution prevention. Research by Michael Porter and Claas van der Linde links the economic value of regulation to resource productivity, a basic industrial ecology measure of sustainability. (Porter & van der Linde 1995A) The authors emphasize the dynamic character of industrial innovation in response to external pressures (regulations). They offer case studies and statistical evidence indicating that companies in the U.S. and Europe are seizing competitive advantage through the higher resource productivity created by their responses to regulatory pressures.

These companies are looking not just at the costs of compliance but also the opportunity costs of pollution/inefficiency ("wasted resources, wasted effort, and diminished product value to the customer"). When the companies act upon the opportunities, they save significantly from their investments in technical changes that improve environmental and economic performance simultaneously. By eliminating inefficiencies in the use of resources all along a product's lifecycle, managers cut costs and create new values. These inefficiencies include incomplete utilization of material and energy resources; poor process controls; product defects; storage of wastes; discarded packaging; costs of products to customers of pollution or low energy efficiency; and the ultimate loss of resources through disposal and dissipative use. Poor resource productivity also triggers the costs of waste disposal and regulatory penalties.

Reflecting this direct experience in industry, the World Business Council for Sustainable Development now champions the concept of "eco-efficiency" as one of the means of achieving sustainability. It has identified 7 elements of eco-efficiency:

1. Reduce the material intensity of goods and services.
2. Reduce the energy intensity of goods and services.
3. Reduce toxic dispersion.
4. Enhance material recyclability.
5. Maximize sustainable use of renewable resources.
7. Increase the service intensity of goods and services. (WBCSD. 2000)

A cross-agency task force at US-EPA is using the theoretical frameworks and tools of industrial ecology to form resource-based policies that support the search for eco-efficiency in the business world. (Allen 2001) This task force is responding to the leadership Japan and Europe are taking in resource-based policies as well as corporate achievements. For instance, major auto and appliance manufacturers are planning their strategies in terms of emerging European and Japanese product take-back policies. They are not counting on the less advanced U.S. approach prevailing. They must control their risks by helping create the more advanced practice. This is also true of corporations like British Petroleum and Shell that are creating world-wide strategies for greenhouse gas emissions and development of renewable energy technologies.

Ultimately resource efficiency will be a factor in national competitiveness, not just the ability of individual companies to compete. A country's products will have to meet standards imposed by the more advanced countries or they may be banned.

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1 Porter is at Harvard Business School and van der Linde at the International Management Research institute of St. Gallen University in Switzerland.
Businesses devoted to resource recovery recommend phasing out the word "waste" altogether from the names of bureaucracies and the legislation giving them their mandate. It is a word that hides the value of the by-products of our industry and commerce. The challenge is creating policies and organizations for managing resources with very high efficiency (by a factor of 4, 10 or higher). These policies should eliminate subsidies for virgin materials; provide incentives to encourage resource efficiency and recovery of materials and energy; and put disincentives on the disposal of materials as waste. Policy needs to encourage full development of resource recovery systems and phase out continued dependence on landfills and incinerators as the primary means of handling discards. This is essential to creating a real free market for by-product resources.

7.4.1.1 Specific Issues in By-Product Utilization

We identified a number of resource policy issues related to by-product utilization in our initial work for the US-EPA in 1995. Variations of these issues may be found in Asian countries that have followed the US example in regulations. If so, addressing them is a basic part of crafting a resource-based policy.

A number of central definitions require clarification or modification to enable intercompany exchange of by-products.

Definition of waste: Current regulatory language makes little distinction between solid and hazardous wastes and secondary materials that are usable inputs for other applications. Without this distinction, companies find reusing and recycling usable materials that are not contained in a closed-loop recycling system difficult. Determining the regulatory implications of redefining waste materials as useful secondary materials requires industry to work in cooperation with regulatory bodies.

Definition of a "source": The term "source" essentially has a dual meaning in policy language. It can be an entire industrial facility that must aggregate emissions to meet the size thresholds for application of the control and permit requirements. More commonly, the term "source" applies to each point at which emissions are released; the emissions limitations may apply individually to each point of release. As a result, a large industrial facility may contain dozens, hundreds, or even thousands of "sources." Specifying applicable requirements for every individual "source" could be a monumental undertaking.

Liability: In many Asian countries policy is still at an early stage of defining legal liability for the results of pollution, such as requiring cleanup of polluted land or facilities. However, policy-makers are beginning to apply international standards for liability. So companies utilizing by-products will have to contend with a number of possible liability concerns, including: the use of potentially hazardous secondary materials in other applications and the treatment of industrial parks or regions under single regulatory umbrellas.

Many companies cite liability as a major concern when asked about their willingness to exchange by-product materials. Their core concern is that if the production or use of a product containing secondary materials had a serious health or environmental concern, the company that supplied the secondary materials also could be held liable for damages.

Industries also face liability issues when one or more industries are treated under a regulatory umbrella within an EIP. All of the companies under the umbrella would be expected to maintain a code of ethics and take responsibility for meeting the compliance standards or the permit. However, from a regulatory standpoint, monitoring releases from individual industries under an umbrella permit is not always straightforward, especially if industries exchange materials. In addition, if one plant is out of compliance, who is held liable—just the noncomplier or all those under the umbrella permit? (See Programmatic EIA below.)

Single-medium permitting focus: environmental regulation has largely focused on imposing regulations on environmental releases by medium. Generally, one legislative act mandates a bureaucracy that formulates and enforces a set of regulations addressing emissions by point source only to the air. Another act creates a bureaucracy that addresses waterborne effluents, again by point sources. As a result of this media-specific
focus in regulations, industries eliminated some air pollution by converting it to another form of waste, such as sludge to be disposed of on land. Similarly, some waterborne wastes were captured and converted to sludges for land disposal or incineration. The single-medium focus of environmental regulations has largely shifted waste from one form (and medium) to another, without significantly reducing the totals.

For EIP development to be successful, a multimedia approach to regulation will be necessary. Issuing true multimedia permits is not, however, a straightforward process. Single permit documents could be issued, but would essentially contain individual permits for air, water, and solid/hazardous waste based on existing regulations. In addition, implementing a true multimedia permit would require a statutory change, which could take a significant amount of time.

A particularly important area of resource-based policy is hazardous materials policy. In the table on the next page we outline an industrial ecology framework for a policies to create a transition to deep reductions in the use of such materials.

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<th>Player</th>
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<tr>
<td></td>
<td>Policy &amp; regulations</td>
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<tr>
<td><strong>Government</strong></td>
<td>Government agencies create, administer, and enforce policy and regulations</td>
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<td></td>
<td>Government is responsible for reducing use and managing toxic materials in its own operations. It also sets priorities and provides funds for research and education.</td>
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<td></td>
<td>Increase effectiveness of enforcement of regulations and create counter-corruption measures.</td>
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<td>Create product take-back policies and</td>
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Hazardous Materials Management as a Whole System
Create toxic use reporting system with full public access. (The US-EPA’s Toxic Release Inventory is a possible model)

Open channels for public education and action through the internet, greater public involvement in environmental impact assessments.

7.5 Incentives

A key instrument of policy is the creation of incentives for eco-industrial park developers, for park managers, and for companies located in EIPs. This is a form of industrial development that seeks major environmental, economic, and social benefits. The public sector should compensate for these benefits by taking measures that reduce the risks and costs of development. We have touched on some of these incentives above and will fill out the list of options here.

- Participation by national agencies in public private partnerships supporting EIP development.
- Creation of revolving loans, grants, and subsidies for environmental investments, Cleaner Production Centers, or community-wide programs.
- Streamlining and integrating of permitting processes.
- Preferences in government procurement for EIP or EIN members with demonstrated excellent environmental performance.
- Facilitation of financing from international sources available for reductions in greenhouse gas emissions and other global environmental issues.
- Technical support and participation in program design and implementation in areas such as GHG reductions, Cleaner Production, and energy efficiency. Training for such programs.
- Green seal type award systems for environmental management systems designed with industrial ecology principles and values and aggressive Cleaner Production goals.
- Research and development to support the clustering of environmental industries as discussed in Chapter 6 or key objectives such as by-product utilization.

Incentive programs are probably already in place that can be directed toward eco-industrial development. For instance, the Indian government has established the following incentives to encourage environmentally friendly activities by industry:

- The government realizes that most medium and small scale manufacturers cannot afford to install pollution control equipment. Therefore, the government will subsidize pollution control treatment facilities in industrial parks.
- Industrial facilities may take a 100% depreciation allowance on devices and systems installed for minimizing pollution or for conservation of natural resources.
- In order to encourage industries to shift away from congested urban areas, the government is providing a tax exemption on capital gains arising from the transfer of used lands or buildings, which must be used for acquiring land or for constructing buildings for conducting business at a new place. This could be used to encourage participants to join EIPs.
A modified value added tax credit has been extended to manufacturers of pollution control equipment, reducing the cost of production by 6 to 7%.

The government has listed machinery on which it will allow an investment allowance of 35% on the actual costs of purchases expected to assist in pollution control or conservation of the environment.

Donations given to any association or institution for programs on conservation of nature and natural resources are tax exempt.

There are a number of excise and duty exemptions: (a) excise duty is exempted on the production of building materials using fly ash or phosphogypsum in 25% or more as raw materials; (b) custom duty is exempted on the import of equipment, machinery, and capital goods required for the production of building materials which use fly ash or phosphogypsum; and (c) excise duty is exempted on the production of low cost building materials and components. (Bowonder 1994)

India’s Ministry of Non-conventional Energy Sources and state governments offer incentives, concessions, and fast-track approvals for such projects. Most of the projects are expected to generate power for their own use, while some will interface with the government power grid. Thus far, most projects have used wind, solar, co-generation, and mini-hydro electric sources.

7.6 Research Partnerships

In Chapter 6 we propose that the emerging sustainable economy opens opportunities for developing countries to be major players in environmental and energy technologies. We outline several clusters for eco-industrial park recruitment, including renewable energy, resource recovery, green chemistry, and support to sustainable farming. All of them will benefit from research support. By-product utilization itself requires technical innovation in materials design.

National R & D policy-makers should work closely with the business and university communities to create an eco-industrial research agenda. There is no reason Asian developing countries should not seek to gain competitive advantage in these emerging areas of opportunity. Clearly Asian markets will be strong in the next decades for advanced business solutions to the environmental problems accompanying their economic growth.

Industrial ecology provides an organizing framework for researching the systems of technologies and business forms needed to achieve key environmental objectives in an economically feasible way, not just individual technologies. The example we gave above of a business system for dealing with the pollution of animal manure from feedlots is one illustration. Government support to technological development needs to be guided by awareness of the potential synergies among separate lines of inquiry and the way in which a breakthrough in one area may make possible commercial application of several other innovations. We discuss more general renewable energy policy issues in the section on energy policy below.

Analysis of the flows of energy, water, and materials in specific watersheds or bioregions is a specific line of enquiry that could support the establishment of eco-industrial networks and the operation of EIPs. Industrial metabolism is the branch of IE that studies the inter-linked natural and human systems as a network of resource flows. Such studies enable regional stakeholders to identify critical threats to human and ecosystem health and to pinpoint strategic points for intervention. Given basic policies seeking to optimize resource utilization, such studies can also be used to identify significant business opportunities. Studies of resource flows in the national economy are also important in setting sustainable resource policy.

To develop this systems approach to technology policy and research in a developing country requires partnering with UN agencies, international aid organizations, overseas universities, and regional research institutes. A number of universities in North America have growing programs in industrial ecology and Cleaner Production, including Yale, the University of Michigan, the University of California at San Diego, and Dalhousie University in Nova Scotia, Canada.
7.7 Umbrella Permitting and Programmatic EIA

The one-stop shop is a relatively easy way to implement a level of umbrella permitting. Local jurisdictions in the US and Asian organizations like the Philippine Board of Investments have offices that coordinate permitting activities for a variety of agencies. This streamlines the process for developers and for companies building new plants. When this works well, the agencies coordinate their processes for each client and cut the time and investment required to complete the permitting step. A developer could request this integrated approach for an industrial park development.

For eco-industrial parks there is a more ambitious concept: site-wide or umbrella permitting. This could ease the burdens of environmental management for companies as well as for regulators. This would make site-wide environmental management of materials and energy flows feasible, support the sense of collaboration among tenants on an industrial park site, and provide to them a performance challenge. In many cases it might require clusters within the bubble for different levels of environmental burden. However, it is a solution that raises a number of critical issues. Would each plant be liable for the noncompliance of any plant under the permit? Would it make sense to lump together large and small companies, or those with very different levels of potential exposure to liability?

Establishing an EIP regulatory “association” would be one effective way to manage regulatory permitting and compliance matters. Through the association, each EIP tenant would pay a weighted up-front cost and monthly fee based on its level of regulated releases. Some of the regulatory association’s funds could be leveraged against future environmental liabilities. When considering joint liability, the association could exercise the authority to fine or remove tenants if they remain in noncompliance.

Another way of resolving the issues with site-wide permitting is to design umbrella permits as administrative structures that leave potential liabilities in the hands of each member. The companies would establish limits for the group as a whole, with distribution of these limits negotiated among those under the permit.

The EIP management could be the administrator, monitoring environmental performance, handling regulatory reporting, and providing feedback to company personnel. A goal of this system would be to reduce time devoted to regulatory issues by companies and regulators. So long as the environmental performance for the EIP as a whole was within targets (both regulatory and self-imposed), companies would have more flexibility in managing individual performance. At the same time, peer pressure rather than external policing would create the sanctions needed to regulate plants that are outside of limits. Another useful variation is to create different umbrella permits for different groups of companies, depending on their size and potential exposure to liability.

7.7.1 The Philippine Programmatic Environmental Impact Assessment

The Philippine Department of Environment and Natural Resources (DENR) has approved administrative orders for application of this umbrella permit concept under the term “Programmatic Environmental Impact Assessment” (PEIA). DENR has accepted this as an appropriate legal procedure for issuing the environmental compliance certificate (ECC) for proposed industrial estates. The Department’s objective is to reduce the burden of permitting on individual businesses while improving the overall environmental management of the site. (DENR 1966-7)

The Programmatic EIA involves the determination of the environmental carrying capacity of the area proposed for development and the prediction of environmental impacts of various development options and expectations. A spatial, temporal and thematic evaluation of the interaction between mixes of development options and the environmental carrying capacity is done through an iterative participatory planning process. Best combinations are further developed and optimized through environmental management measures. The PEIA has the potential of enabling industrial development to enhance and complement, rather than deplete or degrade, existing environmental resources. At the same time it can promote deeply reduced emissions from industrial activities through closed-loop and resource recovery strategies.
The Philippine National Oil Company is using this structure at its site in Bataan. Under the Programmatic Environmental Impact Assessment the entire site will operate under a permit to the Philippine Petrochemical Development Corporation. (PPDC) DENR has issued an Environmental Compliance Certificate to PPDC that covers specific petrochemical plants that it can establish in the Park without having to obtain individual Environmental Compliance Certificates. In return it develops and implements a comprehensive environmental management program. “As park administrator it regularly monitors compliance to the ECC conditionalities by its own site staff, its locators and their contractors. This includes air and water quality monitoring, studies to establish ecological carrying capacities, a solid waste management program, establishment of artificial coral reefs near its pier facility, maintenance of an adequate buffer zone along the periphery of its property, support to the agro-forestry-based watershed rehabilitation program of the DENR in the area, organization of multi-partite monitoring team to ensure compliance with DENR requirements, and compliance with occupational safety and health standards, among others.” (PRIME 2000) PPDC launched the tree-planting program, the water quality monitoring program and solid waste management in 1998.

This umbrella permitting approach streamlines the approvals process for each new facility coming to a site, thus enhancing the recruitment appeal of the industrial park. The park management’s role gives it more capacity to maintain the quality of tenant environmental performance, which is also a strong attractor for new tenants who demand a clean site.

In Puerto Rico Recovery Solutions submitted an EIA taking a bubble permitting approach in the form of a “worst-case impact analysis.” With the Puerto Rican eco-industrial park project at Arecibo the team has drafted the EIA to define the overall development concept, including the resource recovery facility and generic first tenants for the site. (See Appendix, cases.)

7.8 Energy Policy

A major energy crisis began in California during the Summer of 2000, as the result of deregulation of the power industry. California’s electronics and food processing industries have been hit hard by the steep rise in energy prices. Rolling blackouts during the Winter prompted many companies to suspend plans for new facilities and consider moving existing plants out of state.

In the aftermath of Asia’s 1997 economic crisis the IMF mandated an agenda of energy deregulation and privatization for many countries. Any governments attempting to follow this agenda need to learn deeply from the California story. It is still too early to understand clearly what went wrong. The debate between the utilities, energy wholesalers, regulators, and public interest groups has been fierce, with accusations flying back and forth. Some public interest groups accuse the energy companies and utilities of designing a deregulation law to create a crisis from which they could profit. These companies say that the problem was in a poorly designed law that achieved only partial deregulation. However, both sides played a role in the creation of the legislation.

Eventually a clearer picture will emerge of the combination of errors and calculated self-interest that created this crisis. We advise energy policy-makers in Asian developing countries to follow the analysis that will continue through 2001. Scanning the web sites of the Los Angeles Times, San Francisco Chronicle, and Sacramento Bee as well as those of energy institutes at Stanford University and the University of California will provide valuable lessons from a failed deregulation process.

Clearly California would have benefited from more aggressive policy to develop renewable sources of energy. Two city-owned utilities, Sacramento Municipal Utility District and Los Angeles Department of Water and Power, have moved through the crisis without the steep spikes in prices the utilities have experienced. As we describe in Chapter 6, both of these utilities have major programs to install renewable energy.

Policy for encouraging renewable energy is an outstanding example of a field where a whole systems view is of great value. A country can generate new industries, cut dependence upon non-renewable resources,
lower long-term energy prices, and lower greenhouse gas emissions. Energy policy-makers need to track the timing of commercialization of new storage and transmission devices and a wide variety of renewable sources. Extending distributed renewable energy infrastructure into new regions could be cost-competitive by combining smaller, highly efficient fossil fuel plants, co-generation and energy cascading, wind, photovoltaics, passive solar, geothermal, and biomass sources. By avoiding the costs of building more large centralized power plants and a new power grid, emerging technologies would be fully competitive.

Government procurement can play a critical role by creating long-term contracts for renewable energy products to install in public facilities. Such contracts provide the certainty companies need to invest in production capacity and reduce costs.

For industrial estate developers and managers, incorporation of the design strategies for energy infrastructure and building design that we recommend in Chapter 8 would help diversify sources and improve reliability. Firms need reliable and high quality sources of power that cannot be interrupted.

### 7.9 Anti-Corruption Policy

“There is increasing evidence that corruption undermines development. It also hampers the effectiveness with which domestic savings and external aid are used in many developing countries, and this in turn threatens to undermine grassroots support for foreign assistance.” - James D. Wolfensohn, President of World Bank

Corruption may be the most powerful force against achieving sustainable development. Although the forms may be more subtle, many countries and corporations of “the developed world” are also corrupt, not just developing countries. Asian Development Bank, World Bank, and other multilateral development banks have created major anti-corruption initiatives. Countries like Thailand and Indonesia have created national organizations to fight corruption: the National Counter Corruption Commission in Thailand and Corruption Watch in Indonesia. In the wake of the popular movement that removed President Estrada from office in early 2001, the Philippines is seeking to form strong safeguards against continued corruption.

Although bribes may put money in the hands of many middle and lower level bureaucrats and office holders, over all it increases the concentration of wealth. Corruption diverts money from projects intended to create businesses and employment, to reduce poverty, and to protect the environment.

The Thai National Corruption Commission was created by the Counter Corruption Act in 1997. With strong support from NGOs and many business groups, it has pursued charges against public officials including two Prime Ministers and cabinet members. Press coverage of the NCCC cases is intensive and continuing, helping to assure a new level of transparency in Thai society. As well as investigating individual cases, the Commission is also conducting studies on the patterns of corruption in Thailand and the most effective means of combating it.

The World Bank has created a major initiative against corruption. The web site for this initiative contains publications, case studies, online courses, diagnostic tools, and other assistance to people seeking to create institutions to end corruption in their economy. [http://www1.worldbank.org/publicsector/anticorrupt/](http://www1.worldbank.org/publicsector/anticorrupt/)


Asian Development Bank Defines the Costs of Corruption

The effects of corruption—here defined as the abuse of public or private office for personal gain—are complex and varied. However, both recent experience in the Asian and Pacific region and a growing body of empirical evidence indicate that corruption has a strong negative impact on economic and social growth. Various studies have indicated that direct costs of corruption are substantial, as shown in the following examples.

- Corruption can add between 20 percent and 100 percent to the procurement of government goods and services in several Asian countries.
- Foreign investment is rerouted toward more transparent and predictable investment sites.
- Losses due to corruption can total more than a country’s foreign debt.
- In countries where corruption is endemic, senior enterprise managers spend as much as a third of their time dealing with government officials, as opposed to less than 5 percent in countries where it is not a problem.

The indirect costs of corruption are much greater. Scarce resources are squandered on uneconomical projects because of their potential to generate lucrative payoffs, and priority sectors such as education and health suffer disproportionately. The quality of development projects is compromised, and public safety is endangered by substandard products and construction. Civil service morale is eroded and productivity declines. In extreme cases, corruption can contribute to political instability and regime collapse.

ADB’s Anticorruption Policy makes the Office of the General Auditor (OGA) the point of contact for alleged cases of fraud in ADB projects or among ADB staff. The Anticorruption Unit of OGA (OGAU) receives allegations, performs initial review and screening, and determines whether a preliminary review is warranted.

OGAU’s Mailing Address: Anticorruption Unit (OGAU) Office of the General Auditor Asian Development Bank P.O. Box 789 0980 Manila, Philippines. Telephone No.: (632) 632-5004 Facsimile No.: (632) 636-2152 E-Mail: anticorruption@adb.org http://www.adb.org/Anticorruption/default.asp

7.10 Resources and References

This chapter is based upon our own work in the earlier edition of the EIP Handbook and Discovering Industrial Ecology, not yet released draft papers from sources at ADB and US-EPA, and a number of fundamental papers published by the US-Asian Environmental Partnership.

http://www.usaep.org/resource.htm


http://www.usaep.org/policy/reporttoc.htm


Chertow, Marian and Esty, Daniel. 1997. Thinking Ecologically: the next generation of environmental policy. Yale University Press. New Haven. (Dr. Chertow is one of the leading academic researchers on eco-industrial development.)


See DENR Administrative Orders No. 2000-05, DAO 96-37 DAO No. 94-11

Porter, Michael E. & van der Linde, Claas. 1995A “Green and Competitive: Ending the Stalemate,” Harvard Business Review, Sept.-Oct., pp 122-134. Cambridge, MA. A systems view of competitiveness with case studies and quantitative research indicating that well-designed environmental regulations drive innovation in the whole production process and product design. These innovations increase the productivity of resource use, building overall competitiveness. Includes criteria for regulations that will support this process.


“In almost all cases, when GHGs are prevented, all other emissions tend to drop dramatically. Cleaner energy choices such as conservation, renewable energy, and cogeneration can address reductions in all pollutants with about the same long term financial costs.” -- Manfred Klein, Environment Canada
8 Design Strategies for Eco-Industrial Parks

This chapter describes major options to be considered in the physical design of an eco-industrial park, including support for the design process itself. Use it as a broad survey of possibilities to inform each step of the development process—from vision building to completion. A growing body of architectural and engineering professionals—experienced in successfully applying these ideas—can support your team's work.

Many of these concepts and technologies are becoming standard practice in new industrial facility planning (energy efficiency and pollution prevention). Builders have demonstrated others primarily in commercial and residential developments but they should be evaluated for possible use in industrial facilities. They are definitely relevant to the design of an EIP commons, office buildings, or hotels. Major companies such as General Electric have cut costs with ideas once seen as 'far out', i.e., ecosystem restoration and native planting in the land surrounding manufacturing plants. The Herman Miller case we present later in this chapter shows comprehensive application of green design to a manufacturing plant in the US.

Some of these ideas will cost less up-front and save money over time, such as emphasis on daylighting of facilities to cut down on dependence on electric lighting. Some may require a higher initial investment, but cut operating costs for the park or its companies over the years, i.e. a closed-loop water system like the one Hemaraj Land and Development has built at Eastern Seaboard Industrial Estate in Thailand (see case in water infrastructure below). Others may simply cost more but give less quantifiable benefits, as with the use of non-toxic building materials. Cost savings in one area will enable your development team to make trade-offs to arrive at an overall plan that is both financially feasible and environmentally superior.

Please remember, the following is a menu of opportunities, not a prescription. In your planning and design process, your team will need to determine the system of choices that achieves the economic and environmental objectives you have set for your project. The constraints and special needs of tenant companies will shape their design of buildings, but developers can offer guidelines and support for incorporating design options their own designers may not be familiar with.

We have drawn from several major sources in compiling this chapter. Especially important resources are the Proceedings of the 1994 Conference on Sustainable Construction and the book, Construction Ecology (Kibert 1994 and Kibert et al 2001); Dalhousie University’s Designing and Operating Industrial Parks as Ecosystems (Côte 1994), the American Institute of Architecture’s Environmental Resource Guide, and a wide variety of web sites on design, architecture, and engineering. We also conducted interviews with developers, planners, architects and other design professionals in North America and Asia. The resources section at the end of the chapter gives many other organizations and publications your team can consult for detailed information.

The main categories of this chapter are:

1. Design processes and tools;
2. Site planning;
3. Physical infrastructure;
4. Industrial facility design;
5. Building design;
6. Resources and References.
1.1 EIP Design Processes and Tools

"Each of the . . . actors in the design and development process has different incentives (generally perverse), outlook, and language. Developers speak dollars per square foot; financiers, risk and return; bankers, spread; asset managers, net operating income; lenders' counsel, due diligence; electrical engineers, watts per square foot; lighting engineers, foot-candles; mechanical engineers, square feet per ton and kilowatts per ton; and so forth unto Babel . . . Only collaborative design teamwork can bridge the gulfs of language and perception." (Lovins and Browning 1992)

Eco-industrial park development raises a variety of complex issues requiring the expertise of numerous disciplines. Support and integration of the work of these diverse professionals is central to the success of EIP development and operation. During design and planning, lack of integration among architects, a variety of engineering specialists, urban planners, and economic development agents can lead to a fragmented EIP plan. This means that your EIP development team's greatest challenge is effective systems integration.

Fortunately, there are powerful methods and tools to help you implement a whole systems approach to design and planning. Industrial ecology proposes bringing ecological knowledge into the design of industrial systems. IE also offers design for environment tools that are very applicable to EIP and facility planning. Logistics engineering brings well-tested solutions from decades of experience in design and operation of complex military systems. Teams in landmark projects in sustainable architecture and development have discovered means for developing close integration across disciplines. In addition, designers have developed tools to support more systemic evaluation of the tradeoffs between costs of construction and costs of operation and maintenance (life-cycle costing or LCC) Information technologies further add to our capability for integrating complex systems design processes.

In Chapter 4 we discuss the design team as a learning organization. There are many precedents for designing even physical structures as learning systems. Stewart Brand's How Buildings Learn (Brand 1994) surveys the features of buildings that lend themselves to continuous regeneration and reconstruction. The value of the initial capital and natural resource investment can often be extended by designing for modification and updating to meet new needs. Such adaptability is especially important in a time of continuous and rapid technological change, applying both to construction and industrial processes.

This section briefly summarizes a variety of integrative approaches to design. The complexity of designing an eco-industrial park calls for the strong integrative methods and tools we describe in this section to support a basic strategy of coherent team work. The resources and references section at the end gives organizations, web sites, and publications.

1.1.1 Integrated Design Teams

As we have indicated, the design professions have tended to work in relative isolation, tossing their plans "over the transom" from land-use planners, to architects to engineers. As designers began to address issues of energy and materials efficiency, healthfulness of materials, and impacts of construction they found they had to end these fragmented design habits. To effectively meet environmental goals and keep budgets within limits they started to evolve more integrative design processes. An early case is the planning of a headquarters building for Nederlandsche Middenstandsbank (NMB) in Amsterdam, the Netherlands. The bank instructed its team to work across their disciplines—architecture, construction engineering, landscape architecture, energy and art—and to incorporate employees in the design process.

"The bank stated that human and environmental concerns were as important as economic criteria such as flexibility, efficiency, and low operating costs. Engineers, landscape designers, and artists on the design team all were invited to contribute their ideas from the start, rather than being called upon, as is customary, after the architects and clients had settled upon a scheme. All the
participants in the design process were encouraged to stray into one another's areas of specialization in order to encourage a more holistic integration of design factors. The result is an extraordinarily expressive building shaped by a remarkable synthesis of aesthetic, social, economic, and scientific principles." (McClean 1990 and Browning, William. 1992. "NMB Bank Headquarters," Urban Land. June pp 23-25. Washington DC)

The NMB bank designers worked for three years in this integrative fashion, with construction beginning in 1983 and completing in 1987. Special characteristics of the building's energy systems added about $700,000 to construction costs. Annual energy savings, however, are approximately $1.4 million.

Achieving such coherent team work calls for members of your design team to understand the objectives of the project, how their own contributions interact, and how they come together into a whole design. They must learn to communicate across the walls of their disciplines and understand the special capabilities each brings. You may need to explore fee structures that reward rather than penalize this integrative team approach. One option is to work with two-part fees, split between a standard fee and a performance based fee.

One process used a great deal for ecological planning is the charrette. At one time design charrettes were solely intensive architectural design sessions to meet tight project deadlines. Integrative designers of sustainable or green projects have adopted the term for meetings to build project vision and integrate design ideas from various disciplines. Usually a charrette is a two-to-three day intensive session including the project core team, agency personnel, design consultants, and local citizens. A team at Green Development Services, the consulting organization spawned by Rocky Mountain Institute, has written a useful guide to green development including many project case studies and guidelines for integrative design. (Wilson et al 1997)

Real estate developers as integrators

The real estate developer is inevitably a system integrator, needing to coordinate across many agencies and professions to transform an investment in land into infrastructure and buildings that will provide a competitive return on the investment. To insure filling commercial and industrial spaces in mixed-use projects the developer must gain support of economic development agencies as well as the usual planning/zoning, public works, and environmental agencies. This is done through basic business skills and networking, not through any particular methodology. Similarly, the developer integrates the work of a professional team that usually includes urban planners, architects, landscapers, a variety of engineers, and marketing people.

Guidelines for team integration

Case studies of integrative design suggest a number of basic guidelines:

Assemble the full team early in the process, even before site-selection, to insure that all points of view guide the design process.

Brief the team on the whole system being designed, with a focus on the needs of and benefits to the ultimate users/residents.

Establish incentives that reward teamwork and cost savings that derive from integrative planning.

Encourage input from specialists on all aspects of the project. When contributing outside of their area of expertise they may conceive innovative design solutions more readily than those directly responsible.

Keep channels open for input throughout the project; a project intranet and other electronic tools to keep the whole system in view, to keep the team informed, and to encourage communication across disciplines and interests.
Be sure the general contractor participates from the beginning to help designers understand implications of their choices for cutting cost, minimizing waste, and reducing environmental impact in the actual construction.

**1.1.2 Industrial Ecology as an Integrative Context**

We see industrial ecology as a branch of systems science and practice with particular strengths for integrating multi-disciplinary design teams in eco-industrial parks. Its values and methods guide designers to:

- View the industrial parks and its built environment as part of its natural ecosystem.
- Coordinate planning and action across time and space (local to global; short to long-term).
- Coordinate design choices with emerging understanding of environmental challenges (global to local).
- Balance economic, social, and environmental considerations (human needs and ecological needs and constraints).
- Balance efficiency and resilience in system design. (Resilience is adaptability + responsiveness.)

One of the unique contributions of industrial ecology is its values and tools supporting designing an EIP in its natural context. See the next section for our discussion of human systems as part of ecosystems.

Industrial ecology encourages coordination of planning across time and spatial scales. For instance, deciding between an ecological water-treatment system and a standard sewage treatment plant would require evaluating costs and benefits over the lifecycle of the two systems, not simply estimating up-front construction costs. The living system technology integrates management of sewage, water conservation, and economic development. For an arid region this could have broad implications for water use strategy, helping to avoid conflict locally and even internationally.

IE’s long-term perspective brings another essential dimension to design integration – understanding emerging environmental challenges and economic opportunities. In Chapter 6 we outline the areas of development that the transition to a sustainable economy will open. A current instance of this is research on endocrine system disruption caused by many chlorinated substances. Company and economic planners are developing strategies for the phasing out of chlorinated substances. Manufacturers of building materials and designers of the built environment are searching for alternative materials. IE offers useful tools for tracking such changes and evaluating alternatives.

Planning of a major development requires both internal integration of the design team and coordination with regional strategies for sustainable development. Industrial ecology planning steps might include: an inventory of the area’s ecological conditions and constraints (ecology); a survey of the flows of materials and energy in human systems (industrial metabolism); methods for improving industrial, commercial and household use of energy (energy efficiency) and materials (pollution prevention and recycling); and a means of assessing alternative strategies (design for environment and dynamic input-output modeling). The effort would integrate these IE methods with urban planning, economic and community development, education, and citizen input.

**1.1.2.1 Learning from Nature: the EIP as a Living System**

This aspect of industrial ecology suggests that designers view industry at all levels as a living system participating in the larger natural system. They can benefit by using the principles and dynamics of ecosystems to guide industrial design. (Kelly 1994 and Kibert 2001)
What does it mean to view an industrial park (or a factory in it) as a living system? First, it has a metabolism, drawing materials and energy from other living (or once living) systems: forests, farms, fossil fuels, oceans, the atmosphere etc. It disseminates its products to humans and its unsold by-products to natural systems. It is designed, managed, operated, and regulated by homo sapiens. The air that moves through its employees and processes is itself the result of the interactions of forests, oceans, and animal life.

This may appear to be just plain common sense, however, industrial design has been dominated by mechanical models, and more recently by electronic models. Both are necessary, but not sufficient, for designing an industry that can co-exist with nature in a sustainable fashion. We must explicitly add a living system awareness to achieve this goal. 3.5 billion years of evolution is a firm foundation for integrating the work of developers, architects, engineers, and planners into a design for a park that functions in harmony with its environment. (For more detailed discussion of ecological concepts in industrial park design see Côté 1994 and Kibert et al 2001).

However, it is important to avoid simply using the jargon and cliches of industrial ecology, as in, “There is no waste in nature.” (often untrue). Valid uses of this design strategy could involve mapping the dynamics of a desert ecosystem to suggest methods for managing scarce resources useful to your design. Study of the high variety of organisms and processes that decompose matter in nature could point to new methods for turning still unusable by-products into feedstocks.

John Todd’s “Living Machines” demonstrate a remarkable strategy for cutting waste of the increasingly valuable resource of water through ecological and agricultural processing of sewage, essentially viewing this aspect of infrastructure as part of nature (see below under infrastructure for water). This approach to treating water supports economic development planners in creating green job opportunities and augmenting organic food production. It would also connect well with ecological landscaping that creates wetlands for purifying storm water runoff. IE assumes that all infrastructure issues at a site can best be handled as whole systems embedded in natural systems.

An EIP design team will benefit from having an ecologist as a project consultant. Ideally, this would be someone who has knowledge of the dynamics of different ecosystems, good communication skills, and possibly experience in restoration or other applied ecology projects. An ecological consultant could perform a number of valuable functions, such as:

- Playing a key role in evaluating sites for the EIP.
- Participating in design charrettes to help your team model your development as an ecosystem in its natural setting.
- Supporting the design of EIP landscaping.

This level of expertise would complement the more traditional role of ecologists or biologists in determining the impacts of a development project on the environment.

A very valuable work for understanding design and construction in an ecological context is Construction Ecology: Nature as a Model for the Built Environment (Kibert et al 2001). This work resulted from the collaboration of designers and engineers, ecologists, and industrial ecologists at a working conference organized by the Rinker School of Construction, University of Florida in 2000.

1.1.3 Logistics Engineering and Management.

Logistics engineering and management is a support process that crosses all boundaries. It provides a systemic framework and tools to harmonize the complex web of interaction implicit in the development, operation, sustaining and eventual retirement of very large-scale systems such as your EIP. Historically, logistics developed as a set of methods for moving, supplying, and supporting a military force in battle. The
discipline's most complex mission has been the design and operation of aerospace systems such as the Apollo program or major weapons systems. Logistics engineers are now converting their sophisticated skills and tools for civilian applications, including the design of environmentally sensitive industrial systems. (O'Dea & Freeman 1995 and personal communication)

A basic tool-set, Integrated Logistics Support (ILS) is a sophisticated group of methods and tools that have evolved primarily to guide the development of complex military systems, including base and facility design. This well-tested approach could help your team to systematically integrate all down-stream requirements of your EIP into a comprehensive front-end analysis and design process. For instance, ILS methods can support the design of your EIP's water infrastructure. It would insure effective integration of water use in production plants, support buildings, and landscaping; ease and cost-effectiveness of operation and maintenance; and the ability to redesign to meet new industrial or environmental requirements. ILS can also facilitate the integration of water systems design with energy, materials, and telecommunications systems. Logistics engineering methods would also be very relevant to the design of energy and materials exchange networks within an EIP or between a park and regional industry.

*Comprehensive system analysis in EIP planning may be the most critical element of design for successful operation.* All of the quality parameters required for effective operation and support of your EIP must be designed- and built-into the EIP. There are many tools and methodologies available and currently used by various disciplines to accomplish this front-end analysis and facilitate the process of designing for various technical, business, and environmental objectives. Logistics engineering and management offers the means for connecting them into a whole system.

For example Integrated Logistic Support (ILS) in EIP planning could:

- Enable the development of an integration plan your team can continually upgrade as the project moves forward;
- Evaluate all available tools and methodologies in order to select the ones most appropriate to each of the defined objectives and goals of your project;
- Integrate cross-disciplinary application of the selected tools;
- Assimilate results of different realms of analyses into a single, comprehensive information database known as a logistics support analysis record; and
- Support all disciplines involved in the development of your EIP in considering the park's combined economic and environmental mission in their design and development decisions.

Logistics engineering and management functions across the full life-cycle of a project, from initial project vision through retirement and deconstruction of the facility. It can help minimize the number and severity of surprises resulting from the dynamics of EIP physical, metabolic and functional (tenant) inter-dependence.

Your EIP development team can learn more about this approach by working with local logistics engineers to adapt the ILS framework to fit your project and community needs. The Society of Logistics Engineers, the Council of Logistics Management, and the Construction Engineering Research Laboratories are sources of information. See Resources at the end of this chapter.)

1.1.4 Design for Environment

Architects and engineers seeking to apply sustainable design principles in their work have a growing range of environmental options, specifications, and data available. A work like the American Institute of Architects' *Environmental Resource Guide* provides a wealth of possibilities. With so much data, designers need better tools to support their complex decision-making process.
Design for Environment (DFE) offers one approach to decision support for designers. It has evolved out of concurrent engineering and product life-cycle analysis as a vital stream of industrial ecology. Initially, DFE developers have applied this approach to all potential environmental implications of a product or process being designed—energy and materials used; manufacture and packaging; transportation; consumer use, reuse or recycling; and disposal. DFE tools enable consideration of these implications at every step of the production process from chemical design, process engineering, procurement practices, and end-product specification to post-use disposal. DFE also enables designers to consider traditional design issues of cost, quality, manufacturing process, and efficiency as part of the same decision system.

Two industrial ecologists, Braden Allenby and Thomas Graedel, have extended their application of DFE to industrial facility design. (Allenby and Graedel 1994) As in the electronics applications, they recommend a largely qualitative rather than quantitative approach. They believe the design task is generally too complex to lend itself to quantitative analysis. In complex design situations, they state, "Quantitative models simply eliminate too much information that could be valuable to the designer in reaching design decisions." In addition, too many value-judgments are buried in the data; and the data itself is too incomplete to drive a quantitative system.

Allenby and Graedel offer tools to help designers compare alternative options in a more systemic way and to graphically demonstrate those aspects of design that would most improve the environmental performance of a facility. The matrix for design of industrial facilities has question sets for each cell that designers use to score each activity against five environmental concerns. Typically DFE uses more detailed matrices to feed evaluations into each area of a more general analysis like this. The DFE matrices seek to provide a design team speaking many different professional languages a common framework for seeing the whole project and the place of each part in the whole. This industrial facilities matrix and question set is in the Appendix, Supplemental Content.

"Technology is evolving so rapidly, we should design eco-industrial parks for optimal flexibility, disassembly, and reconstruction. We’re moving toward a flexible, modular infrastructure concept. This is a targetable engineering objective. For instance, chemical process and equipment design often enables pulling a few switches and generating different products from the same input stream. This gives resilience to the use of capital equipment in the face of shifting market demand and business cycles.

This principle of design for flexibility may be the easiest way of communicating the idea of the ‘learning system’ to engineers and developers. One of the characteristics of a learning system is that you have ease of making and breaking connections as conditions change. This idea can be used both literally and metaphorically in the design of an industrial park." (Tibbs 1994)

1.1.5 Industrial Metabolism

One IE method, industrial metabolism (IM), traces materials and energy flows from initial extraction of resources through industrial and consumer systems to the final disposal of wastes. This analysis at a community and regional level enables planners and residents to understand how an integrated resource recovery systems could improve the efficiency of energy and materials flows through a local economy. Community metabolism studies enable planners to create strategies for developing new businesses and jobs, for creating education and training programs, and for extending the life of major municipal infrastructure investments. This would help build a strong closed-loop economy operating with high resource efficiency and low pollution. (Lowe et al 1997 Chapter 3)

For the developer of an EIP, such industrial metabolism studies would highlight potential resource recovery companies that could be recruited to the park and indicate the potential for creating a resource recovery park (see Chapter 6).
Other industrial metabolism studies could focus on the flows within the construction industry or for an individual plant. Models of construction metabolism would suggest strategies for reducing waste and otherwise lowering financial costs and environmental impacts in the building of an EIP. (Kibert et al 2001) Study of the metabolism of an industrial plant or even of a major service business, like a hotel, helps managers identify major opportunities for costs savings and pollution prevention.

1.1.6 Life-Cycle Costing

Designers have most frequently used life-cycle costing (LCC) in retrofitting building energy systems or in design of new building energy systems. In these applications, LCC tools calculate the benefits of such features as energy efficient windows, daylighting, insulation, or alternative heating, ventilating, and air condition systems over the full life of the building. A large number of software tools, such as DOE-2, enable simulation of a building’s energy performance in order to determine life-cycle cost and payback on the higher initial investment. Sustainable architectural and engineering teams have pioneered this systems view of the economics of construction in many green buildings, such as the Audubon House in New York City. (Audubon Society 1994)

Designers are now beginning to use life-cycle costing tools to assess all aspects of building design, not just energy systems. Planners of new US government facilities are often required to evaluate the cost of operating the buildings over their full life-cycle. Savings in long-term operations are used to balance possible increases in the costs of materials, products, and equipment used in initial construction. The analysis may include the benefits of increased efficiency, lower pollution, and improved working conditions for employees (which usually translate into increased productivity).

Private sector financial institutions are just beginning to take life-cycle costs into consideration. Development banks can demonstrate to them the overall value of this approach by using LCC and income-capitalization appraisal in reviewing loans and grants. Christine Ervin, Director of the U.S. Green Building Council, says, "Eventually, the superior attributes we find in green buildings should start getting reflected in things like lower insurance rates, better refinancing options or help getting a critical loan in place." The income-capitalization appraisal method can help convince appraisers and lenders that the lower operating costs and other benefits give green buildings a higher value. With this method, a building's asset value is the net operating income (NOI) divided by the prevailing cap rate. If the NOI goes up, the value goes up. (Kozlowski 2000)

Mark Rodman Smith of Pario Research has worked with this method in his design of real estate financing in the US. He says, "It's generally the right understanding and approach. Obstacles include the need for debt and equity finance to buy in and a possible need to restructure cost and revenue flows. The appraiser must agree. Owner-occupants, such as corporations, universities or other institutions, control most of these processes. Because of that they have been the biggest group to adopt income-capitalization of green buildings." (Personal communication 2001)
Tools for Life-Cycle Costing

We have already discussed one set of LCC tools that logistics engineering has developed. These sophisticated life-cycle cost analysis tools are integrated into a more comprehensive logistics planning approach. LCCA is one segment of the integrated logistics support process. This approach to life-cycle costing may be adapted to questions of design in an EIP as a whole system and its infrastructure, as well as the individual buildings.

Several web sites contain descriptions of other LCC software that can be purchased or downloaded for free. The US Department of Energy’s site, http://www.eren.doe.gov/buildings/tools_directory, gives access to over 200 software tools for buildings, with an emphasis on sustainable design, energy efficiency, and using renewable energy in buildings. There are programs here for whole building analysis – energy simulation, load analysis, renewable energy, retrofitting analysis, and sustainable/green buildings. This site also includes tools for evaluating materials, components, equipment and systems.

The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies: http://www.caddet-ee.org/ee_tools.htm has tools for energy efficiency calculations in different sectors.

1.1.7 Webs of integration

Telecommunications and information technology is rapidly enhancing capabilities for integrative design and citizen involvement. Sophisticated 3-D graphics and virtual reality systems, computer assisted design (CAD) programs, geographic information systems (GIS), geographic positioning systems (GPS), teleconferencing, and the World Wide Web are some of the key tools enabling multi-disciplinary teams to coordinate planning and design processes. While electronic tools cannot replace face-to-face design sessions, they can support continuing communication and co-creation once a team spirit is established. (Cohen 2000) The webs of integration can include public web pages, citizen input meetings, displays in public spaces, a series of printed project reports, and focus groups.

An interesting early example of collaborative design via the internet developed in 1998 between the Porto School of Architecture (FA UP), the Lisbon Institute of Technology (IST), and the Massachusetts Institute of Technology (MIT). It was an urban design charrette, focused on an area of Lisbon. Participants worked in teams composed of members from all three institutions, and used virtual design studio technology, including videoconferencing, the World Wide Web, and rapid prototyping to carry out their work. The project concluded with a jury of remote participants via videoconferencing. (Lisbon Institute of Technology 1998)

A Project Operations Center

A project operations center for EIP planning would enhance integration across the many disciplines and languages involved. This room would have computers, graphic projection equipment, faxes, whiteboard and corkboard on all walls. In this facility, any working team would be able to reference a graphic model of the whole project and all of its sub-systems. It could also display project timelines, budgets, geographic information system (GIS), site-photos and renderings of the site-plan, and other conceptual maps of the work they are doing. This level of access to easily absorbed information would enable project teams to better integrate their work and to communicate with future tenants. This operations center would continue to function through all phases of project development and then serve as a hub for eco-park governance.
A Green Factory in the US

Phoenix Designs is a Herman Miller subsidiary manufacturing office systems and furniture, largely from recycled materials. A design team led by William McDonough has applied the company's environmental values to planning a 290,000 square foot building in Michigan, with spaces for manufacturing, storage, offices, a Wellness Center, cafeteria, and docks. The plant is scheduled for occupancy in October 1995. "The environmental impact of the building is a primary concern; the objective is to minimize the visual impact of the building, to preserve and enhance the existing natural habitat and to seek to achieve a zero-emissions building. The health and well being of the employees is also a major concern."

The Phoenix Designs building will be closely integrated into its ecosystem, which is a transition between oak/hickory and beech/maple habitats. Landscaping will feature native trees, shrubs, grasses, and wildflowers. The pattern of reforestation will shelter the new building from winter winds and snow drift. Existing and new wetlands will provide wildlife habitats and cleanse stormwater runoff before it goes into the adjacent Black River. (Runoff from paved areas will first go into settlement basins to remove petroleum or metals.)

Exercise and nature paths for employees will wind through the layered site, prepared with minimal impact on natural forms. The landscape will "enter" the building through plantings in courtyards and along an internal skylit street.

The building itself will be structured to allow maximum flexibility for the rearrangement of manufacturing and warehouse space and easy expansion as the project moves to a second phase. The design also enables possible future "recycling" of the plant into completely different uses, should the company no longer need it for manufacturing, i.e. high-bay areas could be converted to two-story use.

Designers will consider life-cycle analysis of environmental impacts in selecting materials, including their sources, manufacture, embodied energy, and toxicity. In selection of materials, systems, and assemblies they will consider recyclability, durability, disassembly, and reuse, including the 'recycle-ability' of the entire structure.

Phoenix Project designers seek energy efficiency and the comfort of employees through the optimal use of skylights (with solar optic and diffusion features), clerestory windows, and both automatic and manual controls. Electronic sensors will control artificial lighting to adapt it to the level of daylight available and to turn off lights when areas are not occupied.

A central "interior street" will function as a solar furnace and visual magnet for the building. Its features include natural and heat absorbing finishes and a continuous, optimized expanse of sloped glazing formed along a gently curving linear aspect. It will provide substantial daylight for adjoining offices and manufacturing areas, while facilitating movement of people and the warmth it generates.

The Phoenix Project team estimates that these features of the building's design will reduce annual energy consumption by 30% over baseline costs for a moderately energy efficient building. Daylighting and passive solar strategies will save $80,000 annually, with a simple payback period of just over 5 years. Similar projects also show further savings can be expected from increased productivity thanks to indoor air quality, daylighting, and thermal comfort.

Filtered fresh air systems will insure an abundant supply of fresh air to all manufacturing and office workers at their work stations. Also, windows can be opened when weather permits to create air currents. A recent study conducted on the workers at this building provides strong evidence that enhanced habitability is associated with increases in psychological and social well being. (Heerwagen 2000) Such improved well-being translates into increased productivity.

(Based on project design documents, used by permission of William McDonough + Partners and Herman Miller Inc. 1994. The Phoenix Designs Project. Charlottesville, VA. http://www.mcdonough.com/)
1.1.8 The Cost of Whole Systems Design

San Francisco architect, Bill Berks, told us, "Design costs will increase. It takes more time to design a building that is more efficient and environmentally sound." He thought that a multidisciplinary design team calls for professionals working together, learning from each other and billing more hours in the process.

Virginia developer John Clark put the question of ecological design costs in a larger framework (Clark 1995):

"Is it more expensive? In using this type of holistic planning we spend a lot of money in a short time in the beginning. My Haymount project cost $600,000 in planning. But the data that came out of that planning was never questioned for its scientific objectivity and accuracy. The development plan itself was not changed from the day it was drawn to the day it was approved. A sister project planned with a regular process cost 'only' $175,000 to plan. In the course of approval it was changed repeatedly and the design changes cost 8 million dollars before we could go ahead. At the end the plan was unrecognizable, densities were reduced, and locations shifted. What I bought for $600,000 at Haymount allowed me to move through without the plan suffering, costing me less than a tenth of what the other project cost. So good upfront planning is really more economical." (This quote is from a project interview with Clark on April 27, 1995.)

1.2 Site Assessment and Planning

We have applied the environmental performance framework to the process of site assessment as support for your project's site-selection and design teams. This detailed discussion is the Appendix, Supplementary Content -- Environmental Performance Issues in Site Assessment. This guide to assessment also provides many ideas for planning.

In planning site development for an eco-industrial park, your team will need to consider several key issues. What qualities of the surrounding ecosystem could be impacted by construction of your EIP and by its operations? How can you best preserve features of the ecosystem within the site's boundaries in your planning? What natural resources at the site can be incorporated into infrastructure and building design? How can landscaping with native and/or food producing plants be incorporated to enhance your EIPs environment (and value to tenants)?

Industrial park site selection teams usually review capacity of regional transport infrastructure to support tenant needs. We encourage them to give high priority to good rail access as a criterion. Under transportation infrastructure below we detail the advantages of this for an EIP.

You may find it useful to hire an environmental management and ecological planning firm capable of doing both the standard study to prepare an environmental impact statement and of helping your EIP team to respond to this more proactive set of questions. By answering them well you can enhance the potential for success of your EIP and achieve greater harmony with the surrounding environment.

1.2.1 The Ecosystem as Guide to Landscaping

Take into account natural habitats, stability of dominant plant/animal groups, wetlands, and endangered or threatened species in developing the site landscaping plan. A primary question is, to what extent can the existing ecosystem be preserved and incorporated into the design of landscaping and water management? If the site is damaged from previous use, to what extent can it be reclaimed and restored as an ecosystem?

The landscaping of an eco-industrial park will lend itself to recreational uses: walking and jogging trails, picnic grounds, and bird viewing spots, to name a few.
1.2.2 Site orientation

An often overlooked characteristic of a site is its orientation. Simply noting which way is North and where the sun rises and sets provides an initial basis for using a building's exposure to sun. Daylighting can reduce the need for electrical lighting, which also lowers the need for air-conditioning. Passive solar heating and cooling can serve office areas, cafeterias, warehouses, and many other spaces.

1.2.3 Micro-climates

Gathering data on your site's micro-climates provides valuable guidance to design of infrastructure and landscaping and the form and orientation of buildings within the site. Each site may have important variations in wind patterns, temperature, and precipitation. Map the hot, cool, wet, windy and dry places in your site and use this information regularly in your planning process. It can have significant impact on issues like heating and cooling costs.

Your landscape design can help modify wind and storm water flows, and snowdrift patterns through such tactics as planting groves of evergreen trees or building constructed wetlands at critical locations.

1.2.4 Vegetation

Existing native trees, shrubbery, flora and grasses provide clues about the site's climate, micro-climates, hydrology, geology, topography and ecology. They also can be a core component of the landscaping plan. Introduced vegetation (species native to the region as much as possible) can improve micro-climates and energy efficiency by acting as shade and windbreaks. Enough trees can have a major cooling effect in the whole site. Carefully designed landscaping also reduces erosion and adds to biodiversity, which encourages wildlife settlement.

Vegetation with appropriate species in wetlands helps filter pollutants. Drought-tolerant species minimize water consumption. Generally native plant landscaping reduces maintenance costs.

LIMA, a Philippine industrial estate in Batangas Province, has included design elements that protect local ecosystems. LIMA Land has a subsidiary, LIMA Nurseries, Inc. which acts as the caretaker for all 700 hectares of the property. The nursery grows endangered Philippine plant species to plant in LIMA City and on the park's grounds. The estate's wastewater treatment plant ensures that wastewater discharged from the estate is cleaned to class "A" effluent standards. This recycled water will be used primarily in the irrigation of Lima City's fully landscaped environment. (LIMA 2000 [http://www.lima.com.ph])

Below, under infrastructure for water, we discuss a closed-loop water system in a Thai industrial estate that incorporates constructed wetlands for tertiary treatment.

1.3 Design of Physical Infrastructure

Industrial park infrastructure encompasses the physical support systems used by most, if not all, of the tenants of the park (and their employees and support services). This includes facilities for transportation of materials and people to and from the site (e.g., roadways, railways, docks and harbors, and canals); for production and supply of energy (e.g., photovoltaic, wind, and fuel cell generating stations, electrical distribution lines, gas pipelines, etc.); for storage, treatment and flows of water to and from the site; for materials management; and for telecommunications (e.g., telephone cables, fiber-optic networks, satellite dish antennas, and meeting/conference rooms).

We will describe a number of options in each of these areas that can support your design team in achieving your EIP environmental and economic performance objectives.

Several overall guidelines may be useful to consider in infrastructure design:
Infrastructure is the foundation on which the whole EIP will be built. Everything depends upon it. It must be reliable, attractive (where visible), unobtrusive, easy to maintain, and economic to operate.

- Involve regulatory and other permitting agencies early when considering any innovative technologies. Negotiate exceptions to present codes that could block some of them.
- Emphasize ease of maintenance as well as ease of redesign and reconstruction to accommodate continuing cost savings and technical innovation. (For instance, common underground utilities for water, gas, communications flows could be in easily opened sub-surface channels, not requiring breaking up and repaving streets.)
- Seek infrastructure technologies that can operate in a modular and/or decentralized fashion, whenever this is economically and technically feasible. (Energy co-generation units, for instance, can be installed where needed over time, in contrast to a large centralized power plant.)
- Design installation of infrastructure to maintain natural characteristics of the site, including landforms, slopes, waterflows, windflows, trees, and plants.

Modular and decentralized technologies save present investment so long as provision is made for adding additional capacity as it is required. For example, when installing renewable energy equipment, just put in the number of fuel cells, wind turbines, or solar-cell arrays that are needed in the next few years, and place them as close to the point of use as you can. This is much cheaper than building a large, central fossil-fueled power plant, based on the projected needs 15 to 20 years in the future. You are also in a position to upgrade to higher performance technologies easily, as they evolve.

One example of this last principle is a civil engineering approach called trenchless technology. This is a method of laying pipes, cables and other utility items by underground excavation with almost no disturbance at the surface. This can be used in the installation of pipes through tunnelling, microtunnelling and pipe jacking techniques. The method can handle pipes from 100mm (4 inch) up to 3m (10 foot) in diameter.

1.3.1 Transportation

Effective transportation infrastructure is central to any industrial park's success. Each tenant requires easy access for its customers, employees, and suppliers. Each needs dependable and economic transport of raw materials to the site and of finished products from the site to the customer's location.

Key environmental performance objectives in the design of the transportation infrastructure include reducing energy use, air emissions and ground contamination to minimize impact on the land and optimize use of materials. By taking a systems approach in achieving these objectives, your team will integrate physical and social aspects of design. For example, employee transportation services and incentives offered by EIP management can reduce the need for single car trips and parking facilities.

1.3.1.1 Roads and Parking

Porous paving allows water to percolate through the surface rather than run off in concentrated flows. A variety of products including recycled plastic block, wire mesh, and concrete pavers allow some normally paved areas to be solid enough for parking and walking, yet open enough for grass to grow. For solid paving, select materials for durability, i.e., crumb rubber added to asphalt extends asphalt life significantly. It may be useful to calculate a figure-of-merit as a target; perhaps the area of occupied floor space in the EIP divided by the area of paved roadways. Strive to maximize this ratio.
1.3.1.2 Transportation of Materials and Products

In many developing countries developers may be able to benefit from the financial, social, and environmental advantages of rail transportation. If you include rail access in your site selection criteria and build rail infrastructure into your transportation system, you will lower energy and air emissions burdens from transportation. In addition, rail transport is simply less costly as long as flexibility in the logistics of getting product to market is maintained. You can offer tenants this flexibility by including a piggy-backing terminal, with an overhead crane and truck tractors to move trailers onto rail cars when necessary. Depending on the size of your park, rail passenger transportation for employees may also be feasible. Rail also opens access to a potentially useful innovation for materials processing.

1.3.1.3 Mobile Materials Processing Units

You may find that some materials flows create niches for intermediate companies in your EIP to process by-products into usable feedstocks. For instance, a refinery on a truck or railcar could purify toxics for reuse on-site, neutralize them into benign waste, or refine them to reusable elements. Possible technologies include: oil/water separation, neutralization, solidification, centrifuge separation, biological treatment, and distillation of solvents. The unit would include the range of treatment technologies required for the materials generated at each site. Many non-toxic by-products may not accumulate at a rate sufficiently rapid to warrant a processing plant on-site to turn them into usable feedstocks. Processing equipment on a rail car (or truck) could move the service around a circuit of industrial parks. This could eliminate transportation and storage of toxics by processing them where they are used. Rail tank cars transport a major share of toxics and often are used for storage before use. (Personal communication with Jose de Jesus Vargas, chemical engineer and manager of a Gases Industriales air separation plant in Mexico. February 10, 1995. He was part of the design team for a mobile PCB processing unit proposed for US-Mexican border industrial parks.)

Priority in planning should still go to toxic use reduction strategies and searching for effective substitutes or process changes. When there are no alternatives, companies should seek to reduce toxic risks through synthesis at point of use wherever possible.

1.3.1.4 Transportation of People

Movement of employees to and from work and in the course of their work is a major use of energy and source of air emissions. EIP design can reduce these environmental costs by creating a range of transportation services in coordination with the local/regional transportation system. This service may create business and job opportunities in your community.

Some options for employee transportation include:

- When climate and residential patterns permit, make it easy for people to walk or bike to work. (Many industrial parks in Asia include residential areas as part of the development. The merit of such mixed-use planning will depend upon the industrial mix in the park and the willingness of employees to live near their work.)

- Create EIP services to support car-pooling and offer van transportation, integrated with regional transportation services.

- Park management may coordinate access to dependable and prompt transportation services which can be scheduled for off-site work trips by employees of any companies at the site.

- Consider using vehicles (buses, vans, taxis) powered by electricity, compressed natural gas (CNG), or fuel cells. Vehicle manufacturers are seeking high profile sites for demonstrating their new models.

- Provide attractive waiting areas at bus stops and taxi stands with appropriate weather shelters.
Consider limiting or eliminating “free” parking for employees as a disincentive to single-driver trips. Encourage tenants to provide incentives to achieve this goal.

Encourage tenants to consider staggered shifts or starting times which can significantly reduce peak traffic congestion. Management can provide a transportation coordination service to support this.

Telecommuting can be a major contributor to traffic reduction and employee satisfaction.

Some basic services at the EIP can reduce employee transportation needs before and after work: a daycare center for children, a bank branch or ATM machines, a pharmacy, and similar facilities may significantly reduce the need for local travel.

If parking areas are placed under buildings, carefully consider the location of entries to the buildings, so as to avoid having polluted air from the parking areas enter the buildings. Air from underground parking areas in a Japanese office building is captured and blown upward through soil-bed filters, where microbes destroy the toxins, including carbon monoxide and oxides of nitrogen. (“Urban Oasis” in Popular Science. Jan. 1995).

1.3.2 Energy Infrastructure

We have suggested two basic environmental performance objectives for energy infrastructure in an EIP: optimize total energy use and maximize use of renewable sources. A feasible goal within the first objective could be reducing energy usage by 50% in the total system of the EIP, its infrastructure, and its plants compared with conventionally designed parks and plants. The potential for renewable sources will vary greatly from area to area, however many industries need reliable sources of quality energy enough to pay premium rates.

Energy infrastructure offers a good illustration of the need for systems thinking in EIP design. As companies contract to build plants at your park, your design team can offer energy efficiency planning resources to those not already aware of the full range of opportunities. As they design their plants embodying a high level of energy efficiency, their estimates of peak power needs will go down, reducing the capacity of grid and on-site power sources needed.

We will discuss means of achieving energy related performance objectives at the infrastructure level and then again at the plant level. (We have already considered options in transportation for reducing energy use.)

1.3.2.1 Optimize Energy Use

The basic question here is how does your EIP get the greatest amount of work done for each unit of energy input through design of park infrastructure? (Under building design below we discuss how this question is answered for each facility.) Technologies like energy cascading and co-generation are ways to achieve this at the park level. Note that energy has “quality;” electricity is usually the highest quality form. Cooling energy is generally a higher quality form than heating energy. Higher quality energy costs more than lower. As energy is used, its quality degrades, from higher to lower quality. Recognition of these quality levels leads to the concept of energy cascading. Why use high-quality energy (a flame at over 1500 degree F) to heat an office or manufacturing area (to 68 degree F) when low-quality by-product heat from an industrial process (at 150-300 degree. F) is quite adequate?

The process industries (e.g., refineries, chemical plants, and pulp & paper mills) make extensive use of heat exchangers in order to squeeze maximum use out of each unit of energy purchased. Other kinds of industries could do this much more. A bakery, for example, creates abundant hot air in the ovens. How
could that otherwise wasted heat be effectively used to heat offices, or hot water for the kitchen, or some process in the next plant down the street?

**Cascading and Co-Generation**

There are many opportunities for energy cascading or “getting more bang for the buck” by using energy two or more times, at various quality levels. Co-generation is an example of this tactic (generating electricity and heat, together). The fuel-derived energy used to generate electricity degrades to heat (often in the form of steam) which can then be used in a process where high-temperature heat (or steam) is required. Perhaps the low-grade steam from this process can be used to heat the office areas or a warehouse. Cascading tactics may be used within a single facility or between two or more separate plants.

At Kalundborg, the power plant feeds steam and hot water to several other plants rather than discharging it to the environment. This has increased the efficiency of its operation by approximately 10%. With enough customers for steam, Valdemar Christensen, the plant manager, estimates he could gain another 30-40% in efficiency. (Personal communication 1994)

Energy cascading requires conduits for the steam or hot water moving between plants. At Kalundborg, this infrastructure had to be built by the two companies party to the exchange. In a new EIP with an adequate source facility, such piping could be added into the site-plan as companies needing it are recruited and strike their deals. As they negotiate their contracts they will determine who pays for this.

Cooling towers are found in most industrial and commercial facilities. To cool a space or process, heat is discarded into the air or sometimes into surface waters. While developing your EIP, support tenants in avoiding such waste by finding a need for the (low-grade) energy being “thrown away”. The source company or on-site customers can use this waste energy to fulfill needs, rather than buying yet more fuel or electricity. An example; waste heat from a boiler (which goes up the chimney) can be captured by a heat exchanger to provide heat for many industrial processes. At Kalundborg, the power plant’s waste heat dries wallboard at a neighboring plant.

Electricity for an EIP may be generated on-site, brought in via high-voltage lines from the local utility, or both. If it is feasible to generate it on-site, there are excellent opportunities for cogeneration and cascading. If on-site electricity production involves a conventional steam turbine driven generator, explore beneficial use of the by-products from pre-treating the boiler water or from the flue-gas treatment (fly ash, or gypsum, resulting from the use of limestone to “scrub” noxious chemicals from the flue gas).

If a gas-turbine generator set is used, consider how the waste heat (in the turbine exhaust) can be captured (cogeneration) and used for process or space heating/cooling. Gas-turbines have another advantage over conventional boiler/steam turbine/generator sets; they can be installed in smaller capacity modules so that as power needs increase, the capacity can quickly be expanded. This dramatically lowers the cost (and risk) of building a larger power plant sized for the (future) needs of the EIP. This advantage is useful for solar and wind power installations, as well. Modular gas-turbines, when feasible, may be distributed around the EIP. Decentralization reduces the risk (fire, accident, power outage) and the distance that cogenerated heat must be piped.

**Relations with Utilities**

With few exceptions, the EIP will need to be tied into the local utilities electrical grid, even if there is on-site generation capacity. Depending on the load pattern on the local grid, it may be very attractive for the utility to put generating capacity on the EIP site in excess of the site’s needs. The (cogenerated) heat from this additional capacity would then be available for on-site use while the excess electricity goes out on the grid.

Utilities may have conservation or DSM (demand-side management) specialists, to help customers identify energy-savings measures and to counsel them on the purchase and installation of newer, more efficient equipment and appliances. In some cases, they may pay fees for additional design time needed to increase
energy efficiency in a project. If your utility has such personnel, involve them in the design of the EIP. Otherwise there are engineering firms that specialize in all aspects of energy efficiency.

1.3.2.2 Maximize Use of Renewable Sources

The level of use of renewable energy sources in your EIP will depend upon your region's solar, wind, biomass, and other renewable resources. The energy needs of your park's companies will also determine the role these sources can play. So once again, we have an objective that is highly site-specific in its realization. We will discuss why renewable sources offer economic as well as environmental benefits and a few specific options that can be applied.

A major argument for on-site energy generation (from any source) is dependability of supply. Production shutdowns due to blackouts and brownouts are very costly. Avoiding them reduces a significant risk. Photovoltaic or solar thermal energy sources are dependable and clean. They can be deployed in portable or remote units, avoiding the costs of lines. The environmental benefit of renewable sources is that they avoid net emissions of greenhouse gases and the depletion of finite fossil fuel resources.

A simple example of photovoltaic solar cells in an EIP would be using them to power lighting, controls, and environmental sensors at remote locations on the site. This reduces the need for cables and possibly enables more flexible control systems. A more sophisticated option would be including portable photovoltaic or possibly solar-thermal generators to serve seasonal or intermittent processes. These might be used to drive pumps for unloading liquids, grains, and powders from rail calls to plants. Or a food processing plant could use these energy modules to help manage seasonal demand for heating and cooling by augmenting central sources. (The movie industry has pioneered development of solar generators because of their quiet operation.)

Acquiring and using such portable solar generators in an EIP's power system could lower the peak demand of the park on the power grid. This would reduce the cost of transmission lines to the power grid and to the plants. When not scheduled for park use, these modules could feed electricity back into the grid. Take all of these factors into account in determining the cost effectiveness of such renewable energy sources.

A number of corporations have piloted the use of fuel cells as backup power sources, including Sapporo, Kirin, and Asahi Breweries in Japan. Manufacturing plants have tested units ranging up to 200 kW in Japan, the US, and Europe. An industrial park with tenants like food processors producing organic by-products could use biogas as the feedstock to produce the hydrogen used by fuel cells.

1.3.3 Water Infrastructure

As with energy, the first objective should be conservation: reduce demand on external supplies by efficient use and re-use. Consider multiple-use strategies similar to the energy cascading we describe above. It is reasonable to set a goal that all water used on the site will be recycled or reused, in so far as there is demand for it. Also, there are proven alternatives to conventional energy-intensive water treatment systems, including Living Machines® and constructed wetlands, which we discuss below. Such alternatives are useful choices for an EIP water system that seeks to optimize re-use.
Water, just like energy, has different useful levels of quality. Traditionally, we only consider two quality levels: drinking water (potable) or wastewater (sewage), but there are obviously many possible intermediate levels, that can be profitably used in a well-conceived EIP. These include:

- Hyper- or ultra-pure water (for use in making semiconductor chips);
- De-ionized water (for use in biological or pharmaceutical processing);
- Drinking water (for use in the kitchens, cafeterias, water fountains, etc.);
- Wash water (to clean delivery trucks, buildings, etc.); and
- Irrigation water (used on the lawns, shrubs, trees in the EIP landscape).

There is no reason that each of these uses should be met by one common water supply. Wastewater from the semiconductor manufacturer, for example, might be ideally suited for less demanding operations within that same plant, or next door, to scrub down the floors or wash the trucks. EIPs located on coasts, or near brackish surface waters, may find it possible to use this available water for cooling purposes (in power plants, foundries, paper mills, chemical plants, or oil refineries).

In hot climates, it may be feasible to spray wastewater onto the roofs of the EIP buildings, to help cool them, and thereby reduce the air-conditioning costs. Certainly, the site landscaping can be watered or irrigated, as required, with recycled water to enhance the beauty and marketability of the EIP.

To implement these approaches to water re-use and conservation, your design team will need to consider a more complex network of pipe systems for different qualities of water. This suggests planning your site to reduce distances between plants to minimize infrastructure investment.

"Waste" Water Treatment Plant

Local authorities are likely to require on-site wastewater treatment. This is an opportunity, not a burden. There are many innovative ways to deal with wastewater recycling. Not only can the water usually be recycled or made suitable for use in other processes, but the treatment facilities may be developed as integral partners of the whole EIP. The treatment plant may purchase by-product materials from other tenants, or supply them or the park management with dried sludge (as a boiler fuel or for compost to use on the landscaping if it is not polluted.)

The water treatment plant can also become an attractive part of the EIP site. An ecological treatment plant known as a Living Machine® uses anaerobic processes for pre-treatment and then uses the water for greenhouses, lagoons, and wetlands (providing habitat for wildlife). These facilities use no noxious chemicals, release no foul odors, produce salable byproducts, and look more like a horticultural operation than a sewage works. Major steps in the processing use plants and micro-organisms that are specific to the area and the qualities of the input waste water. (As with conventional treatment plans, pre-treatment at the individual factory may be required before sewage or process water moves to this system.) Most Living Machines use ponds and wetlands areas as an essential part of their water recycling processing, which enhances the beauty of the EIP site. These water areas also attract wildlife.

Living Machines are now used to treat municipal sewage waters in communities like Arcata, CA, Providence, RI, Frederick, MD, and San Diego, CA. They are particularly well suited to handling industrial waters and are in use at M&M Mars candy plants in Texas, Nevada, and in Brazil. As part of an EIP’s park-wide water system they could play a useful role for many other industrial sectors.

(http://www.livingmachines.com)

Storm water runoff is a source that you can integrate into your EIP’s water system, reducing demand on the utility. Above we describe the created streams and wetlands at Herman Miller’s Phoenix Designs plant, designed by William McDonough + Partners. These provide purification for road runoff before the water
flows out to a neighboring river and wildlife habitat. In a drier climate, you can view wetlands or lakes as storage basins, holding water for appropriate uses on the site.

<table>
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<th>A Closed-Loop Water System in Thailand</th>
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<td>Management at Eastern Seaboard Industrial Estate has created a closed-loop water system at this site southeast of Bangkok. Vivat Jiratikarnsakul, Sr. Vice President of Hemaraj Land and Development, began the system design from the beginning of the planning process. It was essential to invest early in capacity and alternative piping so the water infrastructure could accommodate all necessary processing for reuse.</td>
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The Estate's companies use a total of 36K cubic meters of water each day, with supplies coming from reservoirs in the region, fed by rainfall. Nearly all factories in the estate are required to maintain their own pre-treatment plant, after which their waste water flows to primary and secondary aerated lagoons. (The Estate maintains an emergency pre-treatment plant in case of breakdown of the factories' plants and an inorganic waste water treatment plant.) A constructed wetland provides tertiary treatment and a holding pond (600K cubic meters) which cleans the water to higher than the Industrial Estate Authority standard. An online monitor shows BOD between 6 and 10, meeting Class 2 standard. Plants in this wetland are selected to remove residual heavy metals remaining after earlier treatment.

A holding pond is the last piece in the system. From here the water goes through a dedicated retreatment plant process and returns to a supplementary system of pipes the Estate uses for landscaping and to supply several factories needing it for cooling. Management is researching the feasibility of using the recycled water for growing rice on adjoining farmland. A U-ditch drainage system manages storm water and will be integrated with the recycled water system in a next step of development.

The holding pond is home to 300,000 fish and diving ducks. The fish can not be marketed for human consumption. (The fish test for heavy metals at a level below legal limits but they would not have a good “image”.) Management is exploring the possibility of supplying them to an alligator farm in the Rayong region. During the winter migratory water fowl use the pond as a resting place.

The Estate engineers are testing a new treatment method, known as “a reed bed purifying system. This will use gravel-filled ponds with floating islands to grow tropical flowers for market. The flowers, other plants, and fixing bacteria will aerate waste-water, possibly replacing the mechanical aeration ponds and cutting the cost of their energy usage. Proceeds from export sale of the flowers will fund local education programs.

In addition, a Ford-Mazda plant at this Estate has its own internal recycled water system for irrigation and wash down.

Select photos also use Ford recycled water photo

1.3.4 Material By-Products and Solid Waste

Materials handling in a traditional industrial park is usually managed by each company. In your EIP, it may be useful to provide an infrastructure to support the exchange of materials among plants and to handle some by-products marketed off-site. These park facilities could also deal with those by-products that no one has yet figured out how to market. (In our chapter on by-product exchanges we suggest that companies should consider giving each significant by-product a product number and account line to calculate costs of production and disposal. It might inspire innovation to quantify this reality: “Wastes are really products we pay to produce and then we pay someone to take them off our hands.”

Select photos also use Ford recycled water photo
When un-marketed by-products are toxic, EIP management and tenants would need a clear legal framework around liabilities, probably similar to those used by toxic waste disposal companies. We discuss a toxic materials system below.

EIP materials infrastructure options include:

- Conveyors, pipes, or other appropriate means of moving by-product materials from one plant to another. (Paid for by individual companies in most cases.)
- Storage structures to accumulate by-products for sale off-site.
- Storage structures to accumulate toxic materials for on-site processing or off-site disposal. (With failsafe design, impeccable quality control, and an instant emergency management system.)
- A toxic storage, treatment, and refining unit. (On-site or perhaps a portable unit making regular visits, as described above in transportation.)
- A composting operation for landscaping and kitchen by-products.

Infrastructure for moving by-product materials or water within the park needs capacity for rerouting, perhaps by placing tubes and conveyor belts above ground in a shed. Or they could be placed in an undersurface channel that is easily opened. Some materials handling facilities (other than toxic storage) might also handle reusable materials from other plants outside the park, making them profit centers for EIP management. A mobile toxins unit could also provide on-site treatment for plants in the area.

Environmental managers at TSS, a Japanese company manufacturing crystals for cellular phones in Thailand, showed us bins of crystal trimmings they were stockpiling. While they could not find any current users for this by-product they felt it was compact enough to save until they could identify a market. (TSS 2000 Personal communication)

1.3.4.1 Toxic Discards Management

Toxic chemicals, heavy metals, batteries, and contaminated materials or equipment are a health and environmental risk that are often poorly managed. With proper handling some substances can become a valuable stream for resource recovery. To support best practices within your EIP companies your overall resource recovery management system and environmental policies need to also include Cleaner Production training and incentives for phasing out the use of toxic materials in your tenant companies. Solutions may be found in product and process redesign; workplace practices such as separation of different toxic materials used; and in using non-toxic products of green chemistry (see Chapter 6 for discussion of green chemistry in the section of Petro-EIPs). Corporate reporting of toxic materials used at each industrial site provides industry peers and citizen groups with the data needed to encourage improvement. The US Toxic Release Inventory is one model for this. ISO 14000 reporting standards should include hazardous materials usage and incidents.

Even when toxic regulations are strong or disposal costs high, companies or collectors may simply dump toxics or subject them to inadequate treatment with serious emissions. Fees for appropriate disposal are high and enforcement of the regulations is often lax. An EIP should work with regulatory and development agencies, trade associations, and NGOs to create a collection system and treatment facility that makes it easy and cost-effective for businesses, government operations, and households to dispose of these substances. Larger industrial parks with tenants requiring it may set up their own system.

It is not appropriate to recommend specific technologies for treatment because this field is evolving rapidly. Don't get stuck with soon outmoded, high priced solutions. Overseas trade and aid agencies are very aggressive in marketing the technologies of their own companies. It is vitally important to have completely
independent evaluation of competing technologies and to not rely upon the claims of the sales force. Your evaluation should determine that the system avoids transferring the environmental damage from one level to another (as in solidification of liquid waste and landfilling, with subsequent ground water contamination).

One proven technology is re-refining used oil and solvents and returning them to their initial user or to the market. So long as these materials are kept separate by the source company and the processing is done to high standards, this is a more eco-efficient solution than treatment and disposal. A facility in Thailand illustrates this technology. (See Chapter 7, Policy, for further discussion of hazardous materials management.)

A Solvent Re-Refinery in Thailand

Recycle Engineering is a solvent re-refining operation developed as a Thai-German joint venture in the Eastern Seaboard industrial region southeast of Bangkok. The facility accepts a wide variety of industrial solvents at a gate fee less than 1/3 the fee at Thailand’s only hazardous materials landfill. The re-refining equipment was built and is operated to German environmental standards, higher than those required by Thailand.

The partners in Recycle Engineering are Patikarn Mahuttanaraks, a chemical engineer, and Thomas Sacks, an inventor and entrepreneur who has build at least a dozen similar facilities in Europe. The Thai plant includes distillation, evaporation, filtration, extraction, and refining processes. (Customers include multinational manufacturers in automotive, electronic and computer industries.)

The facility’s processes produce minimal solid or liquid wastes and emissions to the air. Residues are used as fuel for boilers and the backup generator. The emergency preparedness, prevention, and management system is built to capacity for worst case events, including extended typhoons.

Recycled products may go back to the producer, to other firms, or to export markets. With some customers, the facility set up is dedicated to a specific users’ re-refining requirements because of the need for fail/safe processes. The users’ spent solvent is handled through batch processing and returned to him at standards he specifies. Quality control is done for each barrel, not just the batch. The products are at or very near standards for virgin chemicals.

Capacity of the operation at this phase of build-out is 10 thousand tons per year. Planned expansion will take it to 20K. The business employs 105 workers. Housing is included on the site, for those who choose.

The refinery could handle at least 25 different solvents but so far the facility’s permit only allows processing of 5 solvents. Customers pay the higher rate to send the rest to the toxic disposal landfill, where the only processing is solidification. Recycle Engineering’s managers would like to see hazardous materials policies that would allow them to get permits for classes of substances since their chemical composition does not call for very different processing parameters. At present they must apply for a separate permit for each solvent.

Contact information recycle@loxinfo.co.th Patikarn Mahuttanaraks, is managing director. Thomas Sack is design and operations engineer, as well as co-investor.
Mobile Materials Processing Units

You may find that some materials flows create niches for intermediate companies in your EIP to process by-products into usable feedstocks.

For instance, a refinery could purify toxics for reuse on-site, neutralize them into benign waste, or refine them to reusable elements. Possible technologies include: oil/water separation, neutralization, solidification, centrifuge separation, biological treatment, and distillation of solvents. The unit would include the range of treatment technologies required for the materials generated at each site. Some by-products (benign or toxic) may not accumulate at a rate sufficient to warrant a processing plant on-site to turn them into usable feedstocks.

Processing equipment on a rail car (or truck) could move the service around a circuit of industrial parks. This could eliminate transportation and storage of toxics by processing them where they are used. (Rail tank cars transport a major share of toxics and often are used for storage before use.) (Jose de Jesus Vargas 1995. personal communication)

Priority in planning should still go to toxic use reduction strategies and searching for effective substitutes or process changes. When there are no alternatives, companies should seek to reduce toxic risks through synthesis at point of use wherever possible.

1.3.5 **Telecommunications**

Telecommunications technologies have become central to business success in a world where main street intersects the information highway. At the same time, they can reduce many environmental burdens (i.e., cutting paper use and movement, and the need for travel or providing rapid access to feedback on environmental conditions). Telecommunications technologies will have an impact on eco-industrial parks comparable to those for making energy and materials products available for re-use.

Telecommunications includes a wide variety of technologies: video conferencing, the Internet, World Wide Web, e-mail, telephone, telex, fax, beepers and pagers, satellite linkages, and EDI (Electronic Data Interchange, the protocol used widely today in placing and confirming orders to suppliers). Electronic sensors and controls may also be considered an extension of telecommunications.

Your EIP's telecommunications infrastructure can contribute to the success of your tenants, especially small to mid-size companies, and to the operation of the park itself. The system can include tools to support by-product transactions among EIP companies and with those outside the park and common data bases for shared marketing and research.

A few options for the site infrastructure include:

- Satellite downlink equipment and a site-wide network of fiber-optic cables (for high band width communications) will connect your EIP to the world for business communications and learning, and your companies to one another.
- Employees in the EIP will be able to use this network for long-distance video conferencing and education. They can access video transmissions from universities, colleges, and private training firms as well as computer-based learning networks.
- Automate building and grounds operations by installing a local area network to monitor, sense and control access, lighting, temperature and humidity control, security, and fire or flooding alarms.
- Reduce water usage by installing moisture sensors in the landscape to control irrigation.
- Air and water quality sensors linked to computers can provide a continuing record of environmental conditions at and around the site. Sensors on water and materials lines from one
plant to another or from plants to treatment facilities can indicate potentially dangerous situations. This monitoring record could help resolve regulatory difficulties or conflicts over the quality of by-products.

- Include occupancy sensors to automatically turn lights off and turn down the thermostat in unoccupied conference rooms, auditoriums, and office areas. Install light intensity monitors, to adjust lighting fixtures near windows when sunlight is available.

1.3.6 The Commons

We consider an eco-industrial park as a community of companies, so one vital aspect of the infrastructure is physical space that enables their employees to interact. By building common facilities in your EIP, you will make cost savings available to your tenants and create new revenue streams for the park operating company.

Some possible components of this EIP Commons include:

- An auditorium and meeting rooms suitable for educational/training activities, business meetings, conferences, and community meetings. This could include a learning center operated by a local college or university;
- A cafeteria, restaurants, private dining rooms, and a take-out counter;
- A health, sports and fitness center;
- A library, telecommunications, and audio-visual center;
- An EIP visitor center with educational displays on the design and functioning of the park and reports on its environmental and economic performance;
- A day-care center;
- An emergency response center; and
- Offices for firms providing common support services to tenants.

Such a Commons would add to the marketing appeal of your development through the quality of life it offers employees and the savings for park companies. It would enable tenants to reduce their costs of construction and operation and provide abundant opportunities for employees to get to know one another. Newer industrial parks and estates in Asia are including many of these features. Examples include LIMA in Batangas Province, Light Industry and Science Park in Laguna, Philippines, and Eastern Seaboard Industrial Estate in Thailand.

We discuss shared services using these facilities in Chapter 10, Management.
1.4 Industrial Facility Design

The architectural design of a factory's building shell and offices is usually isolated from the engineering of its industrial process. Companies building new plants in your EIP can gain major advantages by integrating the many innovations of sustainable architecture and process engineering to include advanced technologies and methods for pollution prevention, energy efficiency, and industrial ecology. For future tenants, the likely benefits of linking the engineering and architectural aspects of facility design will be more efficient and profitable plants, more productive employees, and fewer burdens on the environment. These advantages add to the competitiveness of your development and may translate into additional revenues for the park. We will discuss this integrated approach first, and then the many options for sustainable building design.

Some larger companies that you recruit may already be working with more systemic plant design processes. Many smaller firms (and some of the larger ones) may need support to integrate these diverse, and now fragmented, aspects of facility design. Of course, larger companies control their new plant design process in collaboration with major engineering construction companies. They may even have standard facility designs they follow, without much adaptation to local conditions. You need to be sensitive in exploring how your team may support their design process. You can begin setting the context in project recruitment literature and site-visits from prospects. By offering support services and asking the right questions you will discover which companies could benefit from a more integrated approach to design. In most cases plants designed in terms of their local environment will be more effective.

Smaller companies locating in your park may contract with your development company to manage their design and construction processes. Or you may offer pre-built space for them. This will place more of the responsibility for design integration upon your team and the consultants and contractors you bring in. The management of the firms will need a clear understanding of the benefits they will gain since design costs may be higher.

Some options for supporting more integrated facility design include:

- Create a data base of designers and consultants capable of supporting tenants in this integrated approach.
- Include consultants in Sociotechnical Systems (STS) methods of designing facilities and work systems for high performance.\(^1\)
- Offer workshops on integrated facility design for tenants' design teams (possibly through university engineering and architecture schools).
- Link companies' design teams through an online web site for sharing ideas (chiefly, on their design processes, not results).

Questions of facility design are very specific to the industry and company, often involving proprietary information. The tenants' design teams may feel they have little to learn from designers who are not in their industry. However, a more integrated design approach enables visualizing the plant as a whole system, with performance of all subsystems optimized together. For instance, operating costs can be lowered significantly by a holistic approach that links office and plant lighting and heating, process heating or cooling needs, and other plant energy requirements.

An example of such integrated design is Compaq Computers Austin Texas plant. “Facilities manager, Ron Perkins, learned of the Rocky Mountain Institute and its work on efficiency, particularly lighting and the

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\(^1\) Companies using this approach include Volkswagen Canada, Hoescht Celanese, and Exxon Canada. See Appendix 2, Supplementary Information, for a brief overview.
systems integration of lighting with heating, ventilation, air conditioning (HVAC) and building design. It was, in his words, ‘a critical connection.’ Improved lighting alone in the latest Compaq buildings would have provided savings with a direct 2.7-year payback. But coupling the improved lighting with a better insulated building shell allowed the use of smaller HVAC units, which resulted in zero marginal costs when considering the entire building. In other words, the buildings cost the same as the earlier ones to construct but had significantly lower energy costs. Year after year, these efficient buildings have saved Compaq hundreds of thousands of dollars.” (Romm 1995)

Although there are many innovations in sustainable design that are relevant to industrial facilities, there are considerations that place limits on their application. A sustainable construction researcher, Charles Kibert, observes, “A major problem in applying sustainable design to industrial facilities is that technical performance issues in systems and materials are a lot more stringent than those needed for residential and commercial buildings.” For instance, the performance requirements for a power plant or chemical process plant, at any scale, make it difficult to base materials selections on a recycled content criterion. The first order needs are safety, durability, and successful operation and maintenance.

1.5 Building Design

Buildings, like products, have a life-cycle. Effective design demands attention to the full span of a facility’s life. We begin our discussion of building design with a review of what this means for the design process.

We then review some major options for the design of energy, materials, and water systems in buildings that have emerged in the last two decades. (Some are actually re-discovered traditional practices.) They contribute to the design of more efficient, less polluting, and more habitable buildings. Industrial facility designers have generally gone further in incorporating energy efficiency than the materials and water options. Architects and engineers have advanced practice in all three areas; principally in office, commercial, and residential building design. The Resources section at the end of this chapter includes a wide variety of organizations and references to help your team gain access to ideas, cases, and designers in all of these areas.

1.5.1 Life-cycle Building Design.

For designers the long-term challenge is to consider each stage of a building’s life-cycle and to seek an overall plan that balances economic and environmental needs through all of these stages. Ideally, this design will be backed up by a budget using life-cycle costing to demonstrate the return on investment and life time savings gained by paying the possibly higher initial construction costs. The issues range from constructability to maintainability and finally deconstructability.

Recently many integrated methods and tools have emerged to help designers consider these qualities of a building. We discussed these in the early part of this chapter under logistics engineering and other means of achieving integrated design. These methods include support for weighing the trade-offs among the different aims of building design. (Design for environment and analytical hierarchy process methods also support analysis of trade-offs. See Appendix 2.) The following describes a few of the many important environmental factors to design for in planning a building and its production system.

Constructability: The traditional questions regarding constructability are can we put it up within our budget and schedule and are our contractors able to do it? In an EIP a design team will also ask what environmental impacts will each design choice impose in terms of the construction process and how can we minimize them?

Durability: The objective of conserving environmental and economic resources suggests design for durability. How can our structural, energy, and materials choices enable an optimal life for this building?
The quality of structure, materials, and construction must be optimized in terms of the function the building will play. Questions of durability interact with the next concern, flexibility.

**Flexibility:** Building owners will be able to extend the life of the building if it is designed with flexibility, making it easy to redesign, expand, and retrofit as uses and technologies change over time. For instance, William McDonough designed Walmart's environmental demonstration store to enable future conversion into apartments. In an eco-park plant, design should readily enable changes needed to accommodate new materials or energy by-product exchanges.

Energy systems design should include the capability for using new renewable energy technologies as they become cost-effective. Use of modular energy system design enables the expansion of both conventional and renewable sources as demand grows.

Flexible design enables less durable building components to be readily replaced without impacting more durable structures. Also, some building techniques (such as force-fit, no nails technique) facilitate moving interior walls and reusing building materials.

**Maintainability:** Designers can offer building managers major cost savings through designing to minimize the need for maintenance and to enhance the ease of maintenance. These qualities also increase the durability of structures and components and reduce the possibility of costly production shutdowns.

Issues in building design include concern for materials, equipment, components, wires, pipes, inner and outer surfaces, access routes, and the effects of maintenance on the building's inhabitants. Integration of design for maintenance of the building and the manufacturing system is an especially important area. Prevention of failures in either area reduces the likelihood of major losses due to production downtime.

**Livability:** Designers are giving increasing attention to manufacturing, service, and office space as a habitat for homo sapiens. Important questions include: how do we best maintain quality of air and light? What materials choices will insure a healthy environment? Can co-workers interact comfortably with each other? and Do they have access to a natural environment? These have turned out to be questions whose answers have bottom-line results. Employees are more productive in a livable work space, as demonstrated by projects incorporating such features as daylighting, a good supply of fresh air, and avoidance of materials emitting low levels of toxins. (Romm 1994)

**Deconstruction:** Design for deconstruction seeks a regenerative process at the end of a building's life-cycle. The fundamental question is, how can we recapture highest value from the energy and materials invested in this structure when we take it apart? Possibly the intersection between durability and flexibility offers the most fruitful answers in the planning stage. For instance, modular design of structures and equipment could enable recycling of whole construction units into new projects.

### 1.5.2 Energy

"Rather than isolated collections of components, buildings are integrated systems that interact with their environments. Through effective energy use, "whole" buildings levy the smallest possible environmental impact, while enhancing their users' comfort and productivity."— Passive Solar Industries Council, 1998

The costs of operating a building's energy systems over a lifetime may easily surpass its total initial construction costs. This realization has led designers to seek new (and sometimes old) methods for operating buildings with a much higher level of energy efficiency. Utilities with demand-side management programs have offered technical support and loans repaid by savings in energy bills to encourage these innovations. Tools for life-cycle costing\(^1\) of energy systems are more highly developed here than in other areas.

\(^1\) Life-cycle costing is a method for determining the savings in building operating costs provided by initial investments in construction for higher efficiency (or other values).
areas of design. The fields of sustainable architecture and industrial process design have probably advanced further in this realm than any other.

Energy is also the area where designers have clearly demonstrated the benefits of systems thinking in planning buildings. Passive solar design for heating, cooling, and daylighting reduces the required size of heating, cooling, and ventilating systems. Co-generation from industrial processes can also reduce HVAC requirements. This suggests the value of a design integrating the building energy systems and its manufacturing processes.

1.5.2.1 A Building’s Total Energy Budget

A building consumes energy in two fundamental ways:

- Through the operation of its lighting, heating/cooling systems and the equipment needed for the functions performed in it. This is a building’s operating energy.
- Through the energy embodied in it by the creation, processing, and transportation of all construction materials and building equipment, and by all processes of construction and ultimate demolition. This is embodied (or embedded) energy.

A total energy budget is the sum of these two accounts. What do these distinctions mean for designers? The most significant energy savings in recent decades have come from innovations in operational energy, i.e., application of passive solar heating and lighting, or energy efficient equipment and lighting. Designers need to apply these approaches more broadly, but the next real breakthroughs will be in reducing the energy embodied in buildings.

Life-cycle analysis indicates how much embodied energy is necessary to maintain, replace and repair materials over the lifetime of a building, including final demolition and disposition of materials. The more qualitative tools of design for environment may be very useful to support designers wanting to consider embodied energy in their choices. Computer Aided Design programs now often include access to data bases for measuring embodied energy (and other life-cycle data). These enable the designer to determine how materials or process choices impact the embodied energy investment. For instance, how do the energy demands of high-rise complexes differ from those of low-rise structures? What is the difference in embodied energy invested for pouring concrete, using pre-cast concrete, or for putting steel structural forms in place?

1.5.2.2 Energy efficiency

Designers can draw upon a variety of building automation technologies to conserve energy. These include:

- Scheduled switching-lights are programmed to turn on or off at prescribed times.
- Occupancy sensors detect when space is occupied and only then activate lighting. When space is vacant, lights are turned off. Systems employing this technology can save 30-50 percent over conventional lighting.
- Occupancy sensors can also detect when a space is too crowded, which leads to oxygen depletion and carbon dioxide build-up. The sensor signals the ventilation system to provide more fresh air.
- Dedicated controllers in HVAC systems enable local adjustment of temperature and air flow to suit the needs of individuals or zones within a building. Users can customize heat, cooling and ventilation, saving energy and increasing employee comfort and productivity.
Integrated HVAC systems can be designed to optimize total system performance. Chiller/heaters can provide simultaneous heating and cooling by recovering waste heat. Load tracking should respond to real space conditioning needs.

Additional means of gaining higher efficiency include the selection of:

- Heating/cooling systems that embody heat exchangers, dedicated controllers, and closed-loop cooling towers.
- Double-glazed windows with high "R" (insulative) qualities are most efficient. Windows that open aid in ventilation and personal comfort. For passive lighting and heating, install windows with low-E glazing, which permits the sun’s visible energy to enter while preventing indoor heat from escaping.
- Select insulation with appropriate R values for the climate.

Motors used in industrial processes and building systems offer another major opportunity for energy efficiency. Joe Romm says, “Motors use a vast amount of energy—in the United States, about half of all electricity and almost 70 percent of industrial electricity. Yet motors are unusually inefficient and oversized. A typical inefficient motor uses ten to twenty times its capital cost in electricity each year. Thus high-efficiency motors, new control systems, and systematic process redesign afford tremendous opportunities for energy savings” (Romm 1994)

Because of the relatively high energy costs in many Asian countries there are many cases of efficient design and retrofitting of facilities. The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies http://www.caddet-ee.org/ee_tools.htm includes cases and tools for analysis and design. Supersymmetry is a Singapore-based engineering company whose web site describes projects throughout Asia. For OlympiaThai the case included design and oversight of construction for mechanical systems in Thailand's first green office building. Components include super efficient pumping and air handling, triple filtration of outside air, water recycling of condensate, efficient fan coil units, and variable speed drives. A Becton Dickinson Medical Products plant in Singapore underwent monitoring and upgrading of central chiller plant pumps, gaining an energy savings of over 60%. Malaysia Telekom worked with Supersymmetry through a "shared-savings” contract to reduce the operating-costs of a central chiller plant by more than 50% “at no first-costs to the client.”

The Alliance to Save Energy has initiated programs in several Asian countries, including India and China. http://www.ase.org/programs/international/

The Energy Conservation Center in Japan is cooperating in energy-saving and anti-global warming measures on a global scale. It promotes and supports energy-saving activities in developing countries, mainly focusing on policy proposals and technical cooperation. <www.ecc.or.jp/index_e.html

### 1.5.2.3 Energy Sources

Industrial facilities typically use fossil fuels as the primary source of energy including coal, natural gas, and oil. The efficiency of this use can be increased through co-generation, as discussed above in energy infrastructure. The cost of operating HVAC systems can be cut by using excess heat from the generation of energy or manufacturing processes.

### 1.5.2.4 Passive solar

Passive solar energy is the renewable energy option for building design most frequently employed so far. Designers are applying this ancient energy technology in state-of-the-art manufacturing, service, and office buildings for lighting and heating. Successful options include:
- Sunspaces collect solar heat for the building when it is needed but can be closed off from the building at night or during the summer.
- Thermal storage walls absorb heat from sunlight, then slowly release the heat during the evening and night.
- Natural air flows cool building spaces on hot days using cross ventilation. Install windows on the windward side that are smaller than those on the leeward side to create a positive air flow.
- Deciduous trees (existing or introduced) shade buildings during the summer and open them to sun exposure in the winter. (Forested areas in the landscaping can reduce temperatures across the whole site.)

Passive solar energy for lighting is known as "daylighting". Test locations and orientation to determine where daylighting can provide a significant portion of a building's lighting needs without heat or glare. Daylighting interiors is practical even on overcast days. "Light shelves" on the outside of a building can bounce light into a room through windows along the ceiling. Reflectors and light tubes are other means of conveying sunlight to work spaces.

1.5.2.5 **Active solar**

See energy infrastructure above for discussion of applications of active solar energy which may be suitable in facility design at current cost levels. You may also find that active or passive solar water heating is useful at your location. Solar photovoltaics are also a potential source of a backup power supply.

Beyond considering such short-term possibilities, the important guideline is to design for flexibility. Plant energy managers should be able to readily incorporate active solar energy sources as the technologies become fully competitive with fossil fuel sources.

1.5.2.6 **Fuel Cells**

Hydrogen fuel cell technology is likely to evolve fairly rapidly in the next decade, thanks to the major investments in both transportation and energy generation and the competition between suppliers like Daimler and United Technologies. Energy utilities are installing demonstration fuel cell systems in order to start their learning process. While wide-spread application may take the next 20 to 30 years, the technology is now suitable for a backup power supply, a resource critical to many industries like electronics manufacturing and food processing.

1.5.3 **Materials**

Sustainable designers are considering several environmental factors in their choice of materials: embodied energy content and other life-cycle impacts of the material; the source; the recyclability of the material; and toxic content. These factors complement traditional criteria of durability, strength, and appearance.

The American Institute of Architects has collaborated with the U.S. EPA in life-cycle analysis of building materials. Results of this analysis are published regularly as installments of the *Environmental Resource Guide*, organized by the Construction Specifications Institute (CSI) materials categories. The Environmental Resource Guide team is currently working to restructure this data to make it more accessible to designers in the course of their work. The US National Institute of Standards and Technology (NIST) has released this life-cycle analysis (LCA) data together with the rest of the Guide in electronic form on a CD-ROM.

Computer Aided Design (CAD) and Design for Environment tools may also be useful to guide materials choices. CAD systems can enable quick reference to life-cycle data bases.
1.5.3.1 Embodied energy

Embodied energy is the total energy required to produce a product, from initial extraction of raw materials to final delivery. Studies of the embodied energy impact of different building materials reveal wide disparities. Production of aluminum requires 70-times more energy than an equal weight of lumber. Steel requires 17-times more energy than wood; brick 3.1-times more; and concrete block 3-times more than wood. (AIA Environmental Resource Guide, Topic III.A.6.) Aluminum and steel, however, are considerably stronger by weight than an equal weight of wood.

The designer should also consider other issues when choosing sustainable construction materials (e.g., durability and recyclability or, is the wood from a certified sustainable forestry source.

To minimize embodied energy, materials should be recycled whenever possible and recycled material should be used. Recycling bypasses the most energy-intensive steps of manufacturing such as the conversion of ores and feedstocks into basic materials, particularly in metals.

1.5.3.2 Sources of Materials

Sustainable building practice favors the use of material that has recycled content, and/or material that comes from renewable resources. At times the high performance standards of industrial facility design may outweigh these criterion. A wide range of materials have recycled or by-product content such as engineered wood systems, agriboard panels, tiles with recycled tire or glass content, roofing shingles made from recycled plastics and many others.

Designers need to use virgin wood products with attention to the renewability of the source. Tropical hardwoods such as mahogany are generally non-renewable. Harvest of such tropical woods leads to rainforest deforestation. Whole logs from old growth forests are still being exported from NW United States and NE Canada. Lumber from these sources should also be avoided.

However, some virgin wood products may be ecologically superior to products containing energy intensive recycled material, as in this example from a Native American tribe.

Sustainable Forestry

An indigenous tribe in Wisconsin, The Menominee, has been practicing sustainable forestry methods since the 19th century. The tribe’s lands contain the most biodiverse commercial forest in the state. Out of 25 species that existed in this forest in 1864 only one species, the elm, has been lost from disease. Otherwise the mature Menominee forest looks and functions as it did in its natural condition.

The Menominee use selective harvesting and strict management plans to maintain the natural ecosystem, while producing about 30 million board feet of lumber each year.

Sustainable forestry methods are being tested in tropical rainforest ecosystems, such as a demonstration project in Palcazu Valley, Peru. The project has been profitable, already producing timber harvests without requiring the devastating swidden agricultural methods (slash and burn) that are used throughout the rainforests. (AIA. 1993. Environmental Resource Guide, Topic III.E 11-13)

1.5.3.3 Recyclability

Another environmental factor in material specification is the ability to recycle materials in the construction process and at the end of the building (or component) life-cycle. We discuss means of recycling during construction in Chapter 6. Designers can specify dimensions and forms of materials to make recycling and re-use easier during construction.
1.5.3.4 Non-Toxic Materials

Designers also need to minimize use of materials with toxic content that affect building inhabitants or the surrounding environment. Over 1,000 indoor air pollutants have been measured in buildings. These toxics are in such products as floor coverings, insulation, composite wood products, floor and wall coverings, paints, ceiling tiles, caulks and resins. For example, some carpets and carpet glues contain formaldehyde and paints often contain VOCs (volatile organic compounds).

Many suppliers are emphasizing non-toxic alternatives. Benign non-toxic material such as hardwood can be used for floors and walls, ceramic tiling in floors, and steel in some internal structure. Adequate supply of fresh air through HVAC and openable windows mitigates the effects of materials for which there are no functional alternatives.

1.5.4 Water

1.5.4.1 Efficiency

Designers can gain significant savings in water use through equipment choices. Options include low-flow shower heads, faucets, and toilets and electronic sensors or foot-pedals to control faucets. Efficient design of open cooling tower systems should reduce water use and minimize pollution from chemicals used.

1.5.4.2 Recycling/reuse

Design options here include:

- Plan dual systems of pipes, separating human wastes from graywater.
- Depending upon reuse opportunities, you may need a system to accommodate several grades of water, with equipment or natural means for filtering and processing. Deep soil beds may be sufficient for most graywater.
- Passive recovery systems or heat pumps can recapture heat in industrial process water.
- Tanks or ponds for capture of stormwater from roofs may be useful in dry regions.

Overall, you will need to design building water systems in terms of actual or potential interchange with other plants at your EIP or with a site-wide water recycling system such as the Thai Eastern Seaboard case described above.
1.6 Sustainable Design in Asia

We have included selected cases from Asian countries above. Developers, architects, and engineers are demonstrating the financial and environmental benefits of green design. In conclusion we will offer some notes on the state of current practice.

Nelson Chen, an architect and planner based in Hong Kong, works in industrial and commercial development in China. He did the master plan and building designs for Crystal Industrial City and Lafa Industrial Park in Guangdong Province. He reports the following:

“I am afraid that our architectural projects in China have not yet addressed many of the sustainable design issues you ask about. Even for our high-tech clients, building construction and systems tend to be very low-tech (not to mention no-frills and low cost) The environmental design issues in China tend to focus on site planning, passive solar, and natural ventilation, both for industrial and residential buildings. Traditionally, north-south orientation is favoured, with sunshades/overhangs allowed for protection of window openings from sun and rains (Hong Kong and southern China may be considered semi-tropical in climate).

“Dormitories are increasingly required in most industrial parks in southern China to accommodate migrant labour from the interior agricultural provinces such as Sichuan, Hunan, and Guizhou. Again, site planning for more desirable solar and ventilation conditions is usually emphasized. However, in a southern climate without need to consider freeze/thaw cycles, developers will build quickly and cheaply: reinforced concrete structure, painted/tiled external finishes, perhaps air-conditioned but not heated spaces, without much concern for material U-values or green design options.

“More specifically, one could answer “yes” to passive solar design, energy efficient equipment (if from overseas, but not domestic), landscaping, water conserving fixtures (faucets with time delayed shut-off to prevent water wastage) and limited recycling of by-products. But most of these features are really part of common-sense good design, and not yet a comprehensive approach to sustainable design. The leaders in this area would likely be US corporations such as Lucent or IBM, etc., for their industrial building developments.”


Japan offers a model for Asian development and technical and financial support to sustainable development projects. So it is valuable to follow the practice of advanced Japanese design companies. We conclude this section with a description of one firm that has committed to many of the aspects of green design we have described above.

**Nikken Sekkei**

Nikken Sekkei, Ltd. is an Asian based planning, architectural, and engineering firm that has incorporated eco-industrial principles into its company philosophy and practice. One of this firm’s basic operating principles is, ‘To create sound and progressive designs that firmly take root in the community and achieve harmony with the environment’ Nikken Sekkei has completed over 14,000 projects in more than 40 countries, including Japan, Thailand, Korea, Malaysia, China, and the Philippines as well as North America and Europe.

Specific examples illustrating how this firm has used eco-industrial principles include:

Osaka Municipal Central Gymnasium (Japan): In an urban area where open space was limited, this project provided both energy efficient buildings and green space. The Gymnasium was essentially built below ground, which provides for energy savings in its heating and cooling. In addition, the roof of the Gymnasium was designed as a hill and planted with greenery, creating open space where none existed before.
The Tokyo Gas Kohoku NT Building, known locally as 'earthport', was designed to save energy and resources throughout the lifetime of the building, from construction to demolition. Based on this 'life cycle energy savings' concept, the building is expected to reduce primary energy consumption by 35% and CO² emissions by 25%, through the positive use of natural energy and the integration of a cogeneration system. To achieve 'life cycle energy savings,' three basic principles were established when planning and designing the building: saving energy and resources; extending the building's service life; and amenity improvement. One of the principal approaches was to reduce thermal loads and utilize natural energy where possible. An open space "ecological core" plays a significant role in creating comfortable office space using natural light and air flow. Another major energy saver is a gas engine cogeneration system.

Head Office of the Research Institute of Innovative Technology for the Earth (Kyoto, Japan) was designed to include examples of methods and materials that reduce pressures on the environment. For example, water features on the facility's grounds store rainwater, which is then used for cooling within the facility.

Based on company web site and publications. Nikken Sekkei Planners/Architects/Engineers. 
http://194.178.172.86/newsdesk/nw298_07.htm Submitted by the Japanese National Team of CADDET.

A number of Asian web sites indicate that there is growing interest in sustainable design and an increasing number of projects applying the sort of principles we have described in this chapter. We include these links at the beginning of the next section of resources.

1.7 References and Resources

Architecture Asia is an architecture and design resource for Asia and the Asian region. The site includes architectural information, companies, organizations, education and events. 
http://www.architectureasia.com/


ArchEAST Discourse on architecture of the Far East: news and polemics on buildings, urbanism, infrastructure, landscape, culture, business, real estate developments in Asia and other emerging markets. 
http://www.usao.net/users/archet/archEAST.html

Environmental Design & Construction: online and free print publication that covers all aspects of environmentally sound building design & construction http://www.edcmag.com

University of Florida, School of Construction, Center for Construction and the Environment:
http://www.bcn.ufl.edu


A site for this book is http://www.communication-design.net/IntDes.01.001-021.pdf.


Kelly, Kevin. 1994. Out of Control: The Rise of Neo-Biological Civilization. Addison-Wesley. Reading, MA for a source reviewing the broad movement toward human and technical systems based on biological models, including industrial ecology, artificial life in computer science, complexity theory, and other emerging fields.


Passive Solar Industries Council, 1511 K St., NW, Suite 600, Washington, DC 20005; (202) 682-7400; PSICouncil@aol.com.


Logistics links http://www.sole.org/links.asp

International Society of Logistics Engineers: http://www.sole.org/ The International Society of Logistics is a non-profit international professional society composed of individuals organized to enhance the art and science of logistics technology, education and management. There are over 90 SOLE chapters in more than 50 countries throughout the world. Chapters conduct technical meetings, symposia and workshops, all designed to provide the SOLE member with opportunities for professional advancement. Chapters and districts also sponsor regional technical meetings.


Tibbs, Hardin. 1994. Project interview with a design engineer whose articles on industrial ecology have helped broadly communicate IE’s principles and concepts.

Tilman, Harm. Integration or Fragmentation: The Housing Generator Competition for South African Cities. Academie van Bouwkunst Rotterdam. Rotterdam. 1997. This document and web site includes the winning design projects for affordable and relatively high density mixed used housing and commercial development projects in South Africa. Available on www.africaserver.nl/hq designcomp C:\docs\SoAfr\SNT\designcomp.doc
Vargas, Jose de Jesus. 1995. Project interview with a chemical engineer and manager of a Gases Industriales air separation plant in Mexico. February 10, 1995. He was part of the design team for a mobile PCB processing unit.)
9 Construction and Implementation

At this stage your team implements your project’s eco-industrial park vision, plans, and designs in wood, concrete, steel, and vegetation and through creating new human institutions. You will need to augment the many standard procedures and codes for construction with performance goals and measures that flow from your vision and plan. You will need to educate contractors and sub-contractors and provide them with specifications that insure your vision will not be buried in the mud of the construction process. In addition, you will need to coordinate with tenants building their own facilities to be sure their contractors are aligned with the project’s objectives. A developer generally places covenants and restrictions or design guidelines in the tenant contract to achieve this. You can also offer more active support, such as design services for small to mid-size firms.

As physical construction progresses and tenants prepare to move in, you will also be implementing the design of institutions that will help them interact as a community of companies. You may work with local and national resources to set up a regional by-product exchange, training programs, or other community initiatives that support your EIP’s functioning. At this time tenant employees will start the process of building ties between companies to achieve the promise of high business and environmental performance that brought them together in your EIP.

9.1 Construction Process

9.1.1 Integrative Project Management

Construction of your EIP’s infrastructure, common buildings, and tenant plants will mobilize a large number of firms, some contracted with the development company, some working for prime contractors, some for the tenants. You may find it useful to inform their employees of the project’s vision and broad objectives. With this context, they will be able to intelligently follow the specifications in your project plans and discover opportunities for superior solutions.

9.1.1.1 Enlisting Contractors to the Vision

Site-preparation and construction for an eco-industrial park makes new demands upon the variety of prime and sub-contractors required. Your development team may use a qualifying process for contractors using a request for qualifications rather than a request for proposals. With an RFQ you set standards and specifications relating to construction practices to insure environmentally sensitive work. Your bidder selection and contracting process then insures that your contractors are fully prepared to fulfill your specifications and to add any capabilities and management systems required to do so.

Contractors’ personnel may need training if they do not already have capabilities such as low-impact site-preparation or re-use/recycling of construction site discards and surplus. You might consider a contractor conferences at the bidding stage and just before construction begins. These meetings will introduce the EIP concept and enable the contractors to develop plans to achieve the project goals in their areas. Outside consultants can also be brought in for training workshops as needed.

9.1.1.2 Setting and Monitoring Performance Goals and Measures

Your development team can require each contractor to create an environmental management system (EMS), with performance goals in line with the overall project objectives. This plan, which would be created within the project construction EMS, would include:
Environmental goals to be met in fulfillment of the contractor's responsibilities.

Procedures for realizing these goals.

Specific work procedures, emergency plans, and management control systems, including a form for reporting on performance and variances.

Provision for auditing performance at regular milestones in the construction process.

You may also create penalties and/or incentives to insure contractor and sub-contractor performance.

Quality control may be largely a matter of self-regulation in the context of open information flows, augmented, of course, by periodic audits and site inspections from permitting agencies.

9.1.2 Minimize Impact of Construction Processes on the Site

By minimizing the impact of construction on your site it will be easier to create landscaping with natural ecosystem features that reflect those of the region. You will need to brief contractors on your landscape design objectives and plan. Consider incentives to encourage low-impact practices and training, as needed. If the firms working on your development clearly understand the result you wish to achieve, they will be better able to create specific performance goals and adapt their processes to achieve them.

The degree of sensitivity required will depend upon the nature of the site. However, even if you are cleaning up and redeveloping a contaminated brownfield property, you should keep in view the objective of redeveloping the site as an ecosystem. This will condition choices in clean up and construction practices.

Some low site-impact strategies include:

- Create site-specific guidelines on site-preparation, movement and compaction of soils, preservation of surface and sub-surface hydrology, avoidance of ground and water pollution, and similar issues.

- Generally preserve site contours as much as possible rather than doing massive leveling.

- Develop with your contractors means of monitoring and reducing emissions and effluents from construction machinery and materials, including control of chemicals, dust, odors, noise, and runoff.

9.1.3 Minimize Energy Demand of Construction

Construction itself requires significant amounts of energy (around 6% of the energy consumed in the United States.) Anticipate and minimize energy consumed during the construction process, as well as pollutants that result from energy use at the site. Some recommendations:

- Heavy machinery should be tuned up and energy efficient.

- Heavy machinery should not be warmed up for too long.

- Fueled equipment and heavy machinery should not run idle.

- Design construction site circulation patterns in advance, with staging of activities to minimize movement.

- Designate machine-free zones for workers on foot and worker-free zones for heavy machine traffic areas.
Apply logistics engineering approaches to effectively schedule machinery usage and preparation of materials.

**9.1.4 Reuse/Recycle Construction Materials**

Construction wastes constitute about 15 percent of the United State's landfill volume. Construction and demolition volume in the US municipal waste stream is around 20 percent. Although much more C & D discard material is generally reused in Asian countries, the construction (and demolition) process still represents a good opportunity for recycling, especially if potential wastes are separated at the source of their generation. Thoughtful design and specification of materials will minimize the generation of discards in the construction process.

**9.1.4.1 Construction Discards Recycling Plan**

Your design team can create a construction materials recycling plan as part of overall project specifications implemented in contracts and subcontracts. The plan includes:

- Performance goals for maximizing recycling of materials.
- Strategies and tactics for achieving these goals.
- An analysis of the project, a plan of the project, record-keeping tools, cost-tracking/cost-control tools, and a post-project evaluation;
- An educational element for planners, designers, and construction workers;

**9.1.4.2 Construction Discards Program Documentation**

Documentation of a discards management plan is achieved through shipment documentation and serves two purposes by showing compliance with the plan and also providing a long-term record for the contractor and owner.

Construction discards program documentation should provide information on: classification of waste (hazardous, inert waste, etc.); description of the material (lumber, sorted; drywall, sorted); amount of materials recycled and disposed (volume and weight); signature of receiving party; tipping fees charged; mileage, and labor/equipment hours for disposal.

**9.1.4.3 Reuse/Recycling Logistics**

The project's reuse/recycling plan can include elements such as:

- Contracts with customers requiring regular pick-ups.
- Use of reusable, standard construction forms to avoid waste generated by single use wooden forms. (This tactic works best when the design team takes it into account from the beginning.)
- Marked bins and staging areas for different materials, with segregation of materials for on-site reuse.

**Recycling Construction and Demolition Waste: The Oregon Arena Project**

A recycling program within a $262 million construction and demolition project in Portland has saved 36,050 tons of waste, while allowing only 1,117 tons to go to the landfill (3 percent). A new 1.7 million square foot Portland sports arena has also saved $141,000 in materials rebates and reduced landfill fees.
Eco-Industrial Parks

The Oregon Arena Corporation (OAC) and its contractors, Drake/Turner, established an overall environmental plan with goals for waste reduction and recycling during construction. Working with environmental consultants, River City Resource Group, OAC also prepared a recycling program for the lifetime of the arena complex.

All bid specification packages put out by Drake/Turner included a detailed section on construction waste management. The section clearly outlined the waste management plan and on-the-job recycling requirements for all subcontractors. The plan also encouraged contractors to reuse as many materials as possible during construction (e.g., wooden framing).

Portland is an ideal location for building material recycling, according to a program designer with River City Resource Group. The Portland area has at least 50 different building material recyclers, with 15 alone devoted to wood recycling. Furthermore, Portland's high landfill tipping fees, about US$80 per ton, made recycling especially cost effective.

River City Resource Group and Drake/Turner analyzed the best possibilities for efficient job-site collection of recyclable material. They established a site plan and clearly marked bins were placed on the job site. Drake/Turner provided separate containers to recover and recycle wood, metals, gypsum board, cardboard, concrete and trash, with bins placed relative to where each product was generated on the large site.


9.2 Implementation of Business and Social Programs

9.2.1 Building the Community of Companies

We assume that EIP tenants, as well as the environment, will benefit from working together as a community. Supply chain management, the Japanese collaborative form known as the keiretsu, and value adding networks are models that firms are using to work in closer partnerships, as a way of building competitive advantage. Managers at Kalundborg have said that their close sense of community was essential to the development of the by-product exchange network there. The developers and managers of eco-parks will be building upon an existing business trend to support tenants in forming their community.
The key method is quite simple: self-organization. If you create the right context for employees from your different companies to get together, they will figure out how they can benefit from working together. Park management can provide events and tools to support the process. These could include:

- Conferences for possible recruits and already committed future tenants.
- A closed web site and e-mail list through which future tenants can start getting acquainted and explore beneficial ways of working together. (This communication then links into the EIP information system once they have moved in.)
- A welcoming party (and informal idea session) as each new tenant moves in.
- Creation of a tenants association as a community system of governance (including conflict resolution capabilities).
- Education in the flexible network (value adding network) concept for business collaboration (See Chapter 4).

If you have succeeded in building a significant by-product exchange network among your tenants, their process of negotiating contracts and implementing the exchanges will contribute to the sense of community. (Park management may play a role in supporting the ongoing viability of the network and identifying new opportunities.) Shared support services the park offers tenants (education/training, dining facilities, day-care, etc.) will also help build relationships.

9.2.2 Implementing Regulatory Agreements

It is likely that you and your tenants will have negotiated regulatory innovations with environmental agencies to enable performance beyond strict compliance. (See Chapter 7, Policy) As your companies start to move in, you will need to work closely with them and the agencies to put these agreements into operation. This coordinating service may become a key park management function (and EIP profit-center), especially for serving small to medium tenants.

Creating the Regional By-product Exchange

The exchange you may have been able to develop within your EIP will be more resilient if local or state agencies or private sector players have helped form a broader exchange network. See the BPX Chapter for discussion of how they can do this. In the Management Chapter, we consider the option of this being a function of EIP management itself.

9.2.4 Other Support to EIP Tenants

Local or national economic development agencies may have supported EIP recruitment through incentives such as employee training grants or industrial development bonds to underwrite equipment purchases. Environmental agencies may have committed to training in pollution prevention or other subjects. Your development team may need to assist companies in insuring effective implementation of these incentives.

9.3 Redesign for Error-correction

In the planning and design phase, your EIP team probably included some options to test and accept or reject at various points in the implementation phase. These may relate to issues in physical design: site preparation, park infrastructure, or guidelines for building design. They may be business issues in areas like recruitment. Or they may concern the local community’s involvement in creating a hospitable context for an EIP.
An example: you might find it difficult to find enough potential tenants responding to a recruitment strategy based on forming a close-knit web of EIP companies trading by-products. If your development team has foreseen this possibility, an EIP focus on BPX will be only one of many potential benefits featured in your marketing plan. Including plans for creating or strengthening a regional exchange would provide a broader network for unused by-products. You might also increase the emphasis on a business incubator generating new companies to be processors of, or markets for, by-products in the EIP. However, if the by-product exchange option does not attract companies, you will have to shift your strategy, emphasizing other attractors for potential recruits.

9.4 Resources

The major source for this chapter was:

Kibert, Charles J., Ed. 1994. Sustainable Construction: The Proceedings of the First International Conference on Sustainable Construction. (held in Tampa, Florida 6-9 November 1994) This volume contains 90 papers written by authors from 40 countries. The various topics covered include: defining sustainability, green initiatives, analytical and assessment tools, economics of sustainability, alternative materials, construction waste studies and methods in design and construction. It includes many detailed articles on deconstruction and construction materials recycling. To order, contact University of Florida, M.E. Rinker, Sr. Center for Construction and the Environment, School of Building Construction.

http://www.bcn.ufl.edu This web site includes many other valuable resources on construction.

Environmental Building News web site contains an extensive set of links on construction.

http://www.ebuild.com
10 Management of Eco-Industrial Parks

In this chapter we examine the unique management requirements for an EIP.1 We begin by considering the distinct business interests of the park's community of companies and the management of the property itself. Separate but overlapping management systems are needed to adequately reflect the two systems.

We then outline the basic functions of EIP management and provide a matrix indicating which would be the primary responsibility of the property management system and which would fall to the community's self-management system. Important key functions include maintaining the community spirit and values, supporting by-product exchange, and enabling continuing evolution of the system.

After discussion of the two management entities, we review several key management issues: autonomy within a community; maintaining the by-product exchange; the importance of total quality management and quality control; an emergency management system; and the ongoing role of the public/private partnership that helped form the EIP.

We then describe how a high-tech operations room could enable both management entities to work more effectively. We conclude with discussion of a number of shared support services.

10.1 There Are Two Management Interests in an EIP

An EIP encompasses two distinct but overlapping business entities. It is a real estate development property that must be managed to provide a competitive return to its owners. At the same time, an eco-park is a "community of companies" that must manage itself to gain common benefits for its individual members. The latter is a looser association in business terms, but the owners of member companies are no less concerned with their investment returns. You will need to respond to the needs of both entities in designing a management system for your EIP. Fortunately, their basic goals are very complementary.

Management of the Property: The team responsible to the property owners will be accountable for the business performance of the developed property. This function includes maintaining the stability of tenancy, filling vacancies as rapidly as possible, and keeping the park functional and attractive. It can also provide high quality and profitable support services to individual tenants and the community as a whole.

Management of the Community: The community of companies will share these concerns, but its members will need a management system that maintains their cohesiveness without compromising their autonomy. Except where external regulation or property covenants are involved, the community will depend on voluntary participation in any common initiatives. The management system for the community will have to use tenants' employees time efficiently. The property management team or firm will also be a member of the EIP community.

Management of the tenant community will be a self-organizing process, with facilitation and support from your project development team and park management. This process will begin in the recruitment and planning phase, as future tenants explore potential advantages they can gain from collaboration, including exchange of unutilized by-products. The process of forming relationships will continue as plant design

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1 The writing of this chapter in the earlier EIP Handbook was supported by two excellent teams of graduate students and their professors. Bill Eldred, John Ormond, and Curt Aasen worked with Dr. Barry Clemson in their engineering management program at Old Dominion University. Their paper is "A Proposal for the Design of the Hampton Roads Eco-Industrial Authority Using the Viable System Model."

In the Haas School of Business at University of California, Berkeley, MBA students, Lisa Callan, Jennifer Lowry, and James Slipe wrote "The Role of Management in an Eco-Industrial Park" under Dr. Chris Rosen. Dr. Allena Leonard provided additional input applying the Viable System Model to EIP management.
teams work to embody project performance objectives in their plans. See Chapter 4, Recruitment and Chapter 9 Construction and Implementation.

By the time tenants are ready to move in, the community may already be taking shape. An effective formal management entity may be a tenant association. (If companies own their own buildings and land, they might set up an owners’ trust.) This association will represent their common interests, which, in an EIP, are continuing evolution of economic and environmental performance. Plants locating at your park may be able to use each other’s energy or material by-products at a significant level. Their market interactions will strongly support the self-organization of the community. Maintaining and growing these markets will require administrative and research support services, which could be supplied by park management.

10.2 The Functions of EIP Management

We will first describe the full range of management functions to be performed by the combination of business community and park management systems. Some clearly belong to one or the other entity. Others require participation by both. Following this general description we will present a matrix for assessing which group may most effectively lead on each function.

We have sorted these functions using an organizational framework known as the Viable System Model (VSM). (Beer 1984) This is a living system model that helps management function as a dynamic learning organization. The VSM identifies the following six basic functions that every organization must perform.

10.2.1 Maintain the Community of Companies
[†] Maintain the values, culture, and identity of the eco-industrial park as a community.
[†] Resolve conflicts between companies, between park management and tenants, and between the needs for future viability and present efficiency.

10.2.2 Assure the Future Viability of the EIP
[†] Facilitate the self-organizing community development process among tenants.
[†] Recruit firms to keep the park fully leased and maintain the mix of companies needed to best use by-products as companies change.
  ♦ Direct marketing efforts and coordinate recruitment with local and state economic development agencies.
  ♦ Qualify prospective tenants and negotiate contracts.
[†] Track present trends and emerging challenges and opportunities, including:
  ♦ Patterns of inter-company collaboration.
  ♦ Technologies and firms that support by-product exchange.
  ♦ Changes in regulations at all levels of government.
  ♦ Domestic and export opportunities.
[†] Support continuous evolution of economic and environmental performance for individual companies and the park as a whole by:
  ♦ Managing a learning center and

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3 A third party company or agency may contract to take responsibility for by-product utilization.
10.2.3 Manage the Present Operations of the EIP

- Manage and maintain eco-park infrastructure to gain synergy across systems. Allocate resources for the by-product materials system; the water system; the energy system, and support services.
- Support full utilization of tenant by-products by facilitating connections with markets on- and off-site.
- Enforce standards governing operations and performance requirements within the site (through EIP performance objectives, deed restrictions, covenants in leases, and performance standards governing land and space use).

10.2.4 Audit EIP Performance

- Conduct audits of successes as well as failures in EIP performance to assure learning and improvement.

10.2.5 Coordinate Administrative and Support Functions

- Maintain EIP property (landscaping, infrastructure, buildings, streets and parking).
- Operate a site-wide information system that:
  - supports inter-company communications,
  - informs members of local environmental conditions,
  - monitors energy and materials flows, and provides feedback on plant and EIP performance (for internal quality control and external compliance and reporting).
- Operate the emergency prevention, preparedness and response system.
- Coordinate provision of shared support services, such as environmental management, training, purchasing, and dining hall(s) or day-care.

10.2.6 Operate the Production Units

This level of the model is distinct for the community of companies and for the property management system.

- The individual companies are the production systems for the community.
- The profit centers in the property management system are the production systems for the property management company (PMC), i.e., the water-treatment and recycling system or shared support services.
Distribution of Management Functions

Our comments suggest the possible balance between the management entities in each function for a generic EIP. You will need to work out the actual distribution to meet the needs of your particular situation.

<table>
<thead>
<tr>
<th>Maintain the EIP Values.</th>
<th>Community Self-Management System (CSMS)</th>
<th>Property Management Company (PMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolve and maintain the community's values, culture, and identity</td>
<td>Ongoing responsibility will be focused in the CSMS</td>
<td>The development team will begin this process. PMC as member of community will participate later.</td>
</tr>
<tr>
<td>Evolve and maintain the values, culture, and identity of the Property Management company.</td>
<td>Support PMC through feedback.</td>
<td>Primary responsibility.</td>
</tr>
<tr>
<td>Resolve conflicts.</td>
<td>Primary responsibility</td>
<td>Secondary responsibility, except in enforcement of covenants</td>
</tr>
</tbody>
</table>

| Assure the Future Viability of the EIP                        |                                                                              |                                                                       |
|----------------------------------------------------------------|                                                                              |                                                                       |
| Facilitate self-organizing community development process.      | Primary responsibility in the long-term                                       | Initially development and park management teams will play key role.    |
| Recruit firms to keep the park fully leased and maintain the by-product exchange. | Secondary support role through suggestions of candidates | Primary responsibility                                                |
| Track trends and emerging challenges/opportunities for the whole system. | Supports PMC through inputs from individual companies                      | Primary responsibility                                                 |
| Support evolution of economic, social, and environmental performance for companies and the park. | Co-equal, with focus on plant EMS and participation in site-wide system.    | Co-equal responsibility through design of a site-wide environmental management system (EMS). |
| Coordinate on-going public involvement process and services to town residents. | Participate in programs to benefit residents.                               | Primary responsibility                                                 |
| Represent the park before public agencies.                    | Indiv companies wouldn't have role too?                                      | Primary responsibility                                                 |
### Eco-Industrial Parks Management

<table>
<thead>
<tr>
<th>Community Self-Management System (CSMS)</th>
<th>Property Management Company (PMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manage the Present Operations of the EIP</strong></td>
<td></td>
</tr>
<tr>
<td>Manage shared infrastructure:</td>
<td>Primary responsibility</td>
</tr>
<tr>
<td>Support by-product exchanges on and off-site</td>
<td>Co-equal responsibility³</td>
</tr>
<tr>
<td>Enforce standards governing operations and performance requirements</td>
<td>Shared responsibility</td>
</tr>
<tr>
<td><strong>Audit EIP Performance</strong></td>
<td></td>
</tr>
<tr>
<td>Conduct audits of successes and failures in performance.</td>
<td>Co-equal responsibility, within EMS.</td>
</tr>
<tr>
<td><strong>Coordinate Administrative and Support Functions</strong></td>
<td></td>
</tr>
<tr>
<td>Maintain EIP property</td>
<td>Primary responsibility</td>
</tr>
<tr>
<td>Operate a site-wide information system, including monitoring and feedback</td>
<td>Secondary responsibility, especially in defining information/data needed</td>
</tr>
<tr>
<td>Operate the emergency prevention, preparedness and response system.</td>
<td>Participation in planning and operating the system</td>
</tr>
<tr>
<td>Coordinate provision of shared support services.</td>
<td>Defining needs and quality standards</td>
</tr>
<tr>
<td><strong>Production Systems</strong></td>
<td></td>
</tr>
<tr>
<td>The companies</td>
<td>The PMC profit-centers</td>
</tr>
</tbody>
</table>
10.2.7 Management Entities

10.2.7.1 The Property Management Company (PMC)
This side of EIP management may be assumed by one of several entities:

- The real estate development company that built the park;
- An economic development agency, if the park is publicly owned;
- An independent industrial park management company; or
- A management company set up as a joint-venture between the developer and EIP companies.

The first three options are the likely choices in most cases. The fourth would probably best suit an EIP where companies own their own facilities and land.

The PMC has primary responsibility for recruitment, interaction with the public, infrastructure, and support services. Fees for value-added services may contribute significantly to the management company's bottom line and the return to property owners.

10.2.7.2 The Community Self-Management System (CMSM)
EIP companies can set up a tenants' association to handle functions for which they share joint responsibility (an owners association or trust if they have purchased their sites). Your development team will probably include a property covenant in the site's CC&Rs requiring membership.

The association's board may include representation from all larger firms and revolving seats for members who represent smaller companies. A member from the PMC would help link the two systems. Sub-committees might be organized in teams for the main functions described in the chart and outlines above. The CSMS has primary responsibility for functions relating to sustaining the community itself.

For example, Laguna Technopark Association (Philippines) is a self-governing entity mandated to serve and anticipate the needs of its tenants. The Laguna Technopark Association counts as members all locator companies in the park. It was formed to ensure the long-term viability of the industrial estate.

"Aside from the maintenance of the Technopark's common areas, the association's officers are tasked with the promotion of smooth relations among the locator companies and their employees. In the past, the Laguna Technopark Association has assisted locators in securing requisite government permits as well as hosted fora on relevant taxation and business issues." [http://www.lagunatechnopark.com.ph/](http://www.lagunatechnopark.com.ph/)

10.2.7.3 The Interconnection
The PMC's highest priority is protecting the investment of park owners. The CSMS's highest priority is maintaining community viability and synergy among its members. These goals are obviously closely connected. The twin management systems may reflect this intertwining of interests through representation on each other's boards and clear agreements on mediation of possible conflicts.

Probably the most important shared responsibilities of the two systems will be the management of by-product exchanges, if that is a significant aspect of your strategy (see below), and the enforcement of standards.
10.3 Key Management Issues

10.3.1 Community and Autonomy

Critics of the EIP concept often suggest that a primary obstacle to their formation is the reluctance of companies to become interdependent. An effective management system must embody fundamental respect for the autonomy of each member company. As far as possible, constraints on this autonomy should develop through incentives, voluntary agreements and market mechanisms. If full participation in the community of companies provides business, environmental, and personal benefits to members, they will see the value of any constraints they agree to.

A fundamental assumption of EIP operation is that companies can self-regulate their behavior more effectively than any outside regulator, so long as information flows and feedback loops are in place. EIP employees know their facilities, technologies, and management and operating systems. Provide the right conditions and staff will act to meet standards, often exceeding them. These conditions include clear performance objectives, a free flow of necessary information, and an incentive system rewarding the desired behavior. Regulatory agencies are beginning to test this assumption in voluntary programs.

This principle of self-regulation will be central to dissolving the fear that participation in a community of companies will undercut the autonomy of members. A well-designed environmental management system for the eco-park and its members will provide the structures for feedback that support this self-regulation. (See the Controls chapter.)

10.3.2 Maintaining and Evolving the By-Product Exchange

In our chapter on by-product exchanges we suggest that the exchange of by-products within an EIP may be seen as a self-organizing market system. For the most part, pairs of companies will negotiate deals and sign contracts like any other supplier/customer agreements. They will cover standard issues such as reliability and quality of supplies; mode and timing of delivery; and legal recourse for non-performance. Purchasing agents will remain aware of alternative sources for critical inputs. The only added level of dependency stems from the lower costs of supplies made possible by co-location.

An alternative, still to be tested in practice, is for a by-product utility to assume responsibility for all non-product outputs of companies that contract with it. See the BPX chapter.

The community and park management organizations will have a role in supporting the operation of this market exchange. Critical support functions include:

1. Recruiting companies to fill niches when key suppliers or customers move, change processes, or go out of business;
2. Modeling the whole network of exchanges to reveal new opportunities;
3. Researching technologies, vendors, and markets for presently unmarketable materials;
4. Linking the park exchange system into regional, national, and global resource exchange systems;
5. Negotiating with agencies to assure a regulatory framework open to exchange.

The park management company will have primary responsibility for recruitment, with informed support from the CSMS and individual companies. Activities 2-4 above are primarily information services that the PMC could provide. Both management entities would need to be involved in negotiations with regulatory agencies. With the utility alternative, this firm would assume primary responsibility for all of these functions, negotiating with each plant to manage its outputs.
10.3.3 Total Quality

Companies attracted to your eco-park are likely to be those that adhere to high performance standards. The park management itself will need to reflect a total quality approach to all of its tasks. This will be especially important if EIP companies share exposure to liabilities through any options like umbrella permitting and shared waste or water management facilities. In our discussion of umbrella permitting in the Controls chapter we suggest that the group permit might be simply an administrative form. The companies would still be individually liable.

Management will have to back up a culture of quality with solid quality control systems, including a sophisticated monitoring and reporting system. All plant managers will need to be confident that they will not be held responsible for someone else’s errors.

10.3.4 Environmental Management System (EMS)

This important management structure and process is covered below in a separate section.

10.3.5 Emergency Management System

A critical environmental and business function of EIP management will be maintaining an excellent emergency planning, prevention, preparedness, and response system. With high quality planning, prevention, and preparedness, the need to respond will not often arise. What is required in a site-wide system will, of course, depend upon the industries present and the quality and proximity of city services.

At minimum, the PMC should manage site-wide emergency prevention and preparedness planning; information systems assuring that all data on hazardous and toxic materials is instantly available; and coordination with public services. In some cases, a park may also need to maintain equipment and personnel for fires, spills, and other accidents.

10.3.6 The Property Management Company

The property management company will handle traditional business functions for the park owners such as negotiating leases, managing the lease and service revenues, and maintaining the property. New services the EIP offers will mean new external expenses for the tenants, offset by cuts in internal costs through outsourcing certain functions. The PMC will gain significant new revenues. Companies may pay in the form of fee for service or some expenses may be factored into the terms of their leases.

It will be important to present a total package to tenants on the economics of locating at your EIP. They will need to understand how higher costs for shared services are balanced by the savings they realize from procuring these functions from the PMC rather than maintaining staff and facilities for them.

With some services, the PMC may be competing with external service companies. It will have the advantage of proximity and synergies between the different services it offers. However, park staff will have to maintain high quality and fair pricing to support these advantages.
10.3.7 Public/Private Partnership with the Host Community

Public/private partnership will probably play a strong role in enabling the development of your eco-industrial park. Managing the interests of public partners who do not have a direct business stake in the EIP will be an important management function. Public agencies may have given incentives to companies and the development in the form of industrial development bonds, advantageous rates for services, tax breaks, or possibly investment of public land.

Any public investment in the project was based on its promise to provide benefits to the community—business and employment opportunities, a cleaner environment, and participation in projects improving the local quality of life. Park management needs to assure that these public benefits are delivered and that community stakeholders have continuing access to information and input to eco-park management.

Tenant companies may need to make their own commitments to the community as the result of their policies or as a condition for receiving incentives from the government. They may find that partnering with other firms in the EIP will enable them to increase the benefits delivered while containing the costs.

10.4 The Operations Room

In Chapter 5 we suggested that the development team consider setting up a project operations center. Such a facility in your operating park would enable integration across the many disciplines and languages involved in managing an EIP. Technologies in the center would enable users to access information rapidly, primarily in graphic and visual form. Teams could use it for planning, for reviewing performance, and for present-time management activities such as emergency management. The operations room complements the intranet in the EIP and provides the bandwidth that can only be achieved when teams work together in person with electronic support.

An operations center in the EIP Commons will support effective work by the park management company and the community self-management system or tenants association. It could also be very useful to individual companies, and pairs or networks of firms planning collaborative projects.

Hardware for an EIP operations center would include:

- Computers with projectors;
- Rear-projection screens;
- Whiteboard (electronic and non-electronic) and corkboard on walls;
- Links to all site monitoring devices, scanners, and other input equipment;
- Links to internal and external (to the EIP) networks, including satellite uplink/downlink.

Software, information, and data for the operations room would include:

- Graphic models of the EIP, its organizational structure, and all of its sub-systems;
- A simulation model of the exchange network (within the park and in the region);
- A quantified flow chart\(^4\) of all materials and energy flows within the park and between the EIP and surrounding region;
- A geographic information system (GIS) with input from economic, environmental, demographic, and other data bases for the relevant region;

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\(^4\) A quantified flow chart indicates magnitude of all flows in a system by the width of the lines symbolizing them. It can be set for whatever value is important, i.e. monetary, physical quantity, potential for emergency, etc.
- Outputs from all EIP environmental monitoring systems, including all flows within the site;
- Data on all chemicals, hazardous materials, and their locations (essential to emergency preparedness and response);
- Access to any other data and information needed for specific business or environmental projects;
- Software tools supporting highly effective group processes for creativity and problem solving.

A valuable tool for park management and tenants would be an evolving computer model of the exchange network, supported by materials and energy databases. (See discussion of software available for this in the BPX chapter.) This would enable tenants to simulate process interactions within your network of companies, playing "what if" to discover what exchanges will be effective. The model would allow each company to test the feasibility of possible trades and to simulate potential impacts of technical and business modifications on their exchanges. Park management or a third party BPX manager would also be able to use it to work toward optimization of the whole system.

10.5 Shared Support Services

The companies in your eco-industrial park will need a range of general services indirectly related to their production systems. These include governmental relations, dining facilities, purchasing of common supplies, information access, and many others. By acting in common to procure these services, they can reduce indirect operation costs (especially important for smaller companies). By coordinating satisfaction of these tenant needs, the park management company can increase its revenues. Sharing services will increase opportunities for communication among employees of different companies and build the community spirit of your EIP.

Well-managed shared services will contribute to the profitability of tenants. At the same time many of these services will also contribute to reduction of the collective environmental burden of park businesses. For instance, common dining facilities would reduce the total construction on the site; an employee transportation system would reduce the number of solo auto trips.

The property management company may directly provide some of these services and coordinate procurement of others from independent companies or agencies. The latter will create business development opportunities for local entrepreneurs. The whole range of support activities will provide the business rationale for an EIP Commons facility, as discussed in Chapter 5 under physical infrastructure.

10.5.1 Environmental Management Services

10.5.1.1 Support to Tenants

All tenants will have to comply with applicable national and local laws and regulations. Many companies find it difficult to keep abreast of changes in these rules and regulations. It is time-consuming and expensive to handle the paperwork, which includes the process of collecting data, filling out the proper forms, and getting these filed on time. Your EIP management team could include a staff person (or a contractor) who would be available to all tenants, though small to medium sized firms might be most interested. This resource would:

- Be knowledgeable about national, provincial, and local regulations and reporting requirements.
- Maintain an on-site library and online information sources, including copies of legislation, newsletters, and other references.
- Assume reporting tasks for smaller companies.
Schedule seminars or workshops on new regulations, beyond-compliance environmental management, industrial ecology, pollution prevention, and other subjects of common interest.

Maintain a data base of consultants to support park companies in environmental management.

10.5.1.2 Administration of Umbrella Permits

If your EIP companies (and its regulators) adopt an umbrella permitting approach to managing regulatory issues, the duties of this EIP service will expand. While each company will still be responsible for their own environmental performance, the EIP environmental management office will be responsible for administering joint permits, providing third-party monitoring and feedback to each company, and reporting to agencies. We discuss this approach to permitting in the Controls chapter.

10.5.1.3 Management of EIP Environmental Facilities

If you have built shared water treatment or materials handling facilities into the park's infrastructure, this office would handle the reporting, monitoring, and other functions they require.

10.5.2 Learning Systems

An EIP Learning Center in the Commons could be a satellite campus for local institutions, making it easy for employees to further their training and education.

- It could offer courses and workshops from universities, community colleges, and private vendors.
- Its telecommunications capabilities would enable electronic distance learning from a wide range of educational institutions.
- A print and media library could also include access to online information services.

A visitor education center would enable people from the community and from around the world to learn how you created your EIP and how it functions. Kalundborg, the by-product exchange network in Denmark, created a symbiosis Institute to manage the heavy load of visitors wishing to learn about this regional network.

10.5.3 Other Possible Shared Services

**Dining Facilities:** The Commons can include a cafeteria, rooms for private business meals, and cafes, perhaps serving food grown onsite.

**Transportation and Logistics:** This service could coordinate employee transportation services such as van lines, carpooling, and access to vehicles needed during the business day. Smaller companies might benefit from logistics services around movement of supplies and products.

**Purchasing:** Group purchases of office supplies and equipment and other common supplies can cut costs for tenants.

**Employee Recruiting and Screening:** A shared office could advertise job openings, receive and process job applicants, and prescreen these applicants. Pre-selected candidates would then be sent to the hiring supervisors in each tenant company. Pre-employment physicals could also be provided, at a central first-aid station in the EIP. By sharing such a facility, it may be possible to afford to have a doctor/nurse team on site, around the clock. Other services could include employee identification, parking permits, or first aid team training.

**Day-care Center:** Time and travel demands on employees could be cut by providing a day-care center.
Many industrial parks and estates are already offering a broad menu of services and amenities to make their sites more attractive and to enhance their revenues. For example, Laguna Technopark will eventually form part of a new regional growth center being developed by Ayala Land. Called Ayala South, the masterplanned development will integrate a business district, commercial centers, residential villages, and community facilities on over 2,500 hectares of prime property. Ayala South, which straddles several municipalities in Cavite and Laguna, is envisioned to serve as an alternate growth center to Metro Manila.

10.6 Environmental Management System

An essential component of an EIP management system is its environmental management system (EMS). Industrial parks and estates all over Asia are gaining certification of their sites and even the Industrial Estate Authority of Thailand has received ISO 14001 certification as the organization responsible for 28 estates. Major multinationals such as Ford are requiring their suppliers to have an EMS. So for many suppliers it is become a basic condition of doing business. However, going through the creation of an EMS may result in a formal system that matches the requirements for certification; but this system may define performance objectives and indicators that do no more than keep the company in compliance with regulations, if that.

Unfortunately research so far is not demonstrating that ISO 14001 or other EMS certification is resulting in improvements in actual environmental performance. A National Database on Environmental Management Systems is gathering performance data from company and other EMS in the US. Many companies are setting only very short-term objectives and some even list achievements from before certification. (BATE 1999 and at the National Database on Environmental Management Systems, http://www.eli.org/isopilots.htm) Research on 280 European companies with and without ISO 14001 certification has shown the certified companies were not superior in environmental performance. This study was conducted for the European Commission by the University of Sussex in England. (The results of the study are at www.environmental-performance.org. (BATE January 2001)

To gain the right to be called an eco-industrial park requires an EMS with challenging and comprehensive objectives, effective indicators, and structures assuring rapid learning and response. We offer guidelines for creating the performance objectives for an EMS that seeks significant continuing improvement. One should see ISO 14001 or other any other EMS structure as the container into which you place eco-industrial objectives and strategies.
The heart of an environmental management system is the feedback loop that enables EIP management to continually learn and improve from the results of their EMS planning. While objectives initially flow from the EIA, covenants, and the EMS formed by tenants, internal feedback and new external inputs support upgrading the objectives and focusing the indicators.

10.6.1 A Process of Continuing Improvement

From early in the development process your team will have been defining initial environmental objectives for your project. Preparing an environmental impact assessment and covenants require statements of expectations regarding environmental performance. (We’ve discussed EIAs and covenants in Chapter 4 and the site-wide programmatic EIA in Chapter 7.) You will keep redefining objectives as tenants start contracting for space and you understand the mix of companies that will set up factories in your park. You will also need to adapt to new inputs on issues such as greenhouse gases and persistent organic compounds and new technologies that enable improvements in environmental performance.
10.7 Setting Performance Objectives for an EIP

A full evaluation framework for an eco-industrial park combines economic, technical, social, and environmental objectives into a whole system. This means that your project can seek a design that optimizes objectives in these four domains as a whole, not separately. Clearly articulated objectives in each area, agreed to by project stakeholders, will be essential. With this clarity you will be better able to determine the trade-offs among the objectives in all four domains. Economic and environmental objectives, social and environmental, or any other pair of domains.

Developers, investors, and accountants have well established frameworks to set objectives for economic performance, i.e. the pro formas of a feasibility study. Engineers and architects have practices, tools, and standards for the technical domain. Objectives for assessing and optimizing the social consequences of development are generally set by planners, in interaction with a variety of community stakeholders. Traditionally, regulations and permits determine environmental performance objectives.

An eco-industrial park may require some innovations in the economic, technical, and social domains, but generally, your team will have to use established performance objectives and practices for setting them.

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5 Optimizing seeks the best or most favorable point, degree, or amount for the purpose of the system (e.g. optimizing temperature, light, or moisture for the growth or reproduction of an organism.)
will focus upon an environmental performance framework for an EIP that aims to create objectives surpassing compliance to regulations. (This will probably be the greatest departure from established practice.)

We will not attempt at this point to outline a full process for optimizing the park as the integration of economic, social, technical, and environmental realms. This process will be similar to the process that we describe below for setting environmental objectives.

10.7.1 Economic Performance Objectives

We will briefly summarize here some of the elements of economic performance unique to an EIP. The feasibility study for an industrial park provides a well-established foundation for determining economic performance objectives. When the project requires public investment, as EIPs are likely to need, you will also set a community level of performance objectives. For instance, to qualify for government incentives or industrial development bonds, the project has to target numbers of jobs created and their economic impact. Manuals such as Urban Land Institute's *Business and Industrial Park Development Handbook,* describe the steps necessary for demonstrating the project's economic viability to investors (defining their return on investment) and to qualify for public support.

However, an EIP calls for another level of objectives. The eco-park concept promises economic benefits to member companies, to management and owners, and to the community in which an EIP is located. At the beginning of a project you will want to set broad objectives for these three levels. (More specific goals can only be set as the design and recruitment process moves forward.)

Potential economic performance objectives for the community:

- Stronger economy through economic multiplier effect of new plants. (An EIP would augment this to the extent that it supports higher efficiency in other local industries through resource exchanges with them.)
- Reduced government costs for solid and liquid waste management responsibilities assumed by EIP infrastructure.
- Increased employment.
- Increased tax revenues
- Reduced costs of environmental degradation.

Potential performance objectives for park management:

- Increased revenues for new levels of service it delivers to companies.
- Increased revenues for use of solid and liquid waste infrastructure.
- Potential performance objectives for park owners:
  - Increased value of property through higher rents reflecting a share of cost savings to member companies.
  - Greater stability of tenancy thanks to the greater cohesiveness in the community of companies and the quality of companies recruited.

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Eco-Industrial Parks Management

- Lower likelihood of pollution of the property.

Potential performance objectives for an EIP company:

- Revenues from exchange of by-products with other companies (within and beyond the park).
- Reduced operating costs due to higher energy efficiency in building and process design.
- Reduced costs for services outsourced to EIP management, i.e. environmental training and emergency management, running food services, etc..
- Reduced costs for landfill disposal and sewage treatment of wastes.
- Reduced regulatory costs.

To determine these objectives for your project you can use a process parallel to that described in the next section for setting environmental performance objectives.

10.7.2 Process for Developing Environmental Performance Objectives

Environmental performance objectives provide an essential framework for design of an eco-industrial park. They express your project vision as a set of high level expectations for how it will actually function. The objectives establish a context for later defining more explicit, measurable goals. The objectives document will be a continually evolving guidance system for your project.

Your team will need to generate a draft document (preferably in an intensive meeting such as a 2-3 day design charrette). You will then review this with key stakeholders (including potential recruits to the EIP) and incorporate their input. The steps of this process include:

- Gather reference information and review the framework described below in the appendix to this chapter.
- Determine initial environmental performance objectives.
- Prioritize the objectives you set in terms of local conditions and perceptions.
- Review draft objectives with key stakeholders and rewrite, as needed.

*(At later stages) set measurable performance goals within the objectives. Revise objectives as needed.*

Begin the process by gathering any available reports on local environmental conditions, community expectations and values, and global environmental factors. This reference information will be useful in your working sessions.

With that support, your team will identify those areas of environmental performance that are necessary and sufficient to achieve the EIP vision and mission you have defined earlier. After setting objectives in each of the categories of performance, you will rank these objectives. Explicit objectives for each of these critical-results areas provide targets for more detailed, time-limited goals to be developed later in the process.

Work your way through the Framework we describe below, beginning with discussion of the four high level categories: Byproduct Management, Resource Utilization, Environmental Interactions, System Issues. What local conditions do you need to take into account for each of these areas? For example, in Resource Utilization, your region may be heavily dependent upon imported materials and energy. This fact will condition the specific objectives you set for this category.

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7 This may be offset by increased risk exposure if the EIP involves “umbrella” permits for infrastructure like a shared water pre-treatment plant.
After discussion at this higher level, start developing specific performance objectives for each of the three sub-categories e.g. eliminate waste, benign emissions, and closing the loop, within byproduct management. Expect that your team will agree easily on some objectives and disagree strongly on others. The first round of this objective setting process may move forward more easily if you do not try to resolve every disagreement when it occurs. First identify all objectives that your team agrees to adopt and earmark those points where you disagree strongly. Then go through the different categories of objectives again, working with the disagreements.

In the next step your team will rank the objectives, determining their relative importance to your community and natural environment. With objectives like air emissions or water resources you will usually have data to support prioritization. Others, like interactions with neighbors, may call for much more subjective judgments. In either case, the basic task is to assign an order of importance to the full list of objectives you have developed. Again, disagreements are a natural part of the process.

In discussing differences regarding objectives or their ranking, keep the dialogue open, listening carefully for the assumptions behind the different views. Understanding these assumptions can help you clarify the issues blocking agreement. (The Analytic Hierarchy Process, which is discussed in the Appendix to this chapter, is one way of resolving such conflicts.) In some cases you may need new information or consultation with stakeholders not at the table to reach resolution.

In each phase of the development process you will be setting more specific goals, guided by the broad objectives you form initially. In some cases, work at the detailed level may prompt you to shift some objectives. For example, setting goals for reduction of atmospheric emissions with the first companies recruited may suggest that your initial objectives were either too modest or too ambitious.
10.8 Appendix: Environmental Performance Framework

In this appendix to Chapter 10, we propose a framework for setting environmental performance objectives for an eco-industrial park. This framework will also enable your team to integrate these objectives with the economic, technical, and social objectives of your project. We give an example of using this framework in the Appendix, under "Applying the Environmental Performance Framework in Site-Selection".

We begin with a very brief overview of the evolution of thinking about what constitutes environmental performance. We follow this with a description of the elements of a proposed environmental performance framework. We then describe one method for analyzing trade-offs between environmental objectives. You can also use this method to consider trade-offs between environmental and economic objectives. Once you establish objectives you design indicators for monitoring progress toward achieving them. Donella Meadows’ *Indicators and Information Systems for Sustainable Development* is a very valuable guide on this subject. It can be downloaded from the web at [http://iisd.ca/about/prodcat/perfrep.htm#donella](http://iisd.ca/about/prodcat/perfrep.htm#donella)

10.8.1 Conceptual Context for Environmental Performance Assessment

Thomas Graedel and Braden Allenby--two industrial ecology pioneers at AT&T--describe the interactions of industry and environment in three time scales, past, present, and future. Speaking to the first two, they state:

“There are three time scales of significance in examining the interactions of industry and environment. The first is that of the past, and concerns itself almost entirely with remedies for dealing with inappropriate disposal of industrial wastes. The second time scale is that of the present, and deals largely with complying with regulations and with preventing the obvious mistakes of the past. Hence, it emphasizes waste minimization, avoidance of known toxic chemicals, and “end-of-pipe” control of emissions to air, water, and soil.” (Graedel and Allenby 1995)

Within the context of these first two time scales, both government and industry have generally viewed environmental performance as compliance with environmental laws and regulations. Graedel and Allenby propose that industry-environment interactions in the third time scale, the future, will be governed by principles and practices of industrial ecology (IE). In the United States and Europe, several major corporations have led the emergence of this movement.

IE’s holistic view of environmental performance focuses on the elements of longer-term sustainability, especially minimizing the use of materials and energy in industrial processes. IE broadens awareness from the regulatory focus on hazardous or environmental problematic materials to analysis of industry’s use of all materials and energy flows. In the past, managers have seen waste as a necessary by-product and cost of industrial production. In the industrial ecology view, residuals from manufacturing are evidence of process inefficiency. Waste is seen as potential feedstock to other processes.

Finally, industrial ecology focuses on the interface and interactions between industrial processes and processes in nature. It views human industrial activity as part of, not separate from, the natural world. This more holistic approach to environmental performance is reflected in our proposed framework of environmental performance.

The environmental performance of an eco-industrial park is most appropriately measured for the entire park, rather than for each individual facility. At the level of an EIP, the facilities cooperate to reduce the environmental burden of the park as a whole. This approach is not well supported by current regulatory practice in the U.S and many developing countries.
10.8.2 Elements of Environmental Performance

Environmental performance is not a single, simple measurement. It is a combination of four elements. At the core of environmental performance is resource utilization within industrial processes (Figure 3-2). This element is concerned with the amount and type of resources used and consumed within a plant's industrial process, (what goes on “inside the fence”). The second element, releases from industrial processes, relates to emissions or releases from processes to the environment (what “passes over the fence”). The third element, interactions of industrial processes and releases with natural system components, concerns the impacts of the industry on the natural environment. A fourth element, context management, involves local and regional or national management systems that influence the other three elements. Environmental performance is a function of combined performance in these four elements. However, we need to break them down further to develop detailed objectives.

Figure 3-2  Relationships among environmental performance elements
10.8.2.1 Resource Utilization within Industrial Processes

Resource utilization focuses on the materials and energy used within the EIP. Three subdivisions of this category are important: energy use, water use, and material usage.

Energy Usage

Energy usage objectives seek to minimize energy use and incorporate renewable sources. It includes: 1) the total amount of energy used, 2) the degree to which energy efficiency measures have been incorporated into design, construction, and operation of facilities, and 3) the use of solar, wind, water power, and geothermal energy.

Some objectives that your design team might consider include:

- Optimize total energy use within the EIP. Stated another way, the objective is to minimize energy usage subject to the requirements of the industries involved.
- Maximize the use of renewable energy sources subject to constraints of the amounts and quality of energy required and the location and setting of the EIP.

In energy efficiency and use of alternative energy, the absolute level of usage is not the most appropriate measure. In most cases, the energy requirements of the industrial processes involved are such that it is neither physically possible nor economically feasible to fully utilize alternative sources. In these cases, the optimal (most favorable for the purpose) level of usage will be lower than the maximum possible level. This optimal level varies depending on the location and situation. You must evaluate the contribution of these strategies to environmental performance relative to the optimal level for your site and the companies located there (or those targeted for recruitment).

Water Usage

Water usage focuses on three aspects of water conservation. 1) the total amount of water used; 2) water-use efficiency (the use of recycling, quality cascading, and other techniques to maximize the utilization of water), and 3) the degree to which the facility captures and uses precipitation and water that enters the site from landscaping sources. Water-use efficiency and use of precipitation and run-on are similar to the analogous elements in energy. They must be evaluated relative to some potential optimum rather than in absolute terms.

Some objectives that your design team might want to consider include:

- Optimize the total water use within the EIP. Minimize water usage subject to the requirements of the park infrastructure and the industries involved.
- Maximize the use of renewable water sources, subject to constraints of the amounts and quality of water required, and the location and setting of the EIP.

Material Usage

Material usage focuses on three aspects of material selection: 1) virgin materials-the types of virgin materials used and relative environmental impacts of materials as determined from life-cycle analysis, 2) recycled materials - the amounts and types of recycled materials used. As with energy- and water-use efficiency, there are potential optimum levels of usage imposed by process and customer quality constraints. Measurement of this element, therefore is relative to those optimum levels of usage, and 3)

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8 For example, alternative energy sources will not be of value in production processes for metals in the near future. However, such sources might be feasible for plant lighting and some options for air conditioning.
hazardous or toxic materials (types and amounts of hazardous materials used in processes and projects to reduce that usage).

The types of objectives that your design team might want to consider include:

- Optimize the total material use within the EIP. The objective is to minimize material usage subject to the requirements of the park infrastructure and the industries involved.
- Maximize the use of recycled materials, subject to constraints of process quality requirements.
- Minimize or eliminate the use of hazardous materials.

10.8.2.2 By-product Management

Industrial processes inevitably produce byproducts, which must be managed by the EIP to improve the environmental performance of the park. Byproduct management involves three related foci.

- elimination of hazardous waste,
- elimination of all wastes,
- utilization of unavoidable process byproducts.

10.8.2.2.1 Elimination of Hazardous Materials

Reduction in the use of hazardous materials offers one of the most significant opportunities to enhance the environmental performance of your EIP. If no hazardous materials are used, the regulatory reporting burden may be substantially reduced, more expensive, special waste handling requirements are reduced, and most importantly, no hazardous materials will be released into the environment. The pollution prevention literature provides numerous examples where substitution of aqueous based solvents for volatile organic solvents and where process changes have enabled firms to eliminate the need for solvents altogether. The lack of existing industrial processes in a developing EIP where firms are developing new plants, creates optimal conditions for redesign of processes to eliminate the need for hazardous materials.

In some cases, where it is not possible to eliminate hazardous materials all together, it may be possible to minimize or eliminate transportation of hazardous materials to or from the site. (The highest form of this objective would be requiring that hazardous materials used within the EIP be generated on site, unless that process poses a greater risk than transport).

10.8.2.2.2 Elimination of Waste

Elimination of waste from industrial processes pays dividends in both economic and environmental performance. The discipline of pollution prevention provides numerous tool targeted at minimizing and eliminating waste. Waste reduction not only reduces costs by increasing the efficiency of industrial processes, it also leads to a reduction in environmental emissions, which include releases from industrial processes to the environment in the form of liquid waste, solid waste, and atmospheric emissions. Solid waste includes factory process residues and refuse and garbage generated by operation of the EIP. Atmospheric emissions include point source releases from stacks and vents and distributed releases from processes or process infrastructure, and fugitive emissions. This includes emissions from process plants and from vehicles involved in transporting people and materials.
Some objectives that your design team might want to consider include:

- Minimize solid waste generation and disposal.
- Minimize the amount of liquid residue requiring treatment.
- Eliminate unnecessary or non-reusable packaging.
- Minimize emissions of greenhouse gases.
- Eliminate the use of ozone depleting substances (ODS).
- Minimize releases of SOx and other acidifying substances.
- Minimize releases of particulate matter.
- Minimize releases of photochemically active substances.
- Minimize the use and emissions of volatile organic compounds (VOC).
- Minimize releases of substances with noxious odors.
- Minimize the treatment burden of water effluent leaving the EIP.

What about zero emissions as a target? Zero emissions is an extremely powerful target. As Beroitz points out, there is no ambiguity about measurement, or intent. In companies where a goal of zero emissions has been accepted, a very high level of creative energy has been generated in finding ways to reduce emissions and remain competitive and profitable. Perhaps the most powerful aspect of a goal of zero emissions for your EIP is that it sets all the enterprises involved in the park on the path of continuous improvement.

The goal of zero emissions by its nature is approached in a series of stages that occur over time. In agreeing to a goal of zero emissions for the EIP, all stakeholders must accept that it is a target, which will take time to approach, and which will never be attained for many substances. The absence of this understanding can create expectations that will not be fulfilled.

In addition, a zero emissions goal for the EIP may create a significant hurdle for recruiting firms to the EIP. From a hard-nosed engineering perspective, zero emissions can appear unrealistic and unattainable. We have used the language “minimize” to acknowledge this concern. If you are more comfortable with this language, approach it with the awareness that, although it is more realistic as a target, it is less effective and powerful than “zero emissions” in creating the desired culture.

10.8.2.2.3 Utilization of process byproducts

Where process byproducts can not be eliminated by process redesign and optimization, environmental performance can be improved by finding uses for the materials in other industrial operations either within the EIP or in the nearby region. The topic of byproduct exchange is discussed at length in Chapter 12. Some specific measures that might be considered include:

- Maximize the re-use of solid residues, subject to product and process quality requirements.
- Maximize the recovery and recycling of solvents, residual oil and other hydrocarbons.

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10.8.2.3 Environmental Interactions

With environmental interactions you consider the impacts of the industrial processes and their releases and emissions on the larger environment. These include: 1) impacts on the natural ecosystem, wildlife and wildlife habitat; 2) interactions with neighbors, both other industries and area residents; and 3) interactions with the physical setting - the land, air, and water. Here you evaluate the hazard and risk inherent in the emissions that were identified in the previous step. This element of environmental performance is very much softer, (i.e., more subjective and value laden) than the other two elements, which are more readily quantified. Also, the interactions can be either positive or negative in terms of their influence.

Ecosystem Interactions

EIP’s may be built within areas that are habitats for a variety of plants and animals, not just endangered species. Routes by which animals travel to reach food or shelter may be affected. Releases of residual material to the land, water, or air have the potential to degrade habitat quality. By properly recognizing these potential problems in the design, construction, and operation of the EIP, you can minimize potential ecosystem degradation. Enhancement of the natural habitat can substantially improve the quality of life for the humans that live and work in and around the EIP.

Some objectives that your design team might want to consider include:

- Ensure that facilities and their landscaping enhance the natural ecosystems.
- Maximize the use of native plants and natural landscaping, subject to requirements of safety, site integrity, and security.

Interactions with Neighbors

The EIP does not exist in a vacuum. Other industrial facilities in the vicinity of the EIP may have already altered the environment. Residential areas border on, or are in the vicinity of, many sites. To the extent that employees working in the EIP commute to work, they pass by and through neighboring communities. By recognizing these realities in the design, construction, and operation of the EIP, you may be able to make its interactions with the existing human environment positive. In addition, pre-existing negative affects can potentially be mitigated, or at least, not exaggerated.

Some objectives that your design team might want to consider include:

- Ensure that the operations within the EIP minimize additive negative impacts upon other neighboring facilities.
- Ensure that the facility enhances the environment of people living in the vicinity.

Interactions with the Physical Environment

Construction and operation of the EIP can alter the landscape and hydrology of the site. The presence of structures in the EIP can alter the local microclimate. Your project designers, builders, and plant operators within the EIP can use objectives in this element to become conscious of these potential changes in the physical environment and to minimize the disruption of it.

Industrial estates generally involve altering the runoff characteristics of the site in significant ways. Pavement decreases natural infiltration and increases runoff. Grading of the site commonly removes small depressions that hold water on the natural landscape. The resulting, post development landscape tends to produce substantially greater runoff than the predevelopment site, especially in climates characterized by high intensity rain storms. In these cases, site design that captures runoff, at least temporarily, is essential.
Objectives that your design team might want to consider include:

- Ensure that the facility and its operations do not cause deterioration of the physical environmental systems of atmosphere, landscape, habitats, surface water, geologic framework, and groundwater.
- Take measures to enhance the quality of the surrounding physical environment.

See the Appendix for an example of applying environmental performance framework to examine the trade-offs involved in site-selection.

10.8.2.4 Resource Utilization within Industrial Processes

The fourth element of environmental performance involves ensuring that appropriate management mechanisms are in place at every level. Three components of this element focus on (1) the Environmental Management Systems of the EIP, (2) the regulatory and fiscal environment of the jurisdiction, and (3) resource efficient transportation.

10.8.2.4.1 EIP Environmental Management System

Wholehearted participation in the vision and the environmental performance of the EIP is an important role for every employee working in the park. The environmental management systems for both the EIP as a whole and for the tenant firms should ensure that employees have the necessary knowledge and motivation to act. The development of an appropriate EMS is discussed elsewhere in this manual.

10.8.2.4.2 Political Participation

Optimizing environmental performance of the EIP may be made very difficult or impossible as a result of specific regulations that preclude desired activities or mandate undesirable ones. In addition, fiscal policy in some jurisdictions create market conditions that, for all intents and purposes, subsidize practices that would be otherwise uneconomic. It is important for EIP management to participate actively in the political process to identify these types of perverse incentives and to work with government to remove them.

10.8.2.4.3 Resource Efficient Transportation

The transportation infrastructure of pipeline, rail, and highway rights of way as well as the direct emissions to the atmosphere and water from vehicles constitute a significant environmental footprint of an EIP. Unlike many other elements of environmental performance, the transportation system is outside the control of the EIP and of its tenant companies. This element of performance is included here, because it can be influenced only indirectly and only over the long term, by the EIP.

To enhance the environmental performance of the EIP it is important that a conscious awareness and action plan for influencing this system be included in the EIP environmental management plan. At the very least, the EIP information system should track developments in research and technology development and public policy that have the potential to improve the resource efficiency of the transportation system in the region and nation. The EIP may want to work with customers and suppliers of tenant companies to assist them in taking advantage of these developments as appropriate. In some jurisdictions, the policy or fiscal context creates perverse incentives that preclude development or expansion of environmentally superior transportation alternatives. If this is the case with the jurisdiction in which your development is located, the EIP may want to include resource efficient transportation on its agenda for political participation.
Model of elements of environmental performance.
10.9 Resources


Stafford Beer’s Viable System Model offers a dynamic organizational structure grounded in the understanding that organizations are living systems interacting with larger living systems. It is a vital tool for managing the transition to industrial ecology.


Developing Environmental Indicators. A site prepared by the WRI Material Flows project to stimulate discussion on key issues in developing materials flow indicators and how they might be used in EPA policy-making. http://www.wri.org/wri/sdis/


This report was based on a gathering of systems scientists from around the world in 1997. It is a very valuable guide to a process for setting indicators that really monitor critical variables.


11 Greening Existing Industrial Parks

This chapter explores the strategies and methods through which managers of existing industrial parks can gain the right to call their properties "eco-industrial parks". We discuss vision-building and strategic planning processes and the benefits of participating in a regional eco-industrial network and by-product exchange. We offer guidelines for these processes and other resources to support the initiative. The chapter also includes a section with cross references to other parts of the Handbook that are particularly useful for managers of existing industrial parks.

An Initiative to Green Industrial Estates in Thailand

The Industrial Estate Authority of Thailand (IEAT) has launched an initiative to make the 28 estates it manages eco-industrial estates. IEAT Governor Anchalee Chavanich has invited the German Technical Cooperation organization to support development of a program that will begin with four estates as pilot sites. The four estates reflect the issues for older sites with a variety of industries (Bangpoo and Northern Industrial Estates), a petrochemical estate (Map Ta Phut), and a relatively new estate with predominantly state-of-the-art factories (Eastern Seaboard IE). The Authority will seek to extend learning from changes in these pilot sites to the other 24 estates that fall within its domain as well as new estates.

The Governor envisions an initiative incorporating by-product exchange, resource recovery, cleaner production, community programs, and development of eco-industrial networks linking estate factories with industry outside the estates. GTZ will assist through capacity development for IEAT headquarters' staff and personnel at the estates, technical transfer, and policy development. Other GTZ programs in Thailand, such as its energy conservation project with the Bureau of Energy Regulation and Conservation, will be coordinated with the IEAT initiative.

Also, the IEAT is planning to set up Human Resources Development Centers at the Bangpoo and Northern industrial estates with a support from the Japanese government through a special loan program. These training centers will promote skill development of all factories’ technicians, especially, for the Small and Medium Enterprises (SME’s) whose environmental performance the Thai government wants to improve.

Thailand has a unique opportunity to demonstrate the principles and concepts of eco-industrial development at a national level. Top leadership of the Industrial Estate Authority and of four IEAT estates have demonstrated a powerful level of commitment to collaborating with GTZ in a multi-year project likely to transform the performance of industrial estates in Thailand.

This eco-industrial initiative appears to be the most far-reaching eco-industrial effort in either developed or developing countries. It promises to ultimately impact the environmental, social, and economic performance of all industrial estates managed by IEAT as well as the operations of stand alone plants surrounding the estates. The Authority is in a unique position to demonstrate the principles and strategies of eco-industrial development. (Lowe 2000, Koenig 2000)

(See more details on this case in Chapter 8 and in the Appendix, Cases)
11.1 Introduction

Can an already developed industrial park become an eco-industrial park? The very large number of existing industrial parks in the world makes a positive answer to this question very desirable. Improving the environmental, social, and economic performance of companies at this scale would make a significant contribution to the companies and park management, to neighboring communities, and to sustainable development. The resulting EIPs would have more stable communities of tenants, supporting each other’s business success and reducing tenant turnover. New services offered by eco-park management would yield new revenue streams.

An industrial park demonstrates clear patterns of development, ownership, property definition, jurisdiction, responsibility for management and maintenance, and control. The economic self-interest of the property owner and management firm, public regulation and zoning, and the proximity of the companies on the site make industrial parks relatively focused sites for innovation.

If the management of an industrial park and the site’s companies seek to become an EIP there are a number of actions they can take to earn the right to use this name. As with an industrial park in process of first development, these elements form a whole system to guide park redevelopment. If the park has ISO 14001 certification or another form of environmental management system, this could become the basis for setting eco-industrial performance objectives and the means for attaining them. (See discussion of environmental management systems in Chapter 10.)

Eco-industrial development is a means of achieving sustainable industry through local and regional action. The industrial park or estate is a point of leadership and leverage for change in its region’s industrial community. This industrial community may be able to realize innovations larger than a park’s management could undertake, such as an integrated resource recovery system or by-product exchange. A park seeking to become an eco-industrial park can act as the hub of a regional eco-industrial network through its own improvement projects and through the connections of its factories with suppliers and customers outside the estate’s border.

Eco-industrial development seeks to achieve:

- Resource efficiency in energy, materials, water, and transportation, with the cost savings gained through higher efficiency;
- Cleaner production through good housekeeping, reduction and substitution of toxic materials, strict control of emissions, separation of by-product or residual materials, etc.;
- Use of renewable energy and materials to replace fossil fuel sources and finite material supplies;
- Rehabilitation of existing buildings to higher energy and environmental standards and use of green architecture and engineering in new facility and infrastructure design;
- Enhancement of quality of life and economic development in neighboring communities through projects between industry and community government and community-based organizations.
- Ecological site planning and utilization based upon clear understanding of the carrying capacity of air, water, and ground systems and the nature of remaining native ecological systems.
- Establishing environmental management systems such as ISO 14000 with objectives and indicators informed by eco-industrial development, not only compliance with regulations.

Eco-industrial development projects are learning systems that seek to gain multiple benefits from each activity. For instance, an integrated resource recovery system increases industrial resource efficiency, lowers pollution, creates opportunities for entrepreneurs and workers, and strengthens the local and national economy.
As we indicated in Chapter 2, the essence of eco-industrial development is balancing industrial activity with ecological, social, and economic interests. For the management of an existing industrial park, this means working with its tenants and property owners to form a vision and strategic plan. The specifics of this plan will determine the investments required from both private and public sectors to earn the title eco-industrial park. Key activities in this process include:

- Form a project core team and recruit key stakeholders.
- Create a vision for the project and set economic and environmental performance objectives.
- Gather information on the current state of the industrial system by conducting baseline audits and surveys of energy, water, and material flows.
- Assess needs and resources in neighboring communities that could be served by a community enhancement program.
- Develop strategic plans at industrial park and plant levels.
- Recruit public agencies to support the initiative.
- Begin programs to improve in-plant performance (which may be conducted by a Cleaner Production Center).
- Begin programs to develop energy, water, and materials exchanges between firms or in the region.
- Review progress regularly in terms of the performance objectives and goals you have set.

In many cases the initiative will focus within the park and with near neighbors. In other cases, the transition from an industrial park or region to an EIP may start as a major public/private partnership with ambitious intention, as in the eco-industrial projects of the Industrial Estate Authority of Thailand or the PRIME Project in the Philippines.

11.1.1 Certification of EIP Status

Managers of industrial parks should not assume that they can just declare that their sites are eco-industrial parks. They have to earn the right to use this term and before doing this they may only say that they are aspiring to this status. At the time of writing, the details of a certification process are being worked through by a team of international experts in eco-industrial development. See [www.indigodev.com/Certification.html](http://www.indigodev.com/Certification.html) for news on this process.

11.1.2 Benefits to the Management of the Property

The most basic benefit of becoming an EIP is that this status promises to enhance the competitive advantage of the property. As more and more parks and estates win ISO 14001 certification this label will lose its distinction. Many multinational companies may see it as a given in their site-selection process but no longer a special attractor. Tenants may see eco-industrial parks as offering a unique level of excellence in inter-company collaboration and in services and amenities available. This assumes that corporate motivation to improve both their environmental performance and their image will continue to grow, as the market increasingly demands it.

The features of EIP design that help tenants enhance their performance may give management opportunities for sharing in their financial benefits. This may be through direct fee for service or by contracts to participate in cost savings made possible by park infrastructure.

A significant cost of managing industrial parks is maintaining good relations with regulatory agencies and neighboring communities. Both groups of stakeholders are likely to see the actions a park and its tenants have taken to become an EIP as signs of strong commitment to maintaining a site managed with low levels of pollution and high efficiency of resource use.
11.2 Surveying the Present State of the System

As you define the broad vision and the geographic scope of your project, you will need to get a clear picture of the present situation. This may involve a baseline assessment of the park management, and company surveys and audits. To some extent you will be able to compile information from existing data sources. If it appears that a by-product exchange could be a part of your initiative, another step may be studying the management of the stream of discards in the community and region as a source of value.

A well-defined assessment will review achievements as well as problems. Your industrial park may have an effectively implemented environmental management system, special environmental permits, innovative infrastructure, or social amenities such as a training center or a day-care center for employees' children. You need to consider what qualities of management have enabled these positive features of your park. Build on these strengths.

At the end of this chapter we provide questions to guide a baseline assessment of your industrial park's management. In the appendix you can find guidelines for surveys of your tenant companies. The UNEP report, *Environmental Management of Industrial Estates*, gives more detailed guidelines and worksheets. (UNEP 1997)

With a baseline or starting point defined, your team can identify priorities, form a strategic plan, and create initiatives including: a by-product exchange network, and programs for energy efficiency, water conservation, pollution prevention, and other measures.

Collecting information on needs and resources of neighboring communities is another task in this planning stage. This may be done through meetings with public, civil, and private stakeholder groups or through surveys parallel to the surveys of companies in your park. Your team may find that the community has resources to support your effort to become an EIP and that there are needs in the community that you can help meet. (*See Chapter 3 for more discussion of an industrial park's relationship to its host community.*)

11.2.1 Plant Surveys

Facility surveys should include all manufacturing plants as well as service companies in your estate, such as hotels, training centers, or the park commons. The survey and analysis process might be managed by the park tenants' association, a local trade association, or an economic development agency. Company managers may be reluctant to release data if a regulatory agency plays this role. The project team may also seek support from university faculty/student teams and retired professionals. The Philippines Board of Investments PRIME Project consultants worked with environmental managers at each of the participating industrial estates in Laguna and Batangas Provinces to design a survey with a high degree of confidentiality. This is important to assure respondents that their proprietary data will not be disclosed.

The broad categories in this survey include the following:

- Status of environmental management system;
- Participation in cleaner production, waste reduction, pollution prevention, or energy efficiency programs;
- The products/services each plant produces;
- Process technologies used;
- Major material, water, and energy inputs;
- Major by-product material, water, and energy outputs;
- Environmental training resources and needs;
- Services required from the park and third party firms;
- Programs to benefit employees and local communities.

Your project team will work with your survey teams to compile this information into an overview of company resources and needs. Creating a web-site open only to park and tenant personnel is one way to make the survey results available to project participants and to enable discussion among them. This may include a data base of by-products as a step toward creation of a by-product exchange. See the next chapter for fuller discussion of methods for creating BPXs and the Appendix for sample survey forms. The chapter on controls contains guidance on setting the Environmental Performance Objectives.

11.2.2 Strategic Planning

One effective form of strategic planning is to use the project vision and performance objectives your team has developed as the desired future state for the park or region. Chart the present state you have defined through the surveys and audits. Then set multiple teams to the task of discovering the paths for moving from the present to the future. Systems scientist Russell Ackoff has developed a method he calls "idealized planning" for going through this process. (Ackoff 1981) Management teams of many larger corporations have staff expert in this process.

Your strategic plan will need to include public sector initiatives, actions among the community of companies, and support for innovations in each plant participating in the project. It also must integrate these three realms of change. As with any planning process, build in excellent feedback loops and means for course correction as you move into implementation.

11.3 Eco-Industrial Networks as Context for EIP Development

Managers of an industrial park who wish to gain the benefits of making their site an EIP may find much support for this by participating in the development of a regional eco-industrial network. The companies in an industrial park often have numerous suppliers and/or customers in surrounding industrial areas. These connections provide links for building an EIN. Park tenants may have already started improving supplier environmental performance through requirements for ISO 14001 certification. An EIN extends such collaboration across a number of activities and institutions.

<table>
<thead>
<tr>
<th>Eco-Industrial Supporting Institutions</th>
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<tbody>
<tr>
<td>Formation of an eco-industrial network may entail creation of a number of supporting institutions:</td>
</tr>
<tr>
<td>- An integrated resource recovery system (For IRRS see Chapter 6.);</td>
</tr>
<tr>
<td>- A system for encouraging and managing the exchange of by-products between companies (For BPXs see next chapter.);</td>
</tr>
<tr>
<td>- Training and services in all aspects of eco-industrial development;</td>
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<tr>
<td>- A network management/coordinating unit and working groups;</td>
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<tr>
<td>- A community enhancement office to manage projects with neighboring communities.</td>
</tr>
<tr>
<td>- One or more business incubators (for small-to-medium size enterprises or SMEs).</td>
</tr>
<tr>
<td>- Public sector support in R &amp; D, policy development, access to investment, and information management.</td>
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</table>
The development of **by-product exchanges and integrated resource recovery systems** are closely linked in their management of by-product energy, materials, and water. Some company-to-company exchanges develop with little effort, others become complicated and costly transactions. So the exchanges between pairs of companies is only one part of a system for optimizing by-product utilization. A network of companies specializing in collection, reuse, recycling, and remanufacturing offer comprehensive by-product management to industry. This system may be created by an industrial park, a service business or utility, an independent entrepreneur, or possibly by a public industrial development agency. The IRRS companies could be distributed throughout the region or concentrated in a resource recovery park at a central location.

**Training** enables EIP or EIN members to gain the technical and business skills required for eco-industrial development. Course opportunities range from reviews of state of the art technology in energy management, by-product utilization, green chemistry, or hazardous materials recycling to broad themes like sustainable industry and industrial ecology. Training in basic cleaner production techniques like source reduction, materials substitution, and efficient process design allow factory managers to cut the overall volume of by-products generated at their plants, thus avoiding overload of the IRRS. A number of Asian countries, including Thailand, the Philippines, and China are creating national and regional Cleaner Production Centers that will provide training and other guidance in this realm.

**Services in an EIE or EIN** can include consulting to support projects in most of the subjects just listed for training. For instance, a comprehensive audit of materials, energy, and water flows through a facility will prioritize opportunities for increasing efficiency and lowering pollution. It will also evaluate the feasibility of internal reuse, exchange with neighboring plants, or recovery through the IRRS.

Other services in an EIN enable members to cut costs through common procurement of goods and services or by integrating employee transportation management. For instance, a service firm could do bulk purchases of office supplies or commonly used process chemicals. Environmental service firms could handle permitting, monitoring, and reporting requirements for SMEs who cannot afford their own environmental staff.

**A network management/coordinating unit and working groups**

An eco-industrial network needs a management and coordination system to do needs assessment, set priorities, conduct organizing events, and oversee common projects. In the Philippines the EIN project started by the Board of Investments PRIME project in 1999 enlisted six industrial estate management teams. This management committee started planning by-product data collection processes, using each estate’s environmental managers. The group also planned a feasibility study for an integrated resource recovery system to receive by-products and residuals that could not be exchanged within or between their estates.

In Thailand EIN management units could draw from estate managers, managers of stand alone factories, trade associations, and local government representatives. The focus of control should be in the region so that projects are well suited to the needs and capabilities of network members. The network can then request support from Industrial Estate Authority headquarters, other national agencies, Germany’s GTZ, and other overseas sources.

**A community enhancement unit to manage relations with neighboring communities.**

Initially this could be one of the working teams of the management committee, with the mission of two-way communication, community project development, and enlistment of stand alone firms into the EIN. Thai industry is discovering that it needs to go beyond public relations to active partnering with neighboring towns. Companies and the estate management itself can participate in workforce training, contribution of surplus IT equipment to schools, provision of employee housing located in the community, and other projects enhancing the quality of life in their region.
Business incubators for small to medium enterprises (SMEs)

An EIE or EIN team can enhance the success rate of new businesses by setting up an incubator through public/private collaboration. This resource can play a vital role in developing suppliers to anchor tenants, filling out a theme cluster such as resource recovery or renewable energy, or helping to fill niches in the by-product exchange network. Both the Philippine and Thai projects are exploring the role incubators could play. In Thailand this concept is still new but the Department of Industrial Promotion is creating structures to support business cluster development and could potentially take a lead in incubator development. (personal communication from Supriya Sithikong, Director, Bureau of Industrial Promotion Policy and Planning)

Transportation services: Van lines, shuttle services from terminals, and car-pooling offices can all reduce the environmental burdens of single-driver auto transport while easing employee travel needs.

Environmental management: Small-to-mid-size firms particularly may benefit from outsourcing aspects of their environmental management tasks to consulting and training companies. Permitting, training, and reporting are some of the duties that open business opportunities for local firms. A Cleaner Production Center could provide a site for such businesses as well as one-stop shops for permitting and other regulatory functions.

11.3.1 Enlisting Public Sector Support

The activities of an EIN may be supported by a variety of public agencies in economic and industrial development, energy and natural resources, and environmental protection. International aid organizations such as UN Development Program, UN Environmental Program, US-AID, or other international aid agencies such as Germany’s GTZ may be sources of support. The EIN project in the Philippines was initiated and financed by UNDP and administered by the Board of Investments. The champions of an eco-industrial network initiative should evaluate the potential sources of financial or in-kind support and enlist the stakeholders who can contribute with the fewest bureaucratic complications.

(See Chapter 7 Financing for a detailed list of international sources.)

11.3.2 Individual Company Initiatives

11.3.2.1 Cleaner Production

Each company’s audit will identify opportunities for on-site waste reduction, substitution of non-toxic materials for toxics, process changes to reduce or eliminate emissions, and other fundamental action to cut waste and pollution. Government environmental agencies, universities, or private consultants may be able to provide training and technical support. This is especially important for smaller firms.

11.3.2.2 Retrofitting Existing Facilities

The plant audits may suggest the value of modifying or replacing existing equipment and systems, for buildings and production processes. This will require new investment in existing, sometimes aging, facilities. In many cases, changes to existing facilities will be cost effective investments. In others, the company may find that spending more on the old facility will not have a reasonable return on investment.

Explore all opportunities to conserve energy and recycle materials, especially in rehabilitating old buildings. Here are some suggestions:

- A logical place to start is to maximize energy and water efficiency through minimizing losses and cascading of heat or process water through secondary uses.
- Industrial warehouses often have few people or offices in them, but may still require heating, to protect the products within. Much of this heating energy can be supplied by passive solar systems; don't neglect this opportunity.
Take advantage of the vastly improved quality of windows and doors, and weather-stripping now available.

- Insulate walls and ceilings.
- Upgrade to energy efficient motors in building and production systems.
- As you upgrade the wiring and electrical services, incorporate compact fluorescent lamps, LED “Exit” and other emergency signs and lights, and high-efficiency motors.
- Check with your local utility company; most of them offer many services to architects and building owners to help them reduce their electrical demand. Many also offer subsidies on equipment purchase.
- Air handlers and other portions of the air-conditioning systems are frequently placed on flat rooftops, exposed to the full force of the sun. Ask your engineers about the benefits of shading this equipment, with a simple shed roof, or by placing the equipment in the shadow of a north wall. This can be a very inexpensive way to significantly increase the overall efficiency of the air-conditioning system.
- Is there a construction materials exchange in your community? If not, there may be other ways to promote reuse of salvaged building materials, e.g. Habitat for Humanity, or other volunteer groups building or remodeling low-income housing.

See Chapter 8 for more information on building design, energy efficiency, and recycling of construction materials.

11.3.3 Community Initiatives

Management of an industrial park can work with tenant companies to improve the site, including each plant’s landscaping. In a region, this task may be assumed by a local industrial association, in collaboration with your city parks department. Doing this can improve the environment ecologically and make it a more attractive location for employees and customers. (See Chapter 3 for more on working with local communities.)

11.3.4 Landscaping and the Reclamation of Land

Existing storm-water management systems are designed to expedite water away from the site. Explore with a civil engineer opportunities to capture rainfall runoff on the site, perhaps in a pond, lagoon or wetland area. This has manifold advantages: it can be an aesthetic delight, it helps recharge the groundwater or aquifer, and reduces the (peak) load on the local sewage treatment plant. When it captures the storm water from streets and parking lots it will be necessary to remove the hydrocarbons or other contaminants. The water may then be used within the site or industrial park.

11.3.4.1 Ecosystem Restoration

Consider measures you may take to restore the property to something closer to its original state before it was developed. Restoration can take many forms.

- Constructing wetlands; (Which may be used to process storm water or as a tertiary treatment system for industrial water.)
- Planting trees and shrubs, preferably species native to the region;
- Allowing portions of the property to go “unmanicured” so that the native flora return (prairie grass, forest, wild flowers, etc.); and
- Creating a habitat for birds and other animals.
11.4 Organizational Change

Eco-industrial development offers a breakthrough for government and businesses struggling to create sustainable industry that preserves environmental, social, and economic values. It is holistic and thus quite challenging to managers and staff used to working within a narrow, specialized view of their responsibilities. Becoming an eco-industrial park requires collaboration among industrial park management, the park's companies, and a number of national, provincial, and local agencies. A basic condition for the project's success is achieving a new level of flexibility and creativity in the management team and in its relations to other stakeholders.

To realize the vision of an eco-industrial park the park management team may need to go through an organizational change process that reshapes its culture, structure, and dynamics of operation. There are many methods available to support this evolution into an organization in which individuals, teams, and the collective learn from each experience and rapidly adapt behaviors. This capacity development program would interweave the mastering of eco-industrial development concepts and methods with the process of becoming a learning organization (see Chapter 4). The park team should seek ways to share the learning process with the site's companies and agencies responsible for regulating and promoting industrial development.

One key tactic in all of this is reviewing organizational reward systems to support the goals of resource efficiency, cleaner production, use of renewable resources, and other key eco-industrial objectives. Another important step is the definition of eco-industrial indicators for industries as well as indicators for the government and civil sector stakeholders.

11.5 Using This Handbook for Existing Parks

Chapter 1 Introduction gives the basic definitions of eco-industrial parks, eco-industrial networks, and by-product exchanges and outlines the design strategies for EIPs.

Chapter 2 Foundations presents the foundations of eco-industrial development in industrial ecology, Cleaner Production, sustainable architecture and planning. Understanding the conceptual background enables existing sites to improvise within the guidelines this Handbook offers.

Chapter 3 Community explores the ways in which EIPs can interact with their neighboring communities. The greenhouse gas reduction program at the end would build strong connections between existing industrial parks and towns near them.

Chapter 4 Planning and Development includes discussion of recruitment strategy that would be useful for existing parks that have vacancies. The section on learning organizations is also relevant.

Chapter 5 Financing provides an extensive listing of sources of financing for environmental and sustainable development projects.

Chapter 6 discusses the emerging sustainable economy which we believe will be an important context for the tenants of existing parks. The recruitment clusters we describe here may match the tenants you already have or provide ideas for filling vacant land in to create such clusters.

Chapter 7 Policy includes ideas on policies that may support many aspects of your site's eco-industrial program. It is especially useful if you are seeking to develop exchanges of by-products among your tenants or between them and neighboring industry.

Chapter 8 Design Strategies includes design ideas you could use in retrofitting your park's infrastructure and to support tenants in improving their buildings. If your park has vacant sites new tenants could use this chapter to guide their designs.

Chapter 9 Construction may be useful if you are still building out your site.
Chapter 10 Management contains many ideas for how to organize your industrial park and its community of companies for the sort of initiative required to become an EIP. This includes potential revenues streams for park management.

Chapter 12 BPX will be an important discussion if your team sees the possibility of developing a by-product exchange within your park or in your region. This also could become a source of revenue for your management company.

The Appendix includes a variety of cases in Asia, North America, and Europe, including a major study of eco-industrial projects in Japan. There are also a variety of forms and tools of use to managers, such as forms for tenant surveys.

11.6 Baseline Assessment of Industrial Park Management

The following lists general directions for inquiry in the baseline assessment of the management of an existing industrial park. In a first round park management should review each question in a qualitative mode to answer three questions:

1) Which questions need to be explored in greater depth?
2) What problems require short-term attention?
3) What are the major achievements in design and management of your site that prepare the way for becoming an eco-industrial park?
4) What short-term opportunities could generate cost savings, new revenues, or other benefits to the industrial park management?

After identifying opportunities, challenges, and additional questions, then go through a second round at a quantitative and more detailed level.

11.6.1 Input-output patterns

Identify the major energy, water, and materials flows into and out of the park itself as an operation. Include any emissions, effluents, or solid wastes from the park operation (as distinct from tenants' operations). The park manager responsible for environmental issues can use reporting documents required by regulations as well as bills of lading and other records of shipments to landfills, recycling centers or incinerators.

Broad categories for assessing the site-wide patterns as well as those of each company:

- Resource utilization for energy, water and materials;
- Environmental emissions: atmosphere, solid and liquid waste;
- Environmental interactions with ecosystems, physical environment, neighbors, and community.

Do a qualitative description of the tenant's major flows, in so far as they are known by park management. Do any of the major by-products streams or supply needs suggest targets for recruitment as suppliers or customers?

Invite park tenants to participate in a confidential survey of their input-output patterns and design it with them. (See Appendix for details on such a survey.)

11.6.2 Park Management

11.6.2.1 Financial performance

Review trends in profit and loss, return on investment, and projections for future performance of the industrial park property.
11.6.2.2 Marketing
What is the demand for industrial space in this area, current and projected?
What is the competition? What services do other parks offer that you do not?
What is your present source of competitive advantage (or disadvantage) relative to other industrial parks?

11.6.2.3 Turnover
How stable is the pattern of tenancy?
Why have tenants left?

11.6.2.4 Services
Evaluate the services the industrial park currently offers tenants. Those offered by 3rd party providers?
What are the revenues and volumes and the profit (or loss)?
What needs for new services have tenants expressed?
Consider surveying tenants needs, especially for services that will improve their environmental and energy performance.

11.6.2.5 Regulatory relations
Are there any unresolved regulatory issues for the park itself? For tenants? (These may include permits or judgements pending decision or possible amendments to environmental regulations.)
What support is available from environmental agencies for training or technical transfer? Do your tenants use it?
Analyze the costs of park environmental management.

11.6.3 The Site
What land on the present property can still be developed? What are your plans for its use?
Is there adjacent land available for expansion, buffer zone, or housing?

11.6.3.1 Buildings available
Are there vacant buildings? For what uses are they suitable?

11.6.3.2 Grounds
What land is reserved for what non-industrial uses?
11.6.3.3 Infrastructure
In each area of infrastructure assess (where relevant):

- capacity relative to past and projected tenant needs,
- quality of service, and
- capacity relative to developing exchange of by-products, cascading of water or energy, and otherwise improving efficiency of resource use.

Energy
Water
Materials
Transportation
Telecommunications
Services

11.6.3.4 Landscaping
How suitable is the landscaping to the climate and local ecosystem?
What are the costs and resources used in maintenance?
To what extent does landscaping add to the market appeal and quality of life at the park?

Contamination
Are there contaminated sites in the park?
Who holds liability?
What is your plan for clean-up?

Special features
Are there geological or ecological features whose value could be developed in the site?
What is the potential for artificial wetlands, native plant restoration, or intensive gardening?

11.6.4 Relations with Neighbors

11.6.4.1 Ecosystem
Does the operation of the industrial park create any negative impacts on the ecosystem in which it is located? Impacts from the operation of tenants? (Include impacts on human populations.)

11.6.4.2 Industrial parks and plants
Are there any negative or positive impacts on neighboring industrial plants? Or do they impact your park in any way?
Are there any obvious opportunities for by-product exchange?
11.6.4.3 Community

Does the operation of the industrial park and its tenants create any negative impacts on the health of area residents?

How well does local economic development support recruitment of companies?

Is there a business incubator to support new ventures serving the park tenants?

What is the quality of education/training for your workforce?

Is there support for technical transfer from colleges and universities?

What level of support for community development is there from the park management and companies?

Support for broader environmental programs?

11.7 Resources and References

We list potential international sources of support for financing eco-industrial initiatives in Chapter 5.


Burnside Industrial Park, Nova Scotia, Canada. The earliest initiative to apply industrial ecology in a large existing industrial park. www.dal.ca/eco-burnside

Canadian Eco-Industrial Network This network seeks to develop new business relationships in order to use existing energy, material, water, human and infrastructure resources to improve production efficiency, competitiveness, human and ecosystem health. CEIN proposes working in the following areas: waste heat recovery; supply chain management; co-generation; product stewardship; district heating and cooling; ‘green building development’; shared emergency response capacity development; natural rehabilitation of degraded sites; collective employee training; resource, recycling and reuse centres; collective transportation infrastructure; numerous by-product (waste) exchanges; and research and development. http://www.peck.ca/cein/main.htm

CADDET Energy Efficiency Toolkit contains links to energy efficiency related tools, including databases, decision support tools, fact sheets, conversion tables, calculation programmes, and analysis tools http://www.caddet-ee.org/ee_tools.htm


Long Island City Business Development Corporation. 2000. [www.licbdc.org](http://www.licbdc.org) This New York organization has been operating a BPX program for five years and is now expanding into a full eco-industrial network.


PRIME Project, Industrial Ecology Module is an eco-industrial network including six industrial estates. [www.iephil.com](http://www.iephil.com)


Symbiosis Institute, Kalundborg, Denmark. Web site for the world famous by-product exchange anchored by a power plant. [http://www.symbiosis.dk/index.htm](http://www.symbiosis.dk/index.htm)


*See also references and links in Chapters 1, 8, and 12.*
12 Creating By-product Exchanges Among Companies

In this chapter we review the most familiar industrial ecology concept, one that goes under many different names: by-product exchange, by-product synergy, industrial ecosystem, industrial symbiosis, green twinning, and zero emissions network. The core of this concept is creating a system for trading material, energy, and water by-products among companies, usually within a park, neighborhood, or region. We review the benefits of participation in by-product exchanges (BPX) for industrial parks and their companies, the challenges in their development, steps in organizing exchanges, and alternative organizational forms for their management. We emphasize the importance of considering by-product exchanges in the broader context of eco-industrial development.

One gap is important to note at the beginning. We have found it difficult to gather more than anecdotal reports of the achievements of BPX or industrial symbiosis projects. Some projects only release qualitative information and limited data on the exchanges companies have actually agreed to. Or they have only completed a planning and analysis stage and do not yet have results to report. There are many maps of hypothetical BPX networks, based upon surveys of the available by-products of companies in a project area. It appears that these opportunity maps are likely to support the next stage of deal-making required to capture the value in these now unutilized resources. However, there is a very strong need for systematic research on the results of these projects and the most effective way of organizing them.

This chapter is based upon our own work in eco-industrial projects, a report we developed for the Philippine Board of Investments, the experience and concepts of a number of engineering and consulting firms, and resources at Cornell and Yale Universities. See the Resources section at the end for references and web sites on by-product exchange.

12.1 Introduction to By-Product Exchange (BPX)

A by-product exchange (BPX) is a set of companies seeking to utilize each other's by-products (energy, water, and materials) rather than disposing of them as waste. The creation of BPXs has been one of the most frequently attempted strategies for applying industrial ecology. This popularity comes from the promise of companies gaining new revenues from some by-products and saving the costs of disposal of others. On the demand side, customers may gain local sources of supplies at reduced costs. Joining a BPX appears to be an easy way for a company to begin practicing efficiency of resource use and to learn other ways to improve environmental performance.

While forming a BPX is a popular strategy, it is only one of many elements in the development of eco-industrial parks or networks. There are many other strategies for achieving higher efficiency of resource use and minimizing waste disposal. See the previous chapter on eco-industrial networks and Chapter 2. A BPX may result in opening of new local business opportunities and jobs so it is worth consideration by industrial park developers and managers. However, this option should be evaluated in the broader context of achieving the full objectives of eco-industrial development.

Forming a BPX may or may not be feasible within any one eco-industrial park project. The companies at one site may not generate a mix of by-products with enough variety and in sufficient quantities to make many exchanges within the park cost-effective. Access to by-product resources may not prove to be a sufficient inducement to attract many businesses to locate at the park. The development or management team of an industrial park should assess the feasibility of trading by-products for the mix of tenants planned for the park or already there. If there are tenants with high volume by-product streams (materials, energy, or water) an internal exchange may work.

A regional BPX, incorporating companies within a number of industrial parks or in an industrial region or zone, may be required to generate the volumes and variety of outputs necessary for an effective exchange. This larger and more diverse pattern of exchange will enable members to gain highest resource efficiencies.
Creating By-product Exchanges

Industrial park management can explore the potential for creating a regional BPX through trade associations, chambers of commerce, and economic development or waste management agencies. A regional inventory of by-products will indicate the possible value that could be generated in this way. In this chapter we outline steps in the process for establishing feasibility and developing BPXs.

If the stakeholders decide to move forward to develop a BPX, they may find that an exchange of outputs among existing companies may fall far short of utilizing all available by-products. To achieve optimal use of by-products, a project may require integration with an integrated resource recovery system (IRRS). An IRRS includes hauling, reuse, recycling, remanufacturing, composting, and bioenergy companies. It supports the operation of a BPX by utilizing by-products no company in the BPX needs as inputs. It may offer more cost-effective solutions than direct company exchanges in many cases. See Chapter 6 for our concept of an integrated resource recovery park.

There are a variety of approaches for forming a BPX. The organizing body may be a government agency, trade association, public private partnership, broker, by-product utility, consulting firm, or others. In many cases, a private sector actor or public private partnership is probably the most effective organizer. A BPX is essentially an alternative form for supplying resources to companies and needs to meet the basic business requirements of industrial procurement. A by-product utility may be a strong candidate for the organizing entity for both BPX and IRRS. A venture with adequate investment and technical depth could contract with industries in a region to manage their non-product outputs, determine industrial customers for those with current markets, coordinate operation of resource recovery companies for other outputs, and responsibly discard the residues. We discuss these alternative organizational forms below.

The exchange of by-product materials, energy, and water is not an end in itself. It is one means toward reducing resource depletion and pollution. Full eco-industrial development requires institutional support for cleaner production and the economic and social aspects of sustainable development. Cleaner production includes cutting resource input requirements and by-product outputs through more efficient process and product design, using alternative resources that are less polluting and more renewable, and cleaning up production processes to lower pollution. These initiatives can benefit local communities by strengthening their economies and providing venture and job development opportunities.

12.1.1 Kalundborg and the BPX Concept

The story of Kalundborg, an industrial by-product exchange¹ in Denmark, has become the premier case illustrating the BPX concept. In the late eighties local high school children traced the network of exchanges between a coal-fired power plant, a refinery, a pharmaceutical company, a plaster board plant, a sulfuric acid plant, the town district heating system, and farmers. Plant managers were surprised to see the complex system of exchange they had created by simply striking deals, one to one, over a 20 year period. Their motivation was financial — to gain new revenues by energy or materials sales and to avoid the costs of waste disposal. By early 2001 they had reduced pollution and waste and by doing so had gained a US$160 million return on an investment of $75 million in infrastructure for conveying by-products from one plant to another. Present annual savings are $15 million. (Symbiosis Institute 2001. personal communication) They call the network an “industrial symbiosis.” See the full case study in the Appendix for details of the by-product flows.

Champions of BPXs often recommend the self-organizing method by which the companies formed this pattern of exchanges as a model of how others can do it. There are now initiatives around the world inspired by this record of success in utilizing by-products profitably. Some researchers have found other sites where by-product exchanges have developed spontaneously. A team led by Erich Schwartz at Karl-Franzens-

¹ Some proponents call Kalundborg “the first eco-industrial park,” however it is not an industrial park at all. It is more accurate to term it a regional by-product exchange including a number of companies and the municipality.
Creating By-product Exchanges

Universitat Graz, Austria has identified a larger, more complex pattern of by-product exchange in the Austrian province of Styria, and one near Hamburg in Germany. Schwartz suggests that the pattern of inter-plant exchanges may occur often, but without self-awareness by the participating firms. His group in the Institut fur Innovationsmanagement, has developed tools for analyzing inter-company resource flows and facilitating exchanges. Dr. Schwarz and his colleagues have been working with economic development agencies to enable development of regional “industrial recycling networks.” ([Schwarz and Steininger 1995, Strebel 2000])

We will outline the typical steps such third party facilitators take with industries in the next section. Then we will explore an alternative model for achieving high utilization of industry by-products – the creation of a business that functions as a by-product utility.

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**Selected BPX Projects**

**Japan** has at least 60 Eco-Industrial Projects, primarily focused on by-product utilization and waste reduction. See our report, *Eco-Industrial Development in Japan in the Appendix.*

Naroda Industrial Estate, in **Gujarat, India**, is a 30 km² industrial estate with 700 companies in many different industries. The Gujerat Industrial Development Corporation is working with the estate’s industrial association to identify by-products that companies there can utilize.

The PRIME Industrial Ecology project in Laguna and Batangas Provinces, the **Philippines** has evolved from a straight BPX project to an eco-industrial network exploring development of an integrated resource recovery system. ([www.iephil.com](http://www.iephil.com)) **Thailand’s Industrial Estate Authority** is at the beginning of a similar comprehensive eco-industrial project.

In **Taipei, Taiwan** the Industrial Technology Research Institute has started an eco-industrial project with exploration of by-product exchange as a means of reducing pollution and landfill.

Triangle Joint Council of Governments, **North Carolina, USA** has conducted an inventory of by-products generated in a 6 county area of North Carolina. (The web site contains many reports, tools, and forms of use to anyone developing BPXs) [www.tjcog.dst.nc.us](http://www.tjcog.dst.nc.us)

The Alberta Heartland initiative in **Canada’s province of Alberta** has analyzed by-product streams in this province dominated by petrochemical industry and farming.

In **Tampico, Mexico** the Business Council for Sustainable Development led a public private partnership in a project it called “by-product synergy”, beginning in 1997. The participants identified 63 potentially usable by-products in the outputs of 21 participating industries. Of those, 13 companies immediately pursued those with immediate commercial potential.

In **Namibia** a beer brewery has created a BPX with neighboring companies using its biomass and water outputs. *See case in Chapter 6, Agro-EIPs.*
Creating By-product Exchanges

12.1.2 The value of BPX for industrial park developers and managers

There are many reasons for developers of new industrial parks or managers of existing ones to consider the feasibility of developing a by-product exchange (BPX) within their park or in their region. They want their sites to have advantages for tenants that support recruitment and retention. If their tenants can operate more efficiently and reduce their environmental burdens, they will protect the investment in developing the property. The park and its tenants are responsible for managing solid and liquid wastes from production, at significant cost and subject to regulation. Reducing these costs and risks will benefit the industrial park management and the companies it serves. When an EIP has recruited a major anchor tenant with large by-product streams, other tenants may be attracted by the availability of its energy, materials, or water as supplies to their operations.

So we encourage developers to explore how this strategy can fit into their broader recruitment and management process. There are several different approaches to organizing BPXs:

- An eco-industrial park (of sufficient scale) initiates a BPX planning process internally;
- A major tenant takes the lead because it has major by-product outputs and disposal costs;
- A third-party firm contracts to develop the trading of by-products or to act as a by-product utility;
- Tenants of an individual EIP participate in a regional program for by-product utilization;
- A government agency may be the initiator
- A by-product utility manages all formerly discarded outputs for its clients and assumes the responsibility of finding the markets and uses for them.

Some cases suggest that a BPX may be most effective if it includes companies across a broader region, perhaps those in several industrial parks and independents. So a by-product exchange may start out as a regional initiative with any individual eco-industrial park one of many players. We describe methods and principles in this chapter which are being used at these different levels of BPX.

As an EIP developer or manager you may implement a by-product utilization strategy yourself or you may recruit a private company, trade association, or government agency to take on the task. Remember, an eco-industrial park is much more than a network of companies engaging in the exchange of by-products. You will gain value from this strategy, if you choose to adopt it, but there are also many other strategies for increasing the competitiveness through the environmental, social, and economic design of your development.
Creating By-product Exchanges

12.2 Guidelines for forming a by-product exchange

We will outline the typical steps BPX organizing projects take with industries in the next section. Then we will explore an alternative model for achieving high utilization of industry by-products – the creation of a business that functions as a by-product utility.

Guidelines for forming a by-product exchange

Mobilize and organize support

Whenever possible identify a respected business leader to act as project champion.

Create awareness of the business, economic, social, and environmental benefits of by-product exchange among stakeholders.

Recruit public sector partners to provide technical and financial assistance, incentives, and regulatory support.

Identify the business entity to manage development of the BPX, whenever possible.

Evaluate the BPX utility model as an alternative to this process.

Enable development of self-organizing teams within the network.

Planning and analysis

Characterize the flows of energy, water, and materials in the target region. Highlight and map existing exchanges of by-products.

Provide training, tools, and support for the development process and data gathering and analysis.

Gather data on resource flows of companies that have committed to the BPX.

Identify potential barriers in regulations, business practices, and environmental management that need to be overcome. Develop strategies for doing so.

Identify companies which could process selected materials, provide collection services for specific by-products, or otherwise support the operation of the BPX.

Develop a strategic plan for expanding from BPX to a full eco-industrial network.

Enable business transactions for by-product utilization

Develop alternative means for companies to begin making deals to trade specific by-products.

Provide further support as needed.
Creating By-product Exchanges

**Monitoring and communications**

Create a map (GIS) of the network of exchanges and opportunities for exchange.

Set performance measures and targets.

Create an internal system for giving feedback on what is being achieved to the immediate participants.

Create an outreach program.

These guidelines are a framework for learning and improvisation, not a rigid formula. They are based upon what we have learned from BPX projects in both developed and developing countries. You may find yourself moving back and forth between the different tasks as they are not necessarily a linear sequence.

**12.2.1 Mobilize and organize support**

Whenever possible identify a respected business leader to act as project champion.

An important early action is recruitment of a respected business person to champion the development of by-product exchanges. Ideally this person will have direct experience of turning his company's wastes into value adding by-products. With this encouragement, potential participants are more willing to invest their time and resources. The many businesses that have demonstrated the value of trading formerly wasted materials provide candidates for the champion role.

Create awareness of the business, economic, social, and environmental benefits of by-product exchange.

Awareness raising can take many forms: talks before business and trade associations, workshops and seminars, newspaper and magazine articles, and circulation of web site addresses reporting successes in by-product management. Project communications should integrate the concept of by-product exchange with other strategies for efficient use of resources, design for environment, prevention of pollution, and reduction of wastes in every stage of the product lifecycle.

Increasing efficiency of resource utilization and revenues from marketing by-products contribute to the profitability of companies. Chaparral Steel demonstrated this by gaining enhanced sales, reduced waste management costs and environmental liabilities, and enhanced profitability from new lines of business. *(See cases at end of this chapter.)* This business advantage also improves environmental and social performance so it naturally captures the attention of competitive business people. To reinforce the fact that this idea delivers value, participating firms should usually pay a fee toward the development costs for a by-product exchange.

Recruit public sector partners to provide technical and financial assistance, incentives, or regulatory support. Include universities and technical colleges.

Economic development, environmental, and waste management agencies have a self-interest in a more resource efficient economy and are natural allies in the formation of a BPX. They may be able to provide financial or in-kind support for the organizing activity and assist communications. University engineering, business and environmental science departments may be able to support data collection and processing. If so, remember the importance of keeping individual company data secret.
Creating By-product Exchanges

Identify the business entity to manage development of the BPX.

One of the most successful BPXs is the one Chaparral Steel formed with the support of Hatch Engineering. Here the steel company decided to recapture value from all possible by-products because of the strong bottom line benefits it would gain. Chaparral was the project champion and lead partner and the engineering firm did the technical and financial work. This project had a driving force much stronger than that generated by a public agency coming to companies with a “new idea”.

We recommend that as early as possible the lead in BPX projects be assumed by a business entity, with public sector players continuing to offer support as required. There are several forms this can take.

- **Industrial park management/ownership** may be interested in filling the park with viable tenants and retaining them.
- A **major anchor firm** may benefit from exchanging materials or energy by-product streams that are not utilized and costly to dispose of.
- A **consulting firm** can manage the whole by-product flow and earn fees and/or commissions. (investment recovery)
- A **by-product utility** could outsource procurement of selected supplies and management of discards for locators at the park.

The **industrial park management/ownership** is interested in filling the park with viable tenants who will stay. Increasing their resource efficiency and lowering their disposal costs will improve their business performance and promote retention of them. Possibly new companies will be attracted by these benefits. If the park has its own landfill and water treatment plant, reducing wastes and pollution will help preserve the value and capacity of these assets.

An **anchor company** may become the organizing force for a BPX in order to deal with its own large materials or energy by-product streams. Chaparral Steel in Texas has essentially broadened its business identity to become a materials processor at the hub of one of the most successful BPXs. A firm with large enough by-product generation may be willing to take the business lead in development of a BPX that utilizes its discards and at the same time generates new revenues for it. Iscor Steel in South Africa actually created a subsidiary, Suprachem, with the mission of finding highest value reuse of all unutilized products. (See this case at the end of this chapter.)

A **consulting and engineering firm** that manages the whole by-product flow for a park, across several parks, or in a region would earn fees and/or commissions. A new field of management, **investment recovery**, takes a very systemic approach to ending waste. This is an integrated business that identifies non-productive assets generated in the normal course of business and seeks means of redeployment, recycling or remarketing them. These assets may include:

- Waste stream and process by-products;
- Excess raw materials, operating inventories and supplies;
- Off-grade, out of specification or discontinued products;
- Construction project residues;
- Idle, obsolete, unused or inoperable equipment, machinery and facilities;
- Machinery, equipment and fixtures in facilities scheduled for demolition.

Investment recovery firms develop strategies and procedures to recapture highest value from all surplus assets in a company or a region. They seek ways to reduce operating and disposal costs, ways of preventing the waste, and markets for redistributing the by-products for increased economic value. Phillips
Creating By-product Exchanges

Petroleum, BASF-US, and MCI Telecommunications are among the companies that have adopted this approach. (Phillips)

An investment recovery firm could integrate the above functions into a comprehensive strategy for an industrial park or for an industrial region. If the firm's fees were based on a retainer plus percent of savings and/or revenues it would have an incentive for supporting this holistic approach.

An investment recovery firm could also negotiate technical assistance from universities, federal labs, and environmental pollution prevention and energy efficiency programs. With client companies it would target unutilized supplies that need this research input in order to be marketable. It could also recruit the right providers.

Evaluate the BPX utility model as an alternative to this process.

A utility or resource logistics management firm could manage all by-products generated by companies, including actual wastes, and procurement of by-products at an industrial park or in an industrial region. There are some limited examples of this business model that suggest it may be a viable alternative to the usually recommended process for creating BPXs. However, it will require a strong entrepreneur to assume leadership and a significant investment. Since this is such a contrasting model we will discuss it in detail after completing this discussion of the more self-organizing process.

Enable development of self-organizing teams within a pilot site location.

Kalundborg's by-product exchange evolved spontaneously as a series of bilateral deals driven in part by regulatory demands, not as a planned system. Environmental regulations made it economically sound to turn some major wastes into products and exchange them locally. Pairs of companies organized themselves into an elegant system of exchange, with market values defining their new relationships. They estimate that so far, the costs of the infrastructure for the exchanges have been repaid twice over.

The transactions between partners in a by-product exchange requires a trust building process. Just knowing a resource or user is technically available may not be enough to generate action. Knowledge may need reinforcement through easy social access. At some sites the meetings of an industrial park locator association may be the right venue. Special workshops dedicated to identifying matches and getting acquainted may be a useful forum. Find the right means of setting the stage for partners to negotiate on the financial, technical, and environmental issues involved in their one-to-one deals.

This ability of businesses to self-organize to achieve goals may be the foundation for success in creating a BPX. The government agencies and the business that supports their effort (as discussed in 1.4.) must remember they are enablers and the primary action is with the participating plants. Help the locator plant managers and their teams set goals and identify their most troublesome by-products. Then let them take the lead in designing the processes for finding uses and customers for them.

12.2.1 Planning and analysis

Characterize the flows of energy, water, and materials in the target region. Highlight and map existing exchanges of by-products.

This task is for larger BPX projects committed to development of a resource recovery system and with strong public sector support.

The project team can use an industrial metabolism study to gather data on major energy, material, and water flows in the target region, whether it be an industrial park, a number of parks, or a more widespread industrial region. The outcome of this study is an inventory of by-products that are presently exchanged, major discards that could be exchanged, and an assessment of environmental burdens of landfills, incinerators, and possible open dumping. It also indicates high priority points of intervention in the broader system, useful in environmental regional planning and business development.
Creating By-product Exchanges

This study may be conducted by university researchers, or engineering companies. It should begin with a very broad analysis to build a qualitative model of flows in the region and then quantify specific streams that offer good opportunities for by-product trading and pollution reduction. In some cases it may focus on specific high risk substances, such as greenhouse gases, chlorinated substances, or heavy metals. Some of the classes of data to be gathered include:

- Percentages and tons of municipal landfill waste by type of material;
- Characteristics of waste from specific sectors: residential, industrial, commercial, and institutional;
- Materials listed by companies in local or state waste exchanges;
- Types and amounts of materials collected in recycling programs;
- Major emissions of waste heat;
- Sites and amounts of wastewater discharges;
- Types of industries by SIC code; and
- Industrial input/output data.

Your community or region can create economic development strategies through analysis of opportunities emerging from this data. This would include setting community targets for reducing wastes; and developing policies and programs that offer incentives and training to local business and citizens. The primary outcome would be an economic development plan emphasizing generation of new businesses that turn former major wastes into feedstocks for other companies or directly into products.

See the discussion of industrial metabolism in the Appendix.

Provide training, tools, and support to the development process and data gathering and analysis.

Once data has been gathered and processed, possible BPX companies will need support as they consider the value of trading by-products. Conferences enable firms to explore potential exchanges, while learning about other environmental performance strategies like waste reduction, pollution prevention, and energy efficiency. This will also allow company personnel to test the idea of collaborating with neighboring plants. The conference might include a session in which participants role play firms in an operating BPX-testing the feasibility of exchanges, dealing with possible breakdowns, and creating strategies for recovery from them.

A potentially valuable tool for the recruiting team and prospective tenants is an evolving computer model of the exchange network, supported by materials and energy data bases. This enables simulation of process interactions within the potential network of companies, step-by-step. The linked DIET and FAST programs created by the US-EPA are two examples that are available (see discussion below.). However, a recruiting team should not depend too heavily on this sort of computer simulation. Personal interactions are vital to building the trust and business relationships that are the foundation of an exchange network. Project meetings should support this creation of trust.

Gather data on resource flows of companies that have committed to the BPX. (Create a strong firewall around the data collected to insure companies confidentiality.)

Potential participants in a BPX may begin with a relatively simple data collection process and then deepen the level of data as needed. (See plant survey form in Appendix.) This makes the first steps easier to take and indicates the broad opportunities available. Possibly the more detailed level of data is relevant only to the companies actually seeking to transact a deal around a specific exchange. The PRIME IE project in the Philippines enlisted the environmental managers in industrial parks and companies to conduct the surveys and build the database. This helped assure tenants that their trade secrets would not be revealed. Several projects in North America have used engineering and consulting firms to gather and analyze data.
Creating By-product Exchanges

Some regional exchanges, such as the North Carolina Triangle Joint Council effort, have started by requesting a much more detailed data set from businesses and entering it into a database linked to a geographical information system. When this system is in operation companies will be able to search the input and output needs of other companies by location.

Companies often look at data collection on their inputs and outputs as a potential threat. Competitors may use it to learn about proprietary processes. Regulators may use it to impose penalties for non-compliance. For these reasons the data gathering process should be coded to insure no surprise disclosures. Pilot site environmental managers, a trade association, or an environmental engineering firm.

Identify potential barriers in regulations, business practices, and environmental management that need to be overcome. Develop strategies for doing so.

Environmental regulations were designed to reduce risks to humans and ecosystems. Corporate environmental management and production practices developed to meet the regulations. The goal of resource efficiency is a relatively late add-on and in some cases conflicts with the earlier regulations. So the exchange of by-products may require some creative adaptation of policy frameworks and specific regulations. Some of the areas for innovation include:

- What changes (or special permits) in water, waste water and solid waste regulations and ordinances will you need to permit by-product exchanges or shared treatment facilities in the park?
- Will you need changes in current zoning to allow the mix of industries needed for such exchanges?
- Will regulatory agencies enable innovations in environmental management like site-wide or umbrella permitting to establish the whole park as the regulated entity?
- If you are in an export zone, how does this impact trading of by-products within your region?
- What are the implications of companies outsourcing some environmental management functions to park management or third parties?

See Chapter 7 for more detailed discussion of policy, regulations, and environmental management systems.

Identify companies which could process selected materials, provide collection services for specific by-products, or otherwise support the operation of the BPX.

Many facets of industrial park and BPX operation open specific opportunities for developing new businesses or attracting firms that would support the functioning of a materials and energy exchange. An industrial park with space may target this sector or, if the need is large enough, there may be an opportunity to develop an integrated resource recovery park. Business niches in resource recovery include:

- Firms practicing resource recovery, recycling, and reuse.
- Niche collection and hauling firms.
- Remanufacturing plants.
- Environmental monitoring and information firms.

(See Chapter 6 where we summarize the model for a Resource Recovery EIP.)

Resource recovery firms include companies that consume otherwise unusable discards, processing them into usable feedstocks and companies that take apart equipment and market re-usable components and materials. Some utilize recovery technologies that allow extraction of valuable materials from waste streams (i.e., extracting metals from liquid or solid wastes); and recycling technologies that prepare a byproduct for reuse (i.e., shredding plastics). These processor companies play a useful intermediate role and are especially important where they accumulate small flows of residues from companies and generate economically useful masses. A solvent re-refiner is one example of such a processor.
Creating By-product Exchanges

By incubating or recruiting firms in this category, an industrial park may better fulfill the goal of becoming a closed-loop system, optimizing the reuse and recycling of surplus products or materials. It also gains locators valuable to its other companies.

**Niche collection firms** are important to keep materials separated and to preserve their quality. They may also help accumulate sufficient volumes of particular by-products when they operate throughout an industrial region. Such a firm might specialize in industrial solvents, wooden and plastic pallets, or compostable discards.

**Rемanufacturing firms** offer potentially strong domestic trade and export opportunities for well-situated industrial parks. An environmental objective is served by extending the life of products (and the energy and materials invested in them). If the rehabilitation process includes upgrades for energy efficiency, process control, and pollution prevention, the resulting products demonstrate environmental and economic benefits beyond extending the products’ life.

**Environmental monitoring and information systems:** A company could assume the role of independent auditor of environmental performance and provide feedback to individual companies, park management, and the community. This firm would operate and maintain monitoring systems and an information system linking all companies. It could also provide third party reporting that is required in many voluntary programs.

The PRIME Project in the Philippines is evaluating the feasibility of creating an **environmental business incubator** that could support such new or expanding businesses. The organization could become a locator in one of the industrial estates. This project is also doing a feasibility study for a resource recovery park. See chapter 4 for further discussion of business incubators.

**Develop a strategic plan for expanding from BPX to a full eco-industrial network.**

The companies in an industrial park, the park management, and the business managing the BPX process can all benefit from applying other methods for improving efficiency of resource use. They can improve both financial and environmental performance by using Cleaner Production tools like design for environment (DFE), pollution prevention (P2), and energy efficiency (E2). The project should include a training program and open access to consultants or university personnel who can support adoption of these practices.

DFE, for instance, enables designers of either products or production processes to view the whole range of options for all potential environmental implications of a product or process being designed—energy and materials used, manufacture and packaging; transportation; consumer use, reuse or recycling; and disposal. DFE enables designers to balance environmental choices with traditional design issues of cost, quality, manufacturing process, and efficiency as part of the same decision system.

DFE tools enable consideration of the implications of design choices at every step of the production process from chemical design, process engineering, procurement practices, and end-product specification to post-use recycling or disposal.

The right design choices at the beginning of creating a product or a production process may eliminate wastes at each step in the cycle, and thereby reduce the need for exchanging many by-products. See Chapter 11 for discussion of the eco-industrial network.

**12.2.2 Enable business transactions for by-product utilization**

Develop alternative means for companies to begin making deals to trade specific by-products.

Once company managers are aware of the opportunities to cut costs and possibly gain new income through exchange of by-products, they may start negotiating with potential trading partners without need for any encouragement. However, workshop meetings, a private BPX web site, and publications may be required to open a more active network of exchanges. The business entity managing the development process can
Creating By-product Exchanges

work with public sector partners to be sure that a number of different channels are open, which we describe in the next section.

BPX projects in India, Canada, and Mexico have created working groups focused on specific resources that the data indicate have major potential for exchange. The Naroda Industrial Estate in Gujerat, for instance, set up teams to evaluate recycling of spent acid, chemical gypsum, chemical iron sludge, and biodegradable waste. (Wilderer 2000, Applied Sustainability 2000)

Provide further support as needed.

Pairs of by-product partners may need technical support or investment to make a particular trade work. The supplier may require process redesign to assure the level of quality required by the consumer. One or both partners may need to construct infrastructure for conveying or storing the by-product, such as pipelines or conveyor belts. These investments may require external sources. The BPX team may be able to attract funds for these purposes dedicated to improving environmental performance of industry, particularly for reducing greenhouse gas emissions.

The partners are basically just creating a new supplier-customer relationship and they both know how to guarantee quality and reliability of supplies. Most deals will require little external support.

12.2.3 Monitoring and communications

Create a map (GIS) of the network of exchanges and opportunities for exchange.

The North Carolina regional BPX project is connecting its data base of industrial and municipal by-products into a geographical information system (GIS). This allows mapping the by-product data and company locations against any other relevant data sets such as transportation systems and resource recovery locations. The GIS helps participants evaluate the logistics of possible exchanges. (TJCOG 1999)

Set performance measures and targets.

While a BPX is essentially a network of one-to-one transactions, its members can benefit from monitoring their individual and collective performance against goals for continuous improvement. Since the fundamental goal is increasing efficiency of resource use, these metrics become valuable business performance tools. The feedback on cost savings helps maintain motivation so the metrics should clearly indicate the financial impacts of these basic patterns of resource use.

Several possible measures enable BPX members to monitor their progress in achieving the standards they set.

- Ratio of virgin to recycled materials (including water);
- Ratio of actual recycled materials to potential;
- Ratio of renewable to fossil fuel sources;
- Ratio of polluting substances to benign substances;
- Materials productivity - economic output per unit of material input;
- Energy productivity — economic output per unit of energy input (calculate the energy waste ratio also);
- Resource input per unit of end-user service — assessment of resource use against the useful function gained and maintained for the end-user (Lowe 1997)

Monitoring socio-economic indicators, such as new businesses and jobs created, will help convey the value of the project to the community.
Creating By-product Exchanges

Create an internal system for giving feedback on what is being achieved to the immediate participants.

A BPX newsletter, a web site open only to BPX participants, regular meetings and roundtables are a few of the ways of sharing news within the membership. The Philippine PRIME Project web site is a good example of both internal and public outreach. www.iephil.com. Peer pressure and peer support help participants use such feedback to improve their performance. In the US, public released data such as the toxic release inventory has often created competition among companies to better their scores.2

Create a public outreach program.

Training seminars in BPX development, tours of the site, a public web site, radio and tv programs, newspaper articles, and talks at meetings of service clubs and trade associations are a few of the obvious channels for communicating the project's achievements to the world. Perhaps a local university could develop a course on BPX development for industrial park managers and entrepreneurs interested in creating enterprises to establish BPXs.

A Valuable Resource on By-Product Utilization

In the late 1970s, Nelson Nemerow, a chemical engineer, started to recommend creating complexes of companies using each other's "wastes" as feedstocks. His phrase for this is "Environmentally Balanced Industrial Complex (EBIC)." (Nemerow 1995) His book, Zero Pollution for Industry: Waste Minimization Through Industrial Complexes, is a very valuable resource for anyone developing by-product exchange networks

After summarizing issues of waste reduction and reuse within a plant, Nemerow describes 10 possible environmentally balanced industrial complexes (EBIC) involving 16 different industries. Like current BPX projects, an EBIC is a co-located materials and energy exchange network. He analyzes the way these potential complexes of plants can become mini-"foodwebs", reducing pollution/waste generation. For instance, four of his complexes focus on connecting fossil fuel power plants to consumers of waste heat and material by-products (the pattern of the Kalundborg industrial symbiosis). Here the partners include cement and cement block, lime, and agricultural facilities. (Nemerow does not account for the CO2 emissions or the residual emissions from the scrubber and other treatments.)

Several complexes are biomass waste intensive as with a sugar plant directly linked to an alcohol fermenter, internal power plant, and an agricultural area. Others involve a tannery, an animal feedlot, and wood mill complexes. Nemerow's conceptual examples illustrate how industries can benefit from jointly redefining wastes as by-products and thereby maximize resource use and minimize pollution. However, a major limitation is that his strategic thinking is primarily focused on technical process compatibility and ignores the many economic, financial, management, social, and institutional elements that are necessary conditions for a successful multi-company project. Forming an industrial complex or ecosystem requires coordination of diverse stakeholders and these non-technical elements must be addressed in the early stage of development.

Nevertheless, the book is a very useful guide for anyone creating BPXs or industrial estates with anchor tenants producing large volumes of by-products. Nemerow's formulation of strategy and the diverse examples he gives will stimulate creative responses in teams designing such projects. (based upon Lowe and Hovarongkura 1997)

2 In Japan the Ministry of International Trade and Industry and the Environment Agency have created a parallel toxic inventory and reporting system known as the Pollutant Release and Transfer Register system.
Creating By-product Exchanges

12.3 BPX Case Experience

So far there has been little rigorous research on the achievements of by-product exchange projects. The literature tends to be dominated by champions of the concept rather than systematic evaluators of the results. It is an appealing concept because it promises to improve the financial performance of participants by improving the efficiency of their use of resources. This integration of business and environmental goals has attracted many companies and other stakeholders to participate in dozens of projects on every continent. However, it is still too early to prove that the concept works in practice or to say which development strategy is the most effective one. (Chertow 2000)

We do know that in many cases by-product utilization on a one-to-one basis works. There is an abundance of data on bilateral trades of materials, water, or energy that are at least cost-effective and often profitable. (See a representative listing of such company-to-company deals in the Appendix.) In some industries there has been a long tradition of internal and inter-company by-product utilization. Petrochemical refineries and downstream companies normally seek profitable uses for every output. (See discussion of the petrochemical EIP in chapter 6.) Many food processing plants also have found profitable uses for their discards. (Desrochers 2000) Finding higher value uses for by-products may be the main value such industries would gain from participation in a BPX. Or they may expand the number and types used.

Many projects to create BPXs have been successful in enlisting industrial and public sector participation in identifying potential exchanges. This survey and analysis process has successfully identified many opportunities in Asian, North American, European, and African projects. There appears to be no inherent barrier to this phase of forming exchange networks. At this point, however, relatively few projects have completed the process to the point where a significant number of trade deals have been made. Many of the deals that companies have struck are one time rather than continuing exchanges.

Projects in Tampico, Mexico, Nova Scotia, Canada, the Province of Styria, Austria and near Hamburg, Germany have released data on the volumes of material and water that are being exchanged among companies. However, so far only Kalundborg, Denmark has provided data on the investment in infrastructure required and the return. “The latest “back-of-the-envelope” numbers from Kalundborg are: US$160 Million in total savings to date, $15 Million in annual savings (today), as return on total investments of $75 Million.” (Symbiosis Institute 2001. personal communication).

Asian projects in the Philippines and Thailand are embedding BPX development in more comprehensive eco-industrial networks. In the US the Long Island City Business Development Corporation is expanding by-product exchange to an EIN. We have discussed these initiatives in the previous chapter and the Appendix.

Some eco-industrial park projects have used the BPX strategy to guide recruitment targeting, including ones in Arecibo, Puerto Rico, Burlington, Vermont, and Londonderry, New Hampshire. This appears to work best where there is a large anchor tenant with major by-product resources available. These three examples are all centered on energy generation plants. The project in Puerto Rico has analyzed the exchange of value as well as by-products between a proposed waste-to-energy plant, a recycled paper mill, a tire shredding plant, a steel mini-mill, and a neighboring sewage treatment plant. This financial analysis by Recovery Solutions demonstrates that the profits of all firms would be enhanced by this BPX within an EIP. (See this case in the Appendix.)

Japan has launched the most ambitious attempt to develop industrial BPXs and more widespread initiatives to reduce waste. National and local governments are motivated to do this by lack of space for additional landfill, the pollution of conventional incineration, and the country's continuing search for higher efficiency in its production. We include in the Appendix a major study of these efforts conducted by Indigo Development.
12.3.1 Waste Exchanges

Waste or materials exchanges are related to BPXs in a very general way. It appears that they are much weaker strategies to attain higher efficiency of resource use in a comprehensive way. Researchers at Rutgers University (Andrews & Mauer 2000) conducted an exploratory survey of U.S. materials (or waste) exchanges, with sixty-three respondents. They found that:

- Few exchanges handle hazardous materials;
- Most focus on pre-consumer items such as building materials or post-consumer durable goods such as appliances;
- Non-profit organizations and state/local government agencies are the most frequent operators;
- There are three implementation strategies: passive listers of materials, active brokers who become involved in each transaction, and operators of warehouses for storage and display of materials and products;
- Warehouse operations are the most frequent form of exchange; and
- The adoption of Internet technology is improving their viability.

12.4 Potential Issues Concerning Creation of a BPX

In industrial ecology and cleaner production, increasing efficiency of resource use at every stage of production is a higher order priority than utilizing by-products at the end of the cycle. Effective design upstream will reduce and in some cases eliminate by-products. This suggests that BPX efforts should be started in a full eco-industrial network context and partners to exchanges should expect changes that may eliminate the outputs they trade.

While participation in a by-product exchange may offer significant revenues and/or cost savings, such activity is still seen by most plant managers as quite separate from producing their primary products. “Waste” management is usually buried in overhead budgets and the staff responsibility is solely to dispose of wastes in a cost-effective manner within regulatory constraints. When a company’s by-products are produced in relatively low volume their standard disposal is viewed as financially insignificant. Even with substantial volumes of by-products, the transaction costs involved in seeking markets may grow too high to continue. One of these costs is the risk that regulations may make the supplier of a by-product liable for damages generated by a customer.

Douglas Holmes, a co-author of our original EIP Handbook, suggests an ideal solution would be, to give every unmarketed by-product a product number and a line in the operations budget. It would show up in the books as a separate production and disposal cost rather than being assigned to overhead. A manager of by-product operations would then be responsible to either find markets or to redesign processes to eliminate by-products without value.

The manager of the Northern Industrial Estate in Thailand indicated a potential obstacle to utilization of by-products is location of companies in export zones. Regulations do not allow these companies to supply any local companies outside of the zone.

While there are strategies for dealing with these issues, an alternative business model may be required to develop the highest utilization of by-products.
Creating By-product Exchanges

12.5 The BPX utility business model

In some projects to create by-product exchanges potential participants have been wary because of the multiple contracts required. These generate transaction costs, which can offset savings or revenues from use of by-product energy or materials. Companies fear entering into so many new relationships around issues separate from their core businesses. These issues have prompted us and others involved in eco-industrial planning to formulate an alternative business model, in which a by-product utility takes responsibility. (Slone and Cohen-Rosenthal 2000 personal communications)

Possible transaction costs of participation in a BPX include

- Time in BPX planning, data reporting, collection and processing, dealing with regulators, and negotiating deals;
- Perception of increased technical, legal, or business risk not present in straight disposal;
- Process changes to yield by-product in form and at quality required;
- Transportation;
- Construction of infrastructure.

A possible means of reducing such transaction costs and streamlining utilization of by-products is to create a by-product utility in an industrial park or region. This might operate as a business within the management structure of an industrial park or as a stand-alone business that creates a profit-sharing relationship with park management. In its fullest form, this utility could manage energy, water, and materials procurement and disposal for all client companies. Its advantage lies in the capability and experience concentrated on by-product utilization. By making this the core business, the utility can handle the technical, business, and economic issues of by-product utilization. It also becomes a force in the political economy supporting regulations and land fill fees that discourage wasting and increase the value of by-products.

The utility would be responsible for creating an optimal price structure for firms, at the level of quality they require. In negotiating prices with clients it would balance reuse of by-products, avoidance of disposal costs, acquisition of external supplies, and on-site and local generation of energy from renewable sources. It could own and maintain infrastructure required for movement, processing, and storage of energy, water, or materials.

The utility would negotiate contracts with each BPX company, offering significant reductions in their transaction costs and other overhead for supply and disposal management. In some cases it could go beyond supplying by-products to outsourcing procurement of chemicals and other commonly used production inputs as well as office supplies and equipment.

The business model for the utility would balance revenues from procurement of external supplies, sales of by-products, services to enhance efficiency of client resource use, and possibly sales of locally generated renewable energy. Services to improve the energy, water, and materials efficiency of its clients will be a major profit center. The utility could negotiate to share in client cost savings from greater resource efficiency to insure that it will not be forced to maximize throughput to boost profits.

The utility would phase its infrastructure investments to avoid large sunk costs requiring continued production of by-products whose quantity can be reduced through tenant facility, process, and equipment redesign. (Newer modular systems for water processing, energy generation, hazardous materials management, etc. will support this phasing of capital investment.)
Creating By-product Exchanges

12.5.1.1 Existing Firms Embody Aspects of the Utility Concept

There are partial precedents for a by-product utility. Several firms reflect aspects of this business concept.

- Suprachem is a wholly owned subsidiary of the major South African steel company Iscor, responsible for managing all company by-products. This internal resource recovery company researches new uses and means of generating higher value from familiar by-products; operates reprocessing plants; and markets all of the reclaimed materials.
- SafetyKleen is a familiar US-based international company that manages the full lifecycle of selected chemicals, particularly solvents, for many companies. It also collects used oil from clients for re-refining.
- In 1997 Strategic Chemical Management Group successfully sold the outsourcing of chemical procurement to major power utilities in the US, including Southern California Edison and Florida Light and Power. Previously these companies had dealt with up to 5000 suppliers. Its initial vision included eventually handling all aspects of chemical management, including waste prevention, pollution prevention, and end-of-life recycling, reuse, or disposal. Radian International is also providing similar chemical management services.

This business model for comprehensive resource management is still relatively new, but it suggests that the BPX utility we have outlined could play a role in industrial parks or eco-industrial networks.

We encourage eco-industrial networks and BPX projects to explore the feasibility of creating such a by-product utility. Are there industrial park developers or entrepreneurs who could manage such a business start-up? Does the local pattern of industrial development and available by-products provide the foundation required to write an effective business plan? Could such a utility increase its business by linking to development of a resource recovery park? Are there sources of capital willing to invest, possibly including some major providers of large by-product streams, such as power plants?

12.6 Software for BPX

Software supporting an analytical approach to creating BPXs is available for testing. Data is collected from individual companies and assembled in a database. Various mathematical programming techniques are then used to identify and optimize possible trades of by-products. In some tools a portion of the database includes generic data on a broad range of industries that are not present in the community. By matching residual by-products from businesses in your community with the generic database, the model can be used to identify the types of businesses that can be targeted to expand the local by-product exchange. Public agencies may encounter some resistance in industry to disclosing proprietary information. An industrial association might be a stronger agent for leading this sort of effort.

The following examples provide a flavor of the types of analytical tools that are under development.

The DIET Model

The "Developing Industrial Ecosystems Tool", or DIET is a decision support tool to help urban planners, developers and community groups identify the optimum mix of industries (and their plant size) for a specific industrial resource exchange site. Industrial Economics, Inc. is developing DIET on contract to US-EPA. DIET, has the following attributes:

Planners can consider objectives, with weights assigned by the planner to: economic output, number of jobs, and environmental gains.

Results generated by the DIET model include:

- Waste generation per unit of activity;
Creating By-product Exchanges

- Size and revenue per unit of activity;
- Opportunities for waste exchange;
- Waste generation at each facility.

DIET includes a database of generic data profiles for a set of representative facilities to assist users where facility information is not known or is difficult to obtain.

Future versions of DIET will integrate the model with Geographic Information Systems (GIS) software and data to:

- Map the surrounding environmental landscape;
- Account for transportation modes with access to the eco-park;
- Test various methods for using GIS to guide eco-park planning. (Giannini-Spohn 1999)

Bechtel Corporation

Bechtel Corporation has developed a planning model that links a linear programming analysis capability to an industry database that identifies company input and output streams, production processes, disposal costs and utility requirements. The model defines multiple possible materials exchange links to allow potential trading partners to be identified. By incorporating both data from actual businesses in a specific community and generic industry-based data the model can be used to identify existing exchange potential and recruitment targets to expand the industrial recycling network. The Business Council for Sustainable Development – Gulf of Mexico and its spinoff, Applied Sustainability, have used Bechtel's model in a number of their by-product synergy projects. (Applied Sustainability 2000)

12.7 Resources & references

There is a very large body of literature on the many variants of by-product exchange. We will include here key references and web sites we have drawn upon and we continue to update links on our own web site, [www.indigodev.com/Links.html](http://www.indigodev.com/Links.html)


Creating By-product Exchanges


Integrated Bio-systems Online Conference. For anyone dealing with biomass this site has many case studies and theoretical papers. http://www.ias.unu.edu/proceedings/icibs/ibs/


Creating By-product Exchanges


Phillips Petroleum, Cleaner Earth, Investment Recovery and Recycling, company brochure. Tulsa, OK. no date

PRIME Project, Industrial Ecology Module. A web site for the Philippine Board of Investments eco-industrial network project that includes valuable material on BPX and resource recovery systems development. [www.iephil.com](http://www.iephil.com)


Suprachem, is a wholly owned subsidiary responsible for all by-products generated by Iscor Steel Co. in South Africa. [http://www.suprachem.co.za/](http://www.suprachem.co.za/)


Triangle Joint Council of Governments (TJCOG) A BPX project in North Carolina, US offers extensive documentation on its web site, including detailed facility survey forms, a mapping of existing exchange patterns, and an extensive project report. The Triangle Joint Council of Governments in surveyed material by-products available in a six county area of North Carolina and built a geographic information system with the resulting data. [www.tjcog.dst.nc.us](http://www.tjcog.dst.nc.us)

Work and Environment Initiative web site at Cornell University is a major source of material on eco-industrial development and BPXs: [www.cornell.edu/WEI/](http://www.cornell.edu/WEI/)

Appendix 1: Case Profiles

PRIME Project, Philippines
IEAT Eco-Industrial Initiative, Thailand
Guigang Group Sugar Refinery, China
Four Indian Industrial Metabolism Studies
Naroda Industrial Estate, Gujerat, India
Eco-Industrial Developments in Japan
An African Brewery Complex in Namibia
A Resource Recovery Park in Puerto Rico
The Industrial Symbiosis at Kalundborg

For additional case profiles please see

- The Philippine PRIME Project web site which contains reports from the April 2001 conference on Eco-Industrial Development in Asia. www.iephil.com
PRIME Project, Philippines

PRIME is an acronym for Private Sector Participation in Managing the Environment, an industrial environmental project under the United Nations Development Programme and the Board of Investments - Department of Trade and Industry in the Philippines.

One of the first eco-industrial initiatives in Asia is an eco-industrial network seeking to create a by-product exchange and a resource recovery system to serve five industrial estates south of Manila in the Philippines. A petrochemical estate in Bataan is also involved, with the objective of becoming an eco-industrial estate. Project development started in 1998, with funding from the UNDP to the Philippine Board of Investments. The PRIME Project encompasses the work of four modules: 1) Agenda 21 for Business, 2) Industrial Ecology, 3) Environmental Management Systems, and 4) Environmental Entrepreneurship. Each module has its own mission but staff members seek opportunities for synergy among the modules. The PRIME web site is: [www.psdn.org.ph/prime](http://www.psdn.org.ph/prime).

The Industrial Ecology Module planned its work through consultation and workshops with industrial estate managers and staff, industrial estate associations, and other governmental agencies. Initially the BOI team focused on formation of a by-product exchange at one estate. This was seen as the leading edge for introducing a broader range of industrial ecology initiatives. "It is a relatively easy strategy to communicate, it requires active business leadership to achieve, and it offers relatively quick returns in cost savings and revenues," says the project web site, [www.iephil.com](http://www.iephil.com).

A crucial decision by the Industrial Ecology Module staff was to follow a self-selection process with the six short-listed estates and to include more than one site in the pilot project. This choice in the Summer of 1999 led to a much more viable pilot project than simply selecting one of the sites. The variety of by-products generated at the different estates will be broad enough to enable more matches between generators and users. The higher level of commitment on the part of some estates provides leadership to the others. All six estates on the short-list decided to participate. Five industrial estates in Laguna and Batangas Provinces are participating in the BPX: Laguna International Industrial Park (Binan, Laguna), Light Industry Science Park (Cabuyao, Laguna), Laguna Technopark (Sta. Rosa, Laguna), Carmelray Industrial Park (Canlubang, Laguna), and Lima Technology Center (Malvar, Batangas). The sixth site, in Bataan Province, is owned by Philippine National Oil Company.

In a planning workshop during June 1999 each team formed its action plan, defined its project investment, and indicated its willingness to be responsible for data collection on by-products available from tenants. This commitment was based on industry's growing concern about the costs of solid waste disposal and pressure from the Laguna government. Through 2000 the PRIME staff has supported the estate teams in the analysis of the data and in facilitating information flows regarding potential exchanges. This analysis has included identification of potential uses and users of specific by-products, reprocessing and conveyance technologies, and opportunities opened for businesses by the BPX. The recommendations include strategies for waste reduction in the factories. By the Fall of 2000 a workshop for estate tenants drew 70 participants who began working in interest groups around specific groups of by-products such as used oils, water, and packaging materials.

The PRIME team discovered that the four estates in Laguna Province had started working together to deal with demands the Provincial government has made for management of their tenants' solid wastes. The PRIME staff has cooperated with them in conducting a feasibility study for a resource recovery system, including a facility that could incorporate businesses accumulating and processing by-products from their tenants. This system would improve the performance of the BPX and could be the site for an environmental business incubator.

The Philippine National Oil Company operates the industrial estate in Bataan, which is too far from the other sites to participate in their BPX. This estate management team has created a strategy for becoming an eco-industrial estate including a regional by-product exchange, a green chemistry business incubator, and a
programmatic environmental impact assessment (PEIA). This form of impact assessment is an innovation in Philippine regulatory structures that enables a site to receive an environmental permit that covers the property as a whole, with a list of potential tenant companies that fall under that umbrella permit. (See Chapter 7 Policy for more detail on the PEIA.) The estate manages community enhancement programs, including housing, training, and micro-enterprise development components. It has also applied for ISO 14000 status. (See Chapter 3 Community for detail on the community enhancement programs.)

The PRIME IE Module has also analyzed policy barriers to the work of this eco-industrial network. These include, “the arbitrary assignment of values for ‘scrap’ materials, imposing of taxes for ‘scrap’ materials being hauled out of economic zones if the customs officer knows that it will be used as a production substitute, and taxing them again when they come back in to the factories that will be using them as feedstocks.” (Personal communication from Georginia Pascual-Sison, IE Module project manager for BOI.)

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The Industrial Ecology Module has also maintained an active outreach and communications program. In June, 1999 staff organized a one day briefing for 100 private and public sector stakeholders in Manila. In November 1999 the Board of Investments hosted a working conference on eco-industrial estates for real estate developers and managers and other stakeholders in industrial estate development. The PRIME team participated in organization of a second conference and workshop in April 2001 for eco-industrial project teams from at least six other Asian countries and the Philippines.

See www.iephil.com for updates on the progress of this project.

An Initiative to Green Industrial Estates in Thailand

We will expand upon the brief overview of this initiative launched by the Industrial Estate Authority of Thailand (IEAT), which manages 28 estates and is planning a 29th. IEAT Governor Avanchalee Chavanich has invited the German Technical Cooperation organization to support development of a program that will enable five sites to become eco-industrial estates. They will be pilot sites for learning how to do this and eventually working with all estates in Thailand. They include a Map Ta Phut Industrial Estate, a petrochemical park; Eastern Seaboard Industrial Estate, with automotive and electronics factories; Amata Nakorn, also focused on automotive and electronics, and two estates built in the 80s with very diverse sets of factories, Bangpoo and Northern Industrial Estates. The pilot sites reflect both newer and older estates and a good cross-section of industries in Thailand. The Authority is in a unique position to demonstrate the principles and strategies of eco-industrial development.

The Governor envisions an initiative incorporating by-product exchange, resource recovery, cleaner production, community programs, and development of eco-industrial networks linking estate factories with industry outside the estates. GTZ will assist through capacity development for IEAT headquarters’ staff and personnel at the estates, technical transfer, and policy development. GTZ will coordinate with the IEAT initiative other programs it has in Thailand, such as its energy conservation project with the Bureau of Energy Regulation and Conservation.

The initiative will begin with the management team of each of the pilot estates forming its individual vision and business plan and budgeting investments required for specific projects. They have identified utilization of by-products as an early concern, but they are aware that opportunities for exchanges among the factories at any one estate are limited. As they develop their estate plans they will start exploring opportunities for building an eco-industrial network between their companies and suppliers outside the estates. Three of the pilot sites are in the Eastern Seaboard area SE of Bangkok, which includes 11 estates within a 50 square kilometer area. This provides a significant opportunity for creating an eco-industrial network across this area. The inter-estate networks would complement the links from each estate to its surrounding stand alone factories.

IEAT and the individual estate teams will consider creating potential supporting structures for their initiative, including:
An integrated resource recovery system (IRRS) or possibly a resource recovery park;

A system for encouraging and managing the exchange of by-products (BPX);

Training and services in all aspects of eco-industrial development;

A network management/coordinating unit and working groups;

A community enhancement office to manage projects with neighboring communities;

One or more business incubators;

Public sector support in R & D, policy development, access to investment, and information management.

Managers of the individual pilot industrial estates highlighted a number of serious barriers they will encounter in their effort to become eco-industrial estates and to form eco-industrial networks. Policy and regulations for the operations of estates and individual factories are defined by several agencies including IEAT, Department of Industrial Works, and Ministry of Science, Technology, and Environment. Eco-industrial development requires harmonization of these policies and adaptation to enable by-product utilization and exchange. For instance, a re-refining company near Rayong is limited to receiving only 5 of the possible 20 solvents that it is designed to recycle. This limits the plant’s return on investment, the cost saving for factories seeking to use recycled products, and the diversion of hazardous materials from the limited landfill devoted to them. Such regulatory barriers are both economically and environmentally damaging. (See Chapter 8 for a description of this facility.)

Estate and factory managers and recyclers all reported a need for research and development to identify new technologies to manage the many by-products not now usable in a resource recovery system. They also need guidance on increasing the energy efficiency of their operations and possible incorporation of renewable energy technologies such as biogas from food, agriculture, and sewage by-products.

External project funding for eco-industrial estate and eco-industrial network activities will be required to augment the investments IEAT, the pilot estates, and factories will be able to make. Fortunately the Thai eco-industrial development concept allows integration of now independent projects, such as the Japanese-based energy efficiency project at Map Ta Phut and GTZ’s own energy conservation project that supports implementation of Thailand’s energy conservation act.

The long-range plan for this initiative in Thailand includes work at the policy level within IEAT and among the different ministries to address the needs estate managers raised. In addition it will support development of more effective emergency management systems in the estates, capacity development to help IEAT staff improve organizational performance within an eco-industrial concept, and transfer of technologies required for greater efficiency and cleaner production.

This eco-industrial initiative appears to be the most far-reaching eco-industrial effort in either developed or developing countries. It promises to ultimately impact the environmental, social, and economic performance of all industrial estates managed by the Industrial Estate Authority of Thailand as well as the operations of stand-alone plants surrounding the estates. The Authority is in a unique position to demonstrate the principles and strategies of eco-industrial development. The proposed vision for the initiative is: “to apply the principles of Eco-Industrial Development as the main strategy for future Industrial Estate development in Thailand.”

(See Chapter 8 for a description of The Eastern Seaboard Industrial Estate closed-loop water system.)

**Sources:**


Site visits and interviews with managers of four of the estates during November, 2000.

China

The Guitang Group and Guigang Eco-Industrial City

China produces 10.5 million tons of sugar annually from 539 sugar industries, the majority from sugar cane. Over the last few years, the sugar industry in China has experienced a significant economic decline. This industry has to increase its productivity to remain competitive with Brazil, Thailand, and Australia, three major sugar producing countries. Low prices for sugar on world markets in recent decades have eliminated the industry in former leading countries, including Hawaii and Puerto Rico in the US. Sugar production is becoming much less competitive in the Philippines.

The Guangxi Zhuang Autonomous Region, in the far south of China, is the largest source of sugar, producing more than 40% of the national output. The cost of producing sugar is high in Guangxi. Most farmers have small landholdings, productivity is low, and sugar content of the canes is low. Most refineries are smaller scale and fail to utilize their by-products. This gap causes them to lose secondary revenues and generate high levels of emissions to air, water, and land. The farmers burn the cane leaves every harvest season, generating air emissions. Ning Duan estimates that there are 70,000 families growing sugar in the Region and that there are 100 sugar mills. The economy of the town of Guigang is 50% dependent upon sugar related industries. (Duan 2001)

The Guitang Group is a state-owned enterprise formed in 1954 that operates China’s largest sugar refinery, with over 3800 workers. The Group owns 14,700 ha’s land for growing cane. Though the sugar industry in China is generally responsible for high levels of emissions, this company has created a cluster of companies in Guigang to reuse its by-products and thereby reduce its pollution. The complex includes: an alcohol plant, pulp and paper plant, toilet paper plant, calcium carbonate plant, cement plant, power plant, and other affiliated units. The goal of the initiative is “to reduce pollution and disposal costs and to seek more revenues by utilizing by-products.” (Duan 2001 and The Guitang Sugarcane Eco-Industrial Park Project website) The following chart shows the present flows of materials and water.
Duan identifies in this chart two primary eco-chains that Guitang has established, each of which has additional members and some internal feedback loops.

The output of the Guitang complex of companies is: 120,000 tons of sugar, 85,000 tons of paper, 10,000 tons of alcohol, 330,000 tons of cement, 25,000 tons of calcium carbonate, 30,000 tons of fertilizer, and 8,000 tons of alkali per year. In the late 1990s the secondary products accounted for 40% of company revenues and nearly as large a portion of profits and taxes paid.

The Guitang Group’s plans for the future include expansions of the industrial ecosystem and changes in processes at various stages. This innovative plan includes: *

- Construct a new beef and dairy farm using dried sugarcane leaves as feed.
- Construct a milk processing factory to make fresh milk, milk powder and yogurt for the local market.
- Construct a beef packing house to process beef, oxhide, and bone glue.
- Build a biochemical plant to make amino acid based nutrition products and other bio-products using the byproducts from the beef packinghouse.
- Develop a mushroom growing company using manure from the new dairy and beef farm.
- Process residue from the mushroom base to use on sugarcane fields as natural fertilizer.

China’s expected entry into the World Trade Organization poses a major threat to the economy of Guangxi. With barriers to lower-priced imports lowered, the economy of this Region could be injured profoundly. So
Guitang Group’s eco-industrial initiative has strategic importance for this and other sugar producing regions in China.

**City of Guigang Plans to Become an Eco-Industrial City**

The Group’s example has inspired the town of Guigang to adopt a five year plan to become an Eco-Industrial City. The heavy dependence of its economy on the sugar industry makes it important to improve the efficiency of its many processing plants. The plan calls for smaller sugar producers to send their by-products to Guitang’s eco-industrial complex and sets targets for high by-product utilization. (Targets for the city: “utilization of sugarcane slag reaches more than 80%, use of spent sugar-juice reaches 100%, use of spent alcohol reaches 100%.”) The plan also calls for consolidation of cane growing land into larger holdings. (It will require a transition for small farmers into other crops or into industrial employment.) It includes training of industry and government managers in eco-industrial principles and methods and broader dissemination of Cleaner Production strategies. Some of the long-term goals of this plan are:

- Develop an eco-sugar cane park to enable planting of organic cane, increases in sugar content of canes, increase in production per mu of land, and extend the harvest period.
- Enlarge the paper mill with a goal of increasing production to 300,000 tons per year in 3 phases.
- Switch some production from sugar to fructose, which has a strong market.
- Build a facility to produce fuel alcohol from spent sugar juice and sugar (capacity 200,000 tons per year). This product will help reduce air pollution from vehicle exhaust.
- Adopt low chlorine technology to bleach pulp. Paper made by this technology will be much whiter than the paper made by traditional technologies. (The Guitang Sugarcane Eco-Industrial Park Project website)

Guitang and the leadership of the town are supported by China’s State Environmental Protection Bureau (SEPA) and the China National Cleaner Production Center (CNCPC). Ning Duan, Deputy President of the Chinese Research Academy of Environmental Sciences, has been a key advisor to the Guitang Group. Financing is from the financial bureau of Guigang City. The local tax administration will return 50% of the agriculture tax to construction of irrigation systems for sugarcane farms.

**In India there are at least twenty sugar industry-based complexes partially similar to what the Guitang Group has created in Guigang. In one of these cases a paper company established sugar cane cultivation and sugar production in order to have bagasse as a by-product feedstock for its mill. Pulp wood prices had risen too high to produce paper competitively with this traditional input. Essentially sugar production in this case can be seen is a “by-product” of paper production. (See Case Study of Seshasayee Paper and Board below.)**

**Sources:**

Site visit in April 2001 by Ernest Lowe.


Nemerow, Nelson, L., Zero Pollution for Industry: Waste Minimization Through Industrial Complexes, John Wiley & Sons, NY, 1995. This text includes an alternative pattern for a sugar refinery complex, with part of the bagasse and all of the sludge going to an anaerobic digester to generate methane, which is used as fuel for boilers. The remainder of the bagasse is burnt in another boiler. The material output from the digester is filter cake that goes to farms for fertilizer.

Wei Xiaolin. 2001. EIP projects in China, e-mail from State Environmental Protection Agency staff person working with the Guigang initiative. Fri, 23 Feb 2001
India

Ramesh Ramaswamy and Suren Erkman have played a central role in introducing industrial ecology into India through field research, conferences, and workshops. Their organization, Institute for Communication and Analysis of Science and Technology (ICAST), organized a major workshop on Industry and Environment in Ahmedabad in 1999, working in collaboration with the Confederation of Indian Industries and the Indo-Dutch Project on Alternatives in Development. (Pangotra, Erkman, Singh 1999) The groundwork for this was laid when ICAST organized an earlier meeting at Kalundborg, Denmark that attracted industrial estate managers and other leaders in environmental management from India.

ICAST has conducted four industrial metabolism studies on different industrial systems in India. These include a cotton clothing production center at Tirapur, foundries in Haora, the leather industry in Tamil Nadu, and a complex integrating a paper mill and a sugar mill. We present extracts from the paper which these two industrial ecologists presented at a UNEP Cleaner Production conference in 2000 (Erkman and Ramaswamy 2000). http://www.agrifood-forum.net/db/cp6/ArticleErkman.doc

The following cases are summarized from the paper by Ramaswamy and Erkman just cited.

Case Study of Tirupur Town

Tirupur is a major center for the production of knitted cotton hosiery. The town is located in the south of India and has a population of about 300,000. The 4000 small units in the town specialize in different aspects of the manufacturing process. The aggregate annual value of production in the town is around US $ 700 million. Much of the produce is exported, bringing in very valuable foreign exchange.

Water is scarce in the area and the wet processing of textiles has rendered the ground water unusable. A large quantity of salt is used in the dyeing process and the process wastewater (90 million litres per day) is highly saline and is contaminated with a variety of chemicals. As there is hardly any source of fresh water nearby, water is brought in by trucks from ground water sources (which are yet to be polluted) as far as 50 Kms away at an enormous cost. A massive US $ 30 million project is under way to treat the wastewater at Central Effluent Treatment Facilities. After such expensive treatment, the water will still be unusable, as the facility does not include any system for desalination of the wastewater.

A Resource Flow Analysis (RFA) was undertaken for the town of Tirupur as an example of how a Regional Resource Flow Analysis could be effectively used. The RFA for Tirupur is shown in Figure 2.
A was carried out for the town. Only when the figures from this detailed Resource Flow Analysis were aggregated did the industrialists realize that they were collectively spending over US$ 7 million annually on buying water and in addition, the annual maintenance cost of the effluent treatment plant would be an enormous burden. The aggregate figures immediately showed that water could be recycled profitably. On the basis of the study, a private entrepreneur developed a water recycling system, which could be installed in each dyeing unit. The system used the waste heat from the boilers already working in the dyeing units for the recycling process. This is a relatively low cost system, which is gaining popularity in the town.
The second outcome of the study was that the study highlighted the fact that the calorific value of the solid waste (garbage) was high as it contained large quantities of textile and paper wastes. This could be used effectively to partially replace the 500,000 tons of scarce firewood being used in the town (there is grave concern over rapid deforestation in India). Since the use of the firewood is distributed over nearly 1200 points, it was not obvious that such large quantities of firewood were being used. The possibility of setting up a central steam source (needed by some of the industries) is also under serious consideration in order to reduce the consumption of firewood.

Case Study of the Foundries in Haora

Industrial Ecology is often discussed in the context of a symbiotic relationship between different industrial units in a region. Hence, the concept of preparing an Industrial Ecology case study on the foundries in a region demanded a new thought process. While carrying out an Industrial Ecology study of the foundries, it is first essential to look at the processes connected directly with the foundries. However, this need not be a limiting factor and it is useful to look at the other activities in the region. Such interrelationships between different activities in the region can have far reaching implications on the strategy options for the available resources (See Figure 3).

There are nearly 500 foundries in Haora, a suburb of Calcutta, in Eastern India The air pollution from the foundries has been a source of concern. The pollution control authorities have been insisting on the foundries installing pollution control systems to mitigate the pollution. The poor health of the engineering industry in the eastern region has affected the financial health of the foundries here, who now subsist on manufacturing very low value-added products like man-hole covers.

A new technology for the use of Natural Gas instead of Coke in the foundries (coke is the main cause of pollution from the foundries) has been developed and it is likely that the authorities may insist on the foundries using the new technology to eliminate the pollution problem. However, since Natural gas is not available in the region, the use of this new technology could substantially increase the cost of production and the foundries would not be competitive.

A detailed study of the foundries and the region showed that the industry could adapt the new technology to use Coke oven gases instead of Natural gas. As the eastern region is a major coal-producing region and as there are many independent Coke ovens, Coke oven gas is easily available in the region and is often wasted. Depending on the economics, either the foundry could be relocated near the coke ovens or the Coke oven gases could be transported to the foundries.

Case Study of the Leather Industry in Tamil Nadu

This case study is intended to highlight the option of strategic relocation of an industry segment to ensure its long-term survival. Tamil Nadu, a state in the south of India, is the premier center in India for the processing of leather. Water is extremely scarce in Tamil Nadu. The leather industry has been flourishing in the region for decades. Its growth has been possibly due to the fact that Madras was a major trading center during the British rule in India. The industry is a major foreign exchange earner and important to the economy of the state. The strict enforcement of environmental regulations in the developed countries have also helped the leather industry to grow, as the buyers in the developed countries prefer to source their tanned products from India. Compliance with strict environment regulations has rendered the processing very expensive in the developed world.

The leather industry (which is made up of thousands of small industries) is a major user of water, as each ton of hide/skin needs 30,000 to 50,000 litres of water for processing. This is a large volume, as the average per capita water availability for human settlement in India is estimated at around 30 litres per day. The industry has been under pressure from the pollution control authorities and many have subscribed to Central Effluent Treatment Plants. The water after treatment continues to be unusable, as it is very saline. The sludge from water treatment, estimated at 250 Kgs per 1000 Kgs of hide processed, continues to be a
problem. The sludge is carelessly dumped and the pollutants leach into the groundwater. The industry often buys water in trucks at a high cost.

A detailed study in the context of Industrial Ecology helped in redefining the problem. The problem till now, was only viewed as a pollution control problem, where the effluents did not meet the specifications laid down by the Pollution Control Authorities. Many academic studies have been undertaken to ensure that the effluent quality “comes as close as possible” to the standards.

However, the problem is much more serious. The industry is using a resource, water, which is extremely scarce in the region. It is also contaminating ground water in the region, which is causing great hardship to the population, as it is depriving them of desperately needed water. The industry has been using the slow judicial process in India to survive. However, it will not be long before the social pressure brings the industry to a halt.

In the long term, an alternate solution will need to be found. One of the options that may be considered in the context of Industrial Ecology, would be to relocate the entire industry along the coast, where the industry draws sea water, desalinates it for use, treats the waste water and discharges the saline waste water into the sea. The process of desalination is expensive. In order to reduce the cost of desalination, it may be possible to set up a thermal power plant and use the waste heat for desalination. The sludge from the process could also be incinerated and the energy used in the desalination process.

Case Study of Seshasayee Paper and Board Ltd.

This case study illustrates growth strategy adopted by a corporate group, by which a majority of the wastes from one activity were used as a feed stock for another activity.

The company started a paper mill some years ago. In order to ensure regular supply of raw material, a sugar mill was set up. The waste from the sugar mill (called bagasse) was used as a raw material for paper-making. Another waste from the sugar mill, molasses, was used in a distillery for the production of ethyl alcohol. In order to ensure regular supply of sugar cane, the company took interest in the cultivation of sugarcane by organizing the farmers in the region. The company struck long term agreements with the farmers to buy back their produce and in turn, took the responsibility of supplying them with water. Part of the water supplied for cultivation was the treated wastewater from the manufacturing operations. The company also used bagasse pith (a waste after the paper making) and other combustible agricultural wastes in the region, as energy source. This example could be viewed as an Agro Industrial Eco-complex.
This concludes the four cases from the paper by Ramaswamy and Erkman. This paper (Erkman and Ramaswamy 2000) continues with an excellent discussion of the methods for conducting regional resource flow studies and strategies for improving their efficiency while reducing pollution.


Ramesh C:\docs\IE\IEin DevelCountries.doc


Naroda Industrial Estate, Gujerat, India

(Based on research from Hauff and Wilderer 2000-2001)

Naroda Industrial Estate is one of the largest sites for eco-industrial development in the world. 700 companies with 35,000 employees operate on 30 km² of land. Naroda was founded in 1966 by the Gujarat Industrial Development Corporation, which also oversees 256 other estates. Industries at this estate include chemical, pharmaceutical, dyes and dye intermediates, engineering, textile, and food production. Naroda Industrial Association (NIA), including 80% of the companies, has founded a Charitable Hospital, a bank, and has constructed a common effluent treatment plant. It has also planted 30,000 trees.

The initiative at Naroda Industrial Estate is an industrial ecology networking project seeking a cooperative approach to achieve pollution prevention. Local leadership comes from the NIA and the Local Bureau of the Confederation of Indian Industry (CII). Researchers from University of Kaiserslautern are providing technical assistance and guidance in eco-industrial principles and methods. (The project is funded by the German Ministry for Education and Research.)

The effort began with a baseline survey of NIA members, focussing on material, water and energy usage. Local university graduates conducted surveys of 477 respondents and data was analyzed in a geo-information system or GIS. This identified common environmental problems as a basis for designing individual projects for the participating companies. The Association convened open meetings in which the companies explored their needs, using a broad eco-industrial network framework proposed by Ed Cohen-Rosenthal (as we describe in Chapter 11 of the Handbook.) In these discussions they identified focus points for projects and created project teams with managers. Subjects of the first four projects were recycling of spent acid; recycling of chemical gypsum; recycling of chemical iron sludge, and reuse/recycling of biodegradable waste.

In the spent acid project four chemical companies planned to collect their spent acid ($\text{H}_2\text{SO}_4$) to produce Ferrous Sulphate ($\text{FeSO}_4$). Their combined by-product outputs would yield enough to attain the concentration necessary for the generation of Ferrous Sulphate. A fifth firm with the necessary technology and energy supply is doing the processing. The companies will pay half of usual waste disposal fees for the recycling. The recycling firm will create 10 new jobs.

The chemical gypsum project started with a company that discovered this by-product could be used in concrete production instead of incurring the costs of transportation and landfill tipping fees. Through project information channels three other companies with the same by-product joined the initial one. This group set up the logistics and a drying area for handling their common output. They are recycling 300 tons per month, instead of adding that mass to the landfill.

The iron sludge project involves producers of dyes and dye intermediates who generate large quantities of iron oxide in a form that is quite hazardous. The project team identified production process changes to reduce the volume of iron oxide and to reduce the hazardous impurities. Through the network this Cleaner Production solution has been shared with all the firms in this industry.

The food companies at Naroda, mostly small operations, collectively generate large volumes of food wastes (ca 100 tons per month). They have done a feasibility study to identify ways of utilizing this output, possibly through fermentation processes. As a group they could act to handle a problem that no one firm could deal with.

After these first four projects started 15 firms in the ceramic industry formed a fifth with a Cleaner Production approach to assuring purity of their input materials. They are jointly investing in a testing laboratory.

The Naroda stakeholders are interested in establishing an Eco-Industrial Networking Centre to disseminate and share their experiences and to help individual companies handle some of their internal CP issues. This would build upon the improved access to information, easier project management, and consideration of new
recycling technologies the eco-industrial network has already achieved. This initiative at Naroda Industrial Estate has demonstrated that once isolated companies can work effectively in a collaborative approach and improve their environmental and financial performance.

The German researchers, Hauff and Wilderer, have also been working with Zona Industri Manis in Indonesia at the town of Tangerang on the outskirts of Jakarta. The latter can be reached by e-mail at wilderer@sozwi.uni-kl.de

Resources
Project updates and Martin Wilderer’s final report will be available on the University of Kaiserslautern website: [http://www.sowi-vwlii.sozwi.uni-kl.de](http://www.sowi-vwlii.sozwi.uni-kl.de)


Eco-Industrial Developments in Japan

See separate file for this research paper, [http://www.indigodev.com/IndigoEco-Japan.doc](http://www.indigodev.com/IndigoEco-Japan.doc)

An African Brewery Complex in Namibia

Zero Emissions Research and Initiatives (ZERI) is a worldwide network that researches and fosters eco-industrial development initiatives. ZERI serves as a public think-tank providing technical and scientific information for the advancement of these projects. This initiative started in 1994 in Japan through collaboration between the United Nations University (UNU) and ZERI. The first Zero Emission World Conference was held in Tokyo in 1995 and many from both public and private sectors participated in the meeting and introduced the idea to their communities. (ZERI undated)

ZERI projects tend to focus in industries generating large waste streams of biomass, such as beer breweries and other food and beverage plants. Namibia Breweries Limited and the University of Namibia have created the ZERI-BAG (Brewing-Aquaculture-Agriculture) project at the Tunweni Brewery at Tsumeb in the north of this southern African country. The project seeks to use the solid and liquid waste streams of the sorghum brewery as production inputs to an integrated farming system near the facility.

The brewery’s outputs include sewage treated in a biodigester, plant wash down and boiler blow down water, and spent grains with high carbohydrate content. The plan for this project envisions the following by-product flows:

- The digester turns the sewage into composted fertilizer and methane.
- The farm uses the spent grains to grow mushrooms and earth worms and to feed pigs.
- The earth worm growing medium forms a superior compost for crops.
- The brewing process water is used to wash down pig pens, with the slurry going into the biodigester.
- The methane gas replaces a portion of the fuel oil needed for the brewery’s boiler.
- Algae basins process water from the digester and grow algae for cattle feed.
The water from these basins flows into deepwater fish ponds to grow 6 species of tilapia that feed at different levels.

Variations on this pattern of brewery and agriculture symbiosis are under development in China, the Philippines, Fiji, Japan and other countries.

Source: Zero Emissions Research and Initiatives (ZERI) http://www.zeri.org/systems/brew.htm

A Resource Recovery Park in Puerto Rico

Although the United States is the definitive developed country it has pockets of relative underdevelopment, including the former Spanish colony, Puerto Rico. This Caribbean island near Venezuela is a US Commonwealth whose development has been dominated by legislation making it an export platform for US pharmaceutical companies. It is a model of unsustainability, importing the majority of its food, construction materials, steel, paper, and other basic economic inputs. At the same time it still uses landfills for the major portion of its waste stream and has a relatively low rate of recycling. The fills are polluting the island’s aquifer and wasting resources that could displace many imports. (Lowe 1999a)

The eco-industrial park in this case is of importance globally because multinational companies are pushing the outdated but profitable “solution” of landfill construction in many developing countries when resource recovery systems offer a real answer to mountains of garbage and trash. In Puerto Rico a resource recovery facility using advanced waste-to-energy technology will be the hub for a park seeking other tenants in resource recovery, renewable energy, and support to sustainable farming. Recovery Solutions Inc. is developing their Resource Recovery Park (RRP) at Arecibo (in the NW quadrant of the island) based on the use of energy and materials recovered from the municipal solid waste stream. See Chapter 6 of this Handbook for conceptual models of resource recovery parks, as well as alternative energy and agro-parks.

The Waste-to-Energy Anchor

The anchor for the eco-park will be a resource recovery facility (RRF), an advanced, low pollution waste-to-energy and materials recovery plant. The facility will have highly efficient energy and materials recovery with near zero residues and environmental impacts. The Project’s design team is applying a core industrial ecology strategy: the creation of an energy and materials by-product exchange between the RRF and the site’s tenants. Though the energy produced and materials recovered will be marketable outside of the park, the first tenants will be those who can efficiently use the energy and materials recovered and produced at the RRF. This will eliminate transportation costs, provide a greater discount on raw materials for park tenants, and enable more complete resource use and waste reduction within the park.

Recruitment for Integrated Resource Recovery, Renewable Energy, and Sustainable Farming

Recovery Solutions plans to create an integrated system at the Resource Recovery Park, one that will contribute in a major way to the self-reliance and sustainability of Puerto Rico, as well as to the management of municipal solid waste (MSW). The RRP will promote long-term business development in the recycling and reuse of now discarded materials, renewable energy, and sustainable agriculture.

The RRF itself will eliminate 2000 tons/day of waste from Puerto Rico landfills and will be the supplier to satellite industries using the facility’s outputs of electricity, steam, steel, non-ferrous metals, fly ash, bottom ash, and aggregate.
The first satellite industries on-site will be a paper mill, a concrete and building products plant, and a metals processing company utilizing products from the resource recovery facility. The project will re-commission a paper mill on the eco-park site to manufacture products from recycled feedstock (old corrugated cardboard). The facility will also attract companies processing higher value segments of the MSW stream and manufacturing products from recycled materials. These could include a plant to shred tires into crumb rubber and steel and a plant to make building products from recycled plastics. The tire processing plant would require an air separation plant to produce liquified nitrogen, as well as other air products.

RRP recruitment will seek companies providing products or services for renewable energy and energy efficiency. These include manufacture of photovoltaic cells and hydrogen fuel cells, distributed energy systems, and ethanol production from discarded biomass. Installation of solar arrays on acres of building rooftops will create a major generating plant as well as an initial market for a PV manufacturing plant.

The park will give high priority to selling energy at a discount to agricultural industries that can support new sustainable farming on the now unproductive land formerly used to grow sugar cane (ca 3,000 acres adjacent to the eco-park site). Target firms include food processing plants, pasteurizing, marketing co-ops, cold storage, and rendering. (Lowe 1999 and Recovery Solutions 1999-2001)

**Allied Community and Economic Development**

The RRP will also include shared support services, which will benefit residents and businesses of the community as well as its tenants. These may include a business incubator, an RRP Learning Center, an RRP Research and Technology Center, environmental management services for smaller tenants, a cafeteria, exercise facilities and a day-care center. Sharing costs on services will lower the overall costs of the park tenants.

Recovery’s planning team is exploring collaboration with the community of Arecibo on other projects that would improve the local economy and quality of life. These include Arecibo Agro-City (already funded by the government), an Agricultural Park Belt and Open Space Preserve, the preservation and restoration of the historical center of the old city of Arecibo, development of a public transportation link to the old city of Arecibo from the park and, appropriate housing development for project employees. The agricultural programs would support redevelopment of former sugar cane land in the region, furthering one of the eco-park’s recruitment goals.

Source

RPP International, Indigo Development Center, Emeryville, CA
The Industrial Symbiosis at Kalundborg

While this is a compelling illustration of the value of inter-firm collaboration, it should not be called an eco-industrial park. To date, the focus of collaboration has been on developing inter-firm exchange of by-products and their plants are not located in an industrial park. The companies at Kalundborg are now considering the next steps in the ongoing evolution of their symbiosis.

One of the favorite cases presented by industrial ecologists is the story of the spontaneous but slow evolution of the “industrial symbiosis” at Kalundborg, Denmark.¹ This web of materials and energy exchanges among companies (and with the community) has developed over the last 25 years in a small industrial zone on the coast, 75 miles west of Copenhagen. Originally, the motivation behind most of the exchanges was to reduce costs by seeking income-producing uses for “waste” products. The latest numbers from Kalundborg indicate that the firms have saved US$160 Million to date ($15 Million in annual savings) as return on total investments of $75 Million. (Noel Brings Jacobsen, Symbiosis Institute. personal communication in January 2001). Gradually, the managers and town residents realized their transactions were generating significant environmental benefits as well.

The Kalundborg system now includes six core partners:

- Asnæs Power Station—Denmark’s largest power station, coal-fired, 1,500 megawatts capacity;
- Statoil Refinery—Denmark’s largest, with a capacity of 3.2 million tons/yr (increasing to 4.8 million tons/yr);
- Gyproc—a plasterboard factory, making 14 million square meters of gypsum wallboard annually [roughly enough to build all the houses in 6 towns the size of Kalundborg];
- Novo Nordisk—an international biotechnological company, with annual sales over $2 billion. The plant at Kalundborg is their largest, and produces pharmaceuticals (including 40% of the world’s supply of insulin) and industrial enzymes;
- A-S Bioteknisk Jordrens, a soil remediation company (a new addition in the late 90s);
- The City of Kalundborg—supplies district heating to the 20,000 residents, as well as water to the homes and industries.

Over the last two and a half decades, these partners spontaneously developed a series of bilateral exchanges, which also include a number of other companies. There was no initial planning of the overall network; it simply evolved as a collection of one-to-one deals that made economic sense for the pairs of participants in each. This suggests that EIP teams seeking to recruit companies to form a similar by-product exchange network must not over-plan. Conceive a strategy, that respects current market forces, and then use industrial data bases and information networks to let companies know what you have to offer.

We illustrate the gradual development of the symbiosis in Figures K1, K2, and K3, showing the extent of the material and energy exchanges in 1975, 1985, and 1995, respectively.

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¹ “Industrial symbiosis. A cooperation between different industries by which the presence of each increases the viability/profitability of the other(s), and by which the demands of society for resource savings and environmental protection are considered. Symbiosis is the living together of dissimilar organisms in any of various mutually beneficial relationships. Here the term is used to mean industrial cooperation with mutual utilization of residual products.” From Industrial Symbiosis, a publication of the Kalundborg companies. No date.
The beginning of the Kalundborg Symbiosis

The symbiosis started when Gyproc located its facility in Kalundborg to take advantage of the butane gas available from Statoil (which enabled the refinery to stop flaring this gas). Today, Gyproc is still the only company to have located there to take advantage of an available supply.

Ten years later

As illustrated in the next chart, the second by-product flow from the pharmaceutical plant to farms, became the largest single exchange. Novo Nordisk provides without charge 1.1 million tons/year of sludge (containing nitrogen and phosphorus) to about 1,000 farms. This began in 1976, four years after the Statoil-Gyproc contract. This was the least-cost solution after the Danish government prohibited dumping of this material into the sea.

Another three years passed before Asnæs began to supply fly ash to the Aalborg Portland cement company, the first contract involving a company not even in Kalundborg. Finally, in 1981-82, more exchanges developed: Asnæs began supplying steam to the city, to Statoil, and to Novo Nordisk. Hence, the first decade encompassed the evolution from one contract to the beginnings of a real "food web" with each of the three largest companies involved in two or more separate contracts.
Ten years later, the web had developed further.

Between 1985 and 2000 the Symbiosis at Kalundborg became even richer in its flows of by-products.

1987  Statoil pipes cooling water to Asnaes for use as raw boiler feed water
1989  Fish production begins at Asnaes site using waste heat in salt cooling water
1990  Statoil sells molten sulfur to Kemira in Jutland (ends 1992)
1991  Statoil sends treated waste water to Asnaes for utility use
1992  Statoil sends desulfurized waste gas to Asnaes; begins to use by-product to produce liquid fertilizer
1993  Asnaes completes flue gas desulfurization project and supplies gypsum to Gyproc
1995  Asnaes constructs reuse basin to capture water flows for internal use and to reduce dependency on Lake Tissø
1997  Asnaes switches half of capacity from coal to orimulsion; begins sending out fly ash for recovery of vanadium and nickel
1999  A/S Bioteknisk Jordrens uses sewage sludge from the Municipality of Kalundborg as a bioremediation nutrient for contaminated soil

Around 1990 high school students charted the network of exchanges and for the first time the plant managers saw what they have unwittingly created.
Figure K3: The web of exchanges in 1995: about 3 million tons per year

**Energy and Water Flows**

The Asnæs power station was coal fired and operated at about 40 percent thermal efficiency. Like all other fossil-fuel power stations, the majority of energy generated goes up the stack. At the same time, another large energy user, the Statoil refinery flared off most of its gas by-product. Then, starting in the early '70s, a series of deals were struck:

The refinery agreed to provide excess gas to Gyproc, which had seen Statoil's flares and recognized that this burning gas was a potential low-cost fuel source.

Asnæs began to supply the city with steam for its new district heating system in 1981 and then added Novo Nordisk and Statoil as customers, too. This district heating, encouraged by the city and Danish government, replaced about 3,500 oil furnaces (a significant non-point source of air pollution).

The power plant uses salt water, from the fjord, for some of its cooling needs. By doing so, they reduce the withdrawals of fresh water from Lake Tissø. The resulting by-product is hot salt water, a small portion of which they now beneficially supply to the fish farm's 57 ponds.

In 1992, the power plant began substituting fuels, using surplus refinery gas in place of some coal. This only became possible after Statoil built a sulfur recovery unit to comply with regulations on sulfur emission; their gas was then clean enough to permit use at the power plant. In 1998 it added a new fuel called orimulsion, a bituminous product produced from Venezuelan tar sands.
Materials Flows

In 1976 the Novo-Nordisk plant started the pattern of materials flows, matching the evolving energy flows at Kalundborg.

- Sludge from Novo Nordisk's processes and from the fish farm's water treatment plant is used as fertilizer on nearby farms. This is a large portion of the entire Kalundborg exchange network, totaling over 1 million tons per year.

- A cement company uses the power plant's desulfurized fly ash. Asnæs reacts the SO$_2$, in its stack gas with calcium carbonate, thereby making calcium sulfate (gypsum), which they sell to Gyproc, supplying 2/3 of the latter's needs.

- The refinery's desulfurization operation produces pure liquid sulfur, which is trucked to Kemira, a sulfuric acid producer.

- Surplus yeast from insulin production at Novo Nordisk goes to farmers as pig food.

- A/S Biotechnical Jordrens, the firm that joined the symbiosis in 1999, uses municipal sewage sludge as a nutrient in a bioremediation process to decompose pollutants in contaminated soils. This has allowed for beneficial reuse of another material stream drawn from the city's wastewater.

- The new fuel at the power plant, orimulsion, contains higher sulfur content, thus increasing the volume of gypsum produced from the plant's scrubber. It also has heavy metal content yielding nickel and vanadium by-products. These must be handled with care to safeguard workers.

This web of recycling and reuse has generated new revenues and cost savings for the companies involved and reduced pollution to air, water, and land in the region. In ecological terms, Kalundborg exhibits the characteristics of a simple food web: organisms consume each other’s waste materials and energy, thereby becoming co-dependent on each other.

One may ask, “How significant are these exchanges at Kalundborg?” To answer this and similar questions is difficult, as we do not have what the engineers call a complete mass and energy balance, covering all of the Kalundborg participants. However, from the information which has been published, we can make some estimates, which we have summarized in Table 9-1 below.
Estimates of the Material Exchanges in the Symbiosis at Kalundborg

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Sold/free</th>
<th>Began</th>
<th>Quantity [T/yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel gas (x-flare gas)</td>
<td>Statoil</td>
<td>Gyproc</td>
<td>sold</td>
<td>1972</td>
<td>8,000</td>
</tr>
<tr>
<td>Sludge</td>
<td>Novo Nordisk</td>
<td>1,000 farmers</td>
<td>free</td>
<td>1976</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Fly-ash &amp; clinker</td>
<td>Asnæs</td>
<td>Aalborg Portland</td>
<td>sold</td>
<td>1979</td>
<td>200,000</td>
</tr>
<tr>
<td>Steam</td>
<td>Asnæs</td>
<td>Kalundborg</td>
<td>sold</td>
<td>1981</td>
<td>225,000</td>
</tr>
<tr>
<td>Steam</td>
<td>Asnæs</td>
<td>Novo Nordisk</td>
<td>sold</td>
<td>1982</td>
<td>215,000</td>
</tr>
<tr>
<td>Steam</td>
<td>Asnæs</td>
<td>Statoil</td>
<td>sold</td>
<td>1982</td>
<td>140,000</td>
</tr>
<tr>
<td>Water (x-cooling)</td>
<td>Statoil</td>
<td>Asnæs</td>
<td>sold</td>
<td>1987</td>
<td>700,000</td>
</tr>
<tr>
<td>Hot sea water</td>
<td>Asnæs</td>
<td>Fish Farm</td>
<td>free</td>
<td>1989</td>
<td>?</td>
</tr>
<tr>
<td>Sulfur (liquid)</td>
<td>Statoil</td>
<td>Kemira</td>
<td>sold</td>
<td>1990</td>
<td>2,800</td>
</tr>
<tr>
<td>Water, biotreated</td>
<td>Statoil</td>
<td>Asnæs</td>
<td>free</td>
<td>1991</td>
<td>200,000</td>
</tr>
<tr>
<td>Fuel gas (x-flue gas)</td>
<td>Statoil</td>
<td>Asnæs</td>
<td>sold</td>
<td>1992</td>
<td>60,000</td>
</tr>
<tr>
<td>Gypsum</td>
<td>Asnæs</td>
<td>Gyproc</td>
<td>sold</td>
<td>1993</td>
<td>85,000</td>
</tr>
</tbody>
</table>

Total annual quantity: 2.9 million

The quantities involved in these exchanges are about the same as the amount of coal which Asnæs buys (2+ million tons/year) or the tonnage of North Sea crude oil refined by Statoil (3.2 million tons, now being increased to 4.8).

Note that by volume water is the material exchanged the most, almost 85% is water, in either liquid or gaseous (steam) form.

**Lessons from Kalundborg**

What can we learn from the Danes’ experience over the past two decades? Here are some comments from those directly involved:

- All contracts have been negotiated on a bilateral basis.
- Each contract has resulted from the conclusion by both companies involved that the project would be economically attractive. It made, in other words, good business sense to do it.
- Opportunities not within a company’s core business, no matter how environmentally attractive, have not been acted upon.
- Each partner does its best to ensure that risks are minimized.
- Each company evaluates their own deals independently; there is no system-wide evaluation of performance, and they all seem to feel this would be difficult to achieve.

Without a conscious intent at the beginning to develop an industrial ecosystem, a very effective, and environmentally beneficial symbiosis among half a dozen companies has evolved, albeit slowly.

Jørgen Christensen, Vice President of Novo Nordisk at Kalundborg, identifies several conditions that are desirable for a similar web of exchanges to develop:
Industries must be different and yet must fit each other.

Arrangements must be commercially sound and profitable.

Development must be voluntary, in close collaboration with regulatory agencies.

A short physical distance between the partners is necessary for economy of transportation (many transfers are not economically or technically feasible over long distances).

At Kalundborg, the managers at different plants all know each other. (This was a big help but may not be absolutely necessary at other locations.)

Suggestion:

Encouraged by the successes at Kalundborg, consider all the ways you can do even better than Kalundborg has done, and achieve your goals in a shorter time. Take advantage of their experience as you carefully plan for a tightly integrated BPX, seeking environmental benefits and providing many tenant services which even today are not available at Kalundborg.

**Applying These Lessons**

**Industry Match**

An important element of the Kalundborg symbiosis has been the match among the industrial players in terms of inputs and outputs. The five major companies are in essentially different industries with different input requirements and by-products. Opportunities to develop symbiotic relationships might be more limited where the companies involved are in essentially the same type of industry, requiring similar inputs and producing similar by-products. As in nature, diversity seems to have its advantages, providing both stability and resilience. (However, in some cases plants in the same industry might be able to cascade materials through firms needing different levels of quality, i.e. plastics.)

As we have seen, water is the most common material exchanged at Kalundborg. Even similar companies may have beneficial exchanges of water and steam. We also have the example of the Houston Ship Channel, older and many times larger in scope than Kalundborg, where most of the participants are in the oil refining/petrochemical industry. So, again, absolute rules are few; *your local conditions will probably be determinant.*

**Size Match**

The companies at Kalundborg are of compatible size in terms of their material flows. Thus, a single agreement between two companies is typically able to utilize a significant proportion of the by-products from the supplier and meet a large proportion of the demand on the part of the buyer. Where large size differences exist between supplier and buyer the complexity of the arrangements involved may increase for the large player.

Scrap metal dealers, of course, have successfully provided a brokerage function for many decades, matching the needs of suppliers and users. Hence, in an EIP, one solution might be to have the park management company play the role of broker, or to have them contract with an off-site broker to serve the needs of the EIP. Then each industrial party would only negotiate with one party, the broker. If internal supply and demand are mismatched, the broker can go outside of the bounds of the EIP to find other sources or customers for suitable materials.

We observe that several companies in Kalundborg have successfully found distant customers for some of their available by-products: Asnæs, fly ash; Statoil, sulfur; Novo Nordisk, sludge.

Suggestions:
You may wish to survey the industries in your area or region; what scrap dealers, recyclers or other intermediaries are already there who might be able to provide the brokerage services required for your exchange.

Check your landfills too; what materials, in large volume, are disposed of there? Are these same materials used elsewhere in the country, rather than being thrown away? Is that because there is no local recycler or (re)user of these materials?

Is some of the waste material (both solid and liquid) produced locally being “exported” to other regions of the country where there are willing buyers?

The answers to these questions may very well reveal local opportunities for new industries and new jobs in your community.

Close Physical Distance

One of the important elements in many of the material and energy exchanges at Kalundborg is the physical proximity of the plants. As distance between plants increases, the transaction costs increase. Where the exchanges involve transfers by pipeline, the capital costs of construction increase; where they involve trucks, or other wheeled transport, the initial costs are less a factor; but operating costs become more important as do the environmental consequences of noise, dust, traffic and fuel usage. Where transactions involve transferring heat in the form of steam or hot water, close physical distance is extremely important in minimizing transmission losses. Low-pressure steam, for example, is generally not attractive for off-site use, unless the quantities exchanged exceed 500,000 lb/hr.

There is no single answer to the question of how close is close enough, as the answer involves a complex analysis of the site specific characteristics of the individual transactions. The following questions should be addressed by the parties to the proposed transaction:

- What material or energy flow is involved?
- What is the cost of obtaining existing or alternative materials or energy?
- What material disposal costs could be eliminated or reduced by finding a willing user, even if you have to pay them to take the material?
- Do you need to change corporate financial or tax factors that tend to block capital spending to reduce operating costs? (Changes in equipment or new infrastructure may be required to supply or use by-products.)

Close Mental Distance

In discussing the conditions that enabled the Kalundborg symbiosis, Jørgen Christensen of Novo Nordisk stresses the importance of what he calls the close mental distance. He goes on to describe a commonality of mind that has existed among the leaders of the local companies and the City of Kalundborg. The city is small, with a population of about 20,000, surrounded by a farming region, and at some distance from other urban centers. All the managers are of about the same age, and have children of similar age who attend the same schools. They are members of the same clubs and attend the same churches. The symbiosis among their companies thus grew out of personal relationships of shared values, understanding, and trust.

One additional lesson from Kalundborg in this regard, is that close interaction at all levels in the companies can be an important ingredient of success. The Danes found that though good, trust-based communication at senior levels is essential to establishing the exchanges, close interaction among employees at all levels is essential for optimal implementation.
Cooperative efforts among the companies on such activities as training have also contributed to the “close mental distance” feeling; as they have worked together on materials and energy related matters, they have learned that they share other problems which can also be profitably dealt with collaboratively.

A critical question, then, is how can a set of company employees create this close mental distance without growing up together in a small Danish town? We discuss some ways to build a sense of community among companies in Chapters 10 and 11.

Regulations Create Financial Incentives

The Kalundborg symbiosis highlights two important aspects about the relationship of government to the success of an industrial ecosystem. The first is that government regulation can be effective in forcing industries to recognize and pay some of the so-called societal or “externality” costs associated with their products. The second involves the clear evidence that the proper role of government is to establish requirements and goals, but not to specify how to meet them.

Government regulations have played a major role at Kalundborg, as the symbiosis has evolved. First, they restricted emissions of certain materials, such as sludge, to the fjord and sulfur dioxide to the air. Second, they banned certain practices, e.g., discharging hot water “thermal pollution” to the fjord. And third, they compelled certain industries to do specific things, but then provided subsidies to help defray some of the costs, e.g., the district heating program for Kalundborg.

Where government has established requirements, but has not specified technological solutions to meet these requirements, the companies have been very creative in finding effective, economically feasible solutions. Once these externalities became costs to the firm, they were quick to find ways of lowering costs. In many cases the solutions have had unanticipated collateral benefits that increased profits, or reduced total resource utilization.

The mandated reduction in allowable level of SO$_2$ emissions is but one example. Asnæs Power Plant was able to find a scrubber technology that produced commercial-grade gypsum as a by-product. Sale of the gypsum to Gyproc resulted in a reduced demand for imported mineral gypsum, thereby lowering Gyproc’s costs while improving the Danish balance of trade. This success required extensive collaboration between Asnæs and Gyproc and others, such as the scrubber manufacturer.

But, where the government has stipulated the specific implementation for the companies to follow, the results have been much less successful. Asnæs was required by the government to initiate a fish-farming operation as a way to consume excess sludge. The operation was a money-loser until the government permitted sale of the fish-farm to an independent operator who has converted it into a profitable venture. (Fish farming just didn’t “fit” into Asnæs’ kind of business.) The government also was in favor of greenhouse operations, but these plans were finally abandoned after growers elsewhere in the country complained of unfair competition; the greenhouses in Kalundborg would have enjoyed especially low heating costs, and the government was not willing to subsidize all the other growers enough to compensate them for their potential losses.

Suggestion:

Either EIP managers or organizers of by-product exchanges should carefully consider membership and participation in the local Chamber of Commerce, in various industry or trade groups, and in periodic discussions with authorities and other regulatory agencies. By being proactive in such areas, the entire project can be in a better position to affect future legislation and rules, as well as being able to communicate back to the tenants the current thinking in the governments about all issues of relevance to successful operation of the tenant companies.
**Negotiations at a Local Level are More Effective**

The companies at Kalundborg, most of which are branch operations with headquarters elsewhere (Statoil is a Norwegian firm, and Gyproc is now owned by a British company) have found that the successful exchanges making up the symbiosis have been negotiated at the local level. In many cases, the success of the negotiations have depended on knowledge of the local situation that was not available to staff at corporate headquarters.

**Suggestion:**

Make sure each potential tenant in an EIP understands the degree of autonomy management requires to function in the exchange. The local plant manager may wish to establish local responsibility for negotiating the details of the EIP participation.

**Sources on Kalundborg**


Symbiosis Institute, Kalundborg, Denmark [http://www.symbiosis.dk/](http://www.symbiosis.dk/)
Appendix 2: Supplemental Content

Using the Environmental Performance Framework in Siting an EIP
Decision Support and the Analytic Hierarchy Process
Design for Environment
High Performance, Socio-Technical Systems, and Viable Systems
Plant Survey Forms
A Sampling of By-Product Exchanges
Audubon Society House: Sustainable Design and Reconstruction
Using the Environmental Performance Framework in Siting an EIP

You can use the Environmental Performance Framework in most aspects of your development process to determine performance objectives and goals specific to your project. The following is a detailed discussion of how this framework could support the selection of a site for your park. This is offered to demonstrate how your team would use the tool in any area, as well as to support actual consideration of sites.

Historically, environmental constraints have rarely been considered in selecting sites for industrial development. Common practice in industrial site selection has focused primarily on economic, and more recently social, issues. As a general rule, environmental considerations have been secondary in the siting decision. Most environmental constraints have been accepted and worked around, engineered and built around, or mitigated. In the past 20 or 30 years, practices, such as "flood-plain zoning" have emerged to preclude development in selected environmentally significant areas. Increasingly, environmental impact assessments and other processes that incorporate public review and input have influenced siting of facilities. In most cases, the siting decision has continued to be influenced by the known economic implications of the environmental constraints, rather than by the environmental constraints themselves.

Siting an EIP involves changing this approach to incorporate environmental implications of the location decision as a primary factor in the location decision. The situation that we discuss in this section involves a community in which more than one site is under consideration for siting an EIP.

The siting of your eco-park can impact each of the elements of environmental performance (See Table below).

The greater the topographic and geologic complexity of the community's region, the more impact the siting decision may have on environmental performance. At the one extreme are areas that are characterized by relatively flat surface topography and surface materials generally the same with minor repeating differences across the area. In these communities, different sites will generally have little difference in the amount of influence of siting on environmental performance.

At the other extreme are regions that are characterized by significant changes in topography and surface geology across the area. In these communities, differences in substrate and microclimate can result in substantial differences in environmental performance among various sites.

The following table summarizes the principle ways that variations in site characteristics can impact environmental performance. We then describe each type of impact is in more detail. We discuss each issue from the perspective of a community in which there is sufficient variability to differentiate specific sites. Finally we discuss data sources and methods of analysis to guide application of these principles in particular communities.
<table>
<thead>
<tr>
<th>ENVIRONMENTAL PERFORMANCE ELEMENT</th>
<th>IMPACT OF SITING ON ENVIRONMENTAL PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Use</td>
<td>Location and orientation relative to sun and wind, access to by-product energy sources</td>
</tr>
<tr>
<td>Water Use</td>
<td>Precipitation, lakes, streams and landscape features favorable to retention and routing water. Access to by-product water flows.</td>
</tr>
<tr>
<td>Material / Resource Use</td>
<td>Existing facilities and infrastructure, prime farmland, access to by-product supplies reducing use of virgin materials</td>
</tr>
<tr>
<td>Atmospheric Emissions</td>
<td>Wind patterns, inversions, existing emission sources, commuting distance, and truck traffic</td>
</tr>
<tr>
<td>Liquid Waste Emissions</td>
<td>A function of facility operation, and proximity to potential users of liquid by-products resulting in lower emissions</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>A function of facility operation, and proximity to potential users of solid by-products resulting in lower waste flows</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>Natural habitat disturbance</td>
</tr>
<tr>
<td>Neighbors</td>
<td>Other industrial sites or facilities, residential areas, traffic and commuting routes</td>
</tr>
<tr>
<td>Physical Environment</td>
<td>Hydrologic setting of the site can affect potential for contamination of surface and groundwater</td>
</tr>
</tbody>
</table>

Effect of siting on environmental performance framework

**Access to alternative energy**

Sun angle, cloudiness, and regional wind patterns vary by region, determining the potential for development of alternative energy sources varies. Some areas are naturally more sunny or more windy than other areas, and therefore afford greater opportunities to supplement energy requirements with alternative sources.

Similar variations occur at the local level within regions. These smaller scale variations are controlled by interactions between local topography and the sun or wind.

**Wind exposure**

Wind exposure can affect EIP facilities in two ways. 1) Exposure to cold winter winds or hot summer winds can increase energy requirements for heating or cooling, respectively. 2) The potential for wind power is controlled by the strength and steadiness of wind. The setting of a site relative to topography, stands of trees, or buildings can result in exposure to or shielding from wind. Variations in effectiveness of wind generation are controlled by interactions between regional wind patterns with local topography, large water bodies, and forested areas.

**Solar exposure**

In areas of steep terrain, specific sites may be shaded from the sun during part of the day. Sites in narrow, deep valleys or at the base of mountainous ridges, may experience fewer hours of exposure to the sun, than sites in the same area that are out in the open. As with wind exposure, reduced passive solar heating during periods of shading can increase requirement for heating during winter or lower energy requirements.
for cooling during summer. More shaded sites have lower potential for using the solar energy to supplement building energy requirements.

<table>
<thead>
<tr>
<th>CONDITION AT SITE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>High wind exposure</td>
<td>Opportunity for wind generation. Minimum potential for atmospheric inversions</td>
<td>Increased requirement for heating in winter</td>
</tr>
<tr>
<td>High sun exposure</td>
<td>Opportunity for solar generation. Decreased requirement for heating in winter</td>
<td>Increased requirement for cooling in summer.</td>
</tr>
<tr>
<td>Location near surface water Natural drainage and depressions</td>
<td>Potential for cost-effective integration of landscape into water management system</td>
<td>Higher potential for contamination of surface water.</td>
</tr>
<tr>
<td>Higher rainfall</td>
<td>Increased water available.</td>
<td>Greater water management challenges.</td>
</tr>
<tr>
<td>Farm land</td>
<td>Relatively low potential for site contamination Low potential for loss of natural habitat</td>
<td>Loss of productive farm land.</td>
</tr>
<tr>
<td>Undisturbed land</td>
<td>No site contamination No loss of productive farm land.</td>
<td>High potential to disturb natural habitat</td>
</tr>
<tr>
<td>Industrial land</td>
<td>No loss of productive farm land. Low potential for loss of natural habitat</td>
<td>High potential for site contamination.</td>
</tr>
<tr>
<td>Proximity to residential areas</td>
<td>Potential to substantially reduce commuting related vehicular emissions</td>
<td>Potential limitation to types of industrial tenants</td>
</tr>
<tr>
<td>Proximity to rail</td>
<td>Potential to substantially reduce vehicular emissions from trucks</td>
<td>May restrict siting options</td>
</tr>
<tr>
<td>Proximity to Industrial Infrastructure</td>
<td>Minimizes truck traffic within community, resulting in lower emissions as well as other benefits.</td>
<td></td>
</tr>
<tr>
<td>Proximity to Industry</td>
<td>Potential to form material or energy exchange transactions that result in reductions in wastes and demand on resources</td>
<td></td>
</tr>
<tr>
<td>Location over major aquifer</td>
<td>May increase (or decrease) potential for heating with stored solar energy</td>
<td>Increased potential for contamination of groundwater</td>
</tr>
</tbody>
</table>

Summary of advantages and disadvantages of various conditions of the natural and constructed environment of potential EIP sites.
Stored Solar Energy

The temperature of groundwater is constant at depths of a few ten’s of metres below the surface. The constant temperature reflects the long-term mean annual temperature of the region. The temperature difference between the groundwater and hotter air during the summer and colder air during the winter creates a temperature gradient that is increasingly being exploited to heat or cool buildings. Sales of heat pumps to utilize this source of energy increased 20% in 1994 compared to the previous year. The higher capital cost of installing this type of residential heating system relative to conventional systems is recovered in three to five years through savings in fuel costs.

Variability in the geology beneath many communities results in variations in subsurface temperature profile and the geologic conditions necessary to exploit this temperature gradient as a heat pump. Mapping these variations will indicate those sites in which greater potential exists to supplement the energy requirements of your EIP.

Facilitation of water-use cascading

Climate, topography and drainage all play a role in creating natural conditions that facilitate retention and integration of natural water and water from facilities within the EIP. You can compensate for the absence of naturally favorable conditions through engineering and construction of ponds and drainage, but at increased cost to the EIP. Site characteristics commonly vary across communities.

Amount of natural water available

The amount of water available within the landscape varies within communities. In regions where water is generally scarce, siting the EIP in a setting with more water than is typical in the area can offer opportunities to achieve environmental and economic benefit. In regions where water is abundant, there may be advantages to selecting a site to avoid excess water and minimize water management requirements.

Proximity to usable streams or lakes

Distribution of lakes, ponds, and streams varies from place to place in most communities. An EIP sited near a body of surface water may be able to integrate the natural drainage with its water management system. Water quality regulations or land-use restrictions of zoning ordinances will place constraints on the degree to which the surface water bodies can be integrated into the site water management system. At the very minimum ponds and streams can be used as part of the storm-water run-off management system. They may provide water for landscaping and potentially for cleaning and cooling.

Variations in precipitation

In many larger metropolitan areas, precipitation varies significantly across the community. The heat and particulate matter released from the city itself commonly results in higher precipitation on the eastern part of the city. In addition, variations in topography across a city can produce substantial changes in precipitation. The rising land on the east side of Salt Lake City, for instance, produces much higher rainfall in the east than in the west. In communities such as this, the selection of a site for an EIP can produce a substantial change in the amount of water available. Depending on the overall water balance of the facility, this difference may be significant enough to factor into the siting decision.

Landscape Features Control Potential for Retention and Routing Water

In many sites, slopes, and natural landscape depressions can be incorporated into a landscape water handling system as part of the EIP (even though not part of permanent, natural drainage). This may
minimize earth moving needed in site-preparation. Siting the EIP with these landscape features in mind can open up options for integrating the total water management system of the park. The lower cost of using natural landscape features relative to the more extensive construction required for a site without natural advantages, may be an important factor in siting.

**Loss of prime farm land**

Location of highly productive farmland is one of the factors that led to the original development of many of the cities in the United States. Over the years, much of this land has been lost to urban sprawl. Industrial development in Asian countries also has frequently occupied prime farmland. Where the only greenfield sites available are high quality farm land, redevelopment of existing industrial land, may be a much better overall solution for the community and the country.

**Atmospheric emissions**

Atmospheric emissions are one of the most significant potential environmental issues related to any industrial facility. Clearly, the most significant factors controlling emissions are the types of industrial operations in the parks, the pollution prevention practices in the design and operation of the facility and the pollution control equipment installed in the plants. Nevertheless, siting of the EIP can influence the potential of atmospheric contamination resulting from the park in two important ways.

**Local atmospheric conditions conducive to inversions or smog**

In some communities, the interaction between atmospheric circulation patterns, air temperature profiles, and local topographic features create conditions leading to atmospheric inversions that trap any airborne contaminants. Some locations within these communities are more susceptible to this type of situation than others.

**Vehicular emissions as a function of commute distances**

The influence of location of an EIP on commuting distances of potential employees may be one of the most significant impacts of the siting decision on the environmental impacts of the EIP. The emissions from automobiles of employees commuting to and from work exceeded all other emissions from the plant itself by a factor of 1.5 times at an aircraft factory in the Los Angeles area. (Beroitz, Denny. 1993. Making pollution prevention profitable, Seminar at Pacific Northwest Pollution Prevention Research Center, June 9, 1993)

**Location relative to rail or truck transportation**

Trucks or trains are used in the shipment of raw materials and parts to industrial facilities and of products to market and by-products to treatment or disposal. In most areas and in most industries trucks play a major role. Trains are able to move the same amount of freight as trucks at a significantly lower burden in atmospheric emissions.

Sitting of the EIP with respect to key facilities elsewhere in the community can effect the number of truck miles driven within the city as well as the total truck miles. As with commuting distances, this impact of siting on truck traffic can influence the total atmospheric emissions related to the EIP. Where the industry mix in the EIP could utilize rail transport, location of the EIP on a rail line maximizes the potential reduction in emissions related to trucks.
**Loss or disruption of habitat**

Construction of an industrial facility on an undisturbed, green-field site results in the loss or disruption of natural habitat. Depending on the degree to which the region has been effected by previous development, this disruption can have greater or lesser impact on the natural vegetation and wildlife in the area. It is difficult to evaluate the importance of this type of loss in financial terms or even in terms of importance relative to other impacts. Where the disruption involves obstruction or blocking of access to water, food, or cover for larger animals, design of the landscaping of the park can mitigate the loss.

**Impact on neighbors**

**Proximity to residential housing**

Close proximity of industrial sites to residential areas is generally considered undesirable. This concern reflects the noise, unpleasant odors, risk, and general perception of unsightliness associated with many of the industrial operations of the "old economy". Many of the industries of the "new economy" tend to be quiet and have low emissions and low visual impact. Siting such a facility relatively close to residential housing, therefore can create no especial adverse effect. A buffer such as a landscaped greenbelt of adequate width to produce visual and audio separation of houses from the industrial facilities can render the site an innocuous neighbor. Clearly, such a location would make certain types of operations that are noisy, smelly, or create physical or environmental risks problematic for an EIP. Careful planning of truck and rail access as well as scheduling of truck and train operations would be required to ensure minimum disruption within the community.

An EIP sited in close proximity to the homes of employees working in the park creates opportunities to substantially reduce use of vehicles by commuting employees and thereby significantly reduce atmospheric emissions.

**Proximity to other industry**

The potential success of the EIP can be enhanced during the siting phase by identifying the potential to link the closed-loop recycling within the proposed EIP with the existing industrial base of the community. The first step in this process is to conduct a material input/output analysis of major industries in the area. This analysis involves determining the (1) location, (2) type, (3) amount, (4) quality (in terms of consistency with time and purity), and (5) distribution in time (steady, periodic, episodic, or irregular) of the major materials used. This material mix is then analyzed to identify potential opportunities for exchanges with the proposed EIP.

Because the potential for an exchange to occur decreases with increasing distance and transportation complexity, sites close to high potential sources or users of material would be favored over those at greater distance.

**Pre-existing industrial conditions**

Pre-existing industrial sites may be the optimum location for the EIP, either as an addition to an operating industrial site or as a redevelopment of an abandoned industrial site. Existing infrastructure can reduce the costs of developing a new site. Using land that is already industrialized prevents loss of farmland or natural areas.

Existing industrial sites create challenges for the potential EIP that, although difficult, may create real opportunity. Previously used industrial sites frequently contain areas of contaminated soil or groundwater. If the areas of contamination are not well understood, investigations to determine location and severity of such contamination can be protracted and expensive. Where such contamination exists, it may be
necessary to clean the site to comply with regulations and to render the site safe. Because of the potential liabilities, former industrial land is difficult to sell and the price is generally low.

Some jurisdictions are recognizing that not all contaminated sites represent sufficient hazard to health or the environment that they must be remediated. Before dismissing a former industrial site out of hand, it is worth taking the time to determine the likely nature and degree of potential contamination. With that information, it will be relatively simple to determine from regulatory authorities whether a prohibitively expensive remediation program would be required for the site.

Where expanding an existing industrial site or considering a site in close proximity to existing industrial activity, it is important to determine if there are existing air quality problems that could be amplified by either the load or character of emissions from the new park.

*Potential contamination of surface water and groundwater*

Industrial operations that handle liquids or chemicals always have the potential to produce contamination of surface water and groundwater. Siting restrictions, construction codes, and operating practices have sought to prevent the occurrence and severity of incidents of contamination. Location of the EIP with attention to surface water and groundwater systems can contribute substantially to preventing future contamination.

Engineered containment can minimize potential for contamination, but concrete does crack, pipes do break, and fluid loading of containment structures is exceeded. If the facility is sited so as to enable ready access of spilled fluids to groundwater reservoirs or to surface streams or lakes, contamination will occur. If the geology and hydrology of candidate sites is considered in site selection you will incur minimum expense to engineer the same level of containment and you will reduce the potential for contamination.

*Site Investigation and Analysis Methodology*

We propose a five-stage process for evaluation of potential sites.

1. Preliminary characterization of the physical and biological environment of the sites.

Rely on existing data sources on geology, soils, groundwater, surface water, climate, wildlife and vegetation as a basis for the preliminary characterization of the physical and biological environment of the sites. The government may have conducted scientific surveys and provide data at a nominal cost. Professors in the relevant disciplines at a local college or university can provide expert advice on accessing this type of information. If your team does not include professionals in the earth sciences or biology, it will be important to access professional assistance in synthesis of these data.

2. Identification of potentially significant differences among sites.

In the second stage of the siting analysis you will be interested in differences between or among the sites. You can save considerable time and money by not making a complete description of the site until later in the process. By using this approach, you will invest in the characterization of a smaller number of sites, thereby saving money. In communities with very limited topographic relief and minimal geologic variability, significant differences are likely to be much less than in communities with more variability.

Some communities are characterized by flat to very low relief topography, a limited variation in soils that represent repetition of a few basic types, and minor micro-climatic variability. In this type of community, the natural factors influencing siting are much less likely to produce significant differences among sites. In communities with higher relief and complex topography or geology, substantial natural differences can be expected among sites.
3. More thorough characterization of elements relating to significant differences.

In the third stage of the investigation, you may need to collect new, primary data to confirm or further define the substantive differences that appear to differentiate various sites. Any data collection during the site selection phase should focus on properties that differentiate the sites. Once a site is selected, you will probably want to do a more thorough characterization of the site to support the design process.


In the fourth stage you will map the various properties of interest on a common base and overlay the maps. The properties of the landscape combine to create particularly favorable or unfavorable conditions for siting the EIP at each location under consideration. Most soils, geological, and engineering environmental consulting firms use this type of technique as a standard tool for siting facilities such as landfills. Geographic Information System (GIS) methodology has been highly evolved to support this type of analysis. By its nature, GIS technology requires significant amounts of high quality data. Where there are adequate data to support application of a GIS, the analysis can be a powerful analytical and presentation tool to select a site and sell the site selection within the community.

5. Comparison of impacts of differences among sites on environmental performance.

The fifth stage involves comparison of the candidate sites using an explicit decision support process that provides a systematic way to evaluate the trade-offs among various sites. The previous table summarizes the impact of various siting characteristics on the environmental performance framework that we described in Chapter 10.

In addition to the environmental performance aspect of the siting decision, the AHP hierarchy should be set up to include economic, social and other factors relevant to the siting decision. Figure 10 - 1 is an example of the types of factors that might be included in the over all siting decision. An analysis at a level of detail similar to the environmental analysis is required to support the other elements of the siting decision. The importance of the environmental performance factors relative to the other factors in the decision will vary among communities and sites. You can establish the relative importance of each factor in your community using a technique such as the AHP paired-comparison, which is briefly outlined in this Appendix.
Example of a decision hierarchy for a typical EIP siting decision
Decision Support and the Analytic Hierarchy Process

In Chapter 10 we discussed an environmental performance framework and outlined a process for applying it to various aspects of an eco-industrial park. A critical aspect of this process is the decision process. It is important to use some formalized, explicit decision support process throughout the initiation, site selection, design, construction and operation of an EIP. A variety of stakeholders with different points of view, interests, and biases will be involved throughout the process.

A formalized, explicit decision support process enables the project team to understand and value the perspectives of its disparate members. Techniques of this type also assist individuals to identify and understand their own assumptions and biases, thereby making them more constructive contributors to the team effort. Such a process also provides an "audit trail" that enables others to understand and evaluate decisions at a later date.

Practitioners of decision analysis have developed a wide variety of such techniques. Most management-consulting firms have staff skilled in using one or more of these techniques. Decision analysis techniques generally provide a discipline to clearly differentiate the decision alternatives from the criteria by which the decision is made.

Most of us make most decisions on the basis of implicit assumptions and "emotional logic". The decision analysis techniques use various approaches to bring these assumptions to the surface, and to develop explicit statements of the criteria by which the decision is reached. All good decision analysis tools recognize the fundamental emotional, non-cognitive nature of decision making by incorporating a final "gut-level" check of the outcome of the analysis. If the result doesn't make sense or doesn't feel right, the practitioner is sent back to re-evaluate the inputs to the analysis.

We have found the Analytic Hierarchy Process to be a strong method for decision support. The AHP has a sound mathematical foundation, allows inclusion of monetary and non-monetary, as well as abstract "values" in the same analysis, and can be used effectively in group process. Expert Choice software supports teams in applying this method. The AHP is used by a wide variety of business and government organizations as their primary decision making tool.

Sources


Gamma Software offers demos of decision support software tools, including Expert Choice which is used to implement the Analytic Hierarchy Process. Expert Choice 2000 is a web-enabled decision support system based on the Analytic Hierarchy Process (AHP). Expert Choice assists decision-makers by organizing complex problem-related information into a hierarchical model consisting of a goal, possible scenarios, criteria, and alternatives. Expert Choice 2000 captures both quantitative and qualitative data for a complete audit trial of the decision process. Expert Choice 2000 generates comprehensive reports for tracking and justifying decisions. Sensitivity analysis can be performed, reports and sensitivity graphs can be printed, and the decision data can be exported to a spreadsheet file.

http://www.gamma.rug.nl/catalog/catalog4.htm
Environmental Performance

- Energy Usage
- Water Usage
- Material Usage
- Liquid Waste

Emissions

- Atmospheric Releases
- Solid Waste
- Habitat / Wildlife

Interactions

- Neighbors
- Physical Setting /
Brownfield Site-Assessment Process

Before the area is redeveloped, you will need to thoroughly inventory the current state of the property. This is normally done in the form of a “Phase I Site Assessment.” A similar process is currently used to evaluate closing military bases and serves as a good model for all brownfield sites. The following steps are important in your evaluation of the property:

**Historical Uses of the Property:** Determine all past owners by conducting a title search. Gather information on the use of the property for all owners, or tenants that operated facilities on the property. On many former industrial sites, the land is divided into a number of parcels, each with separate ownership, and each with its own history. Determine the operations for each user (including building systems such as heating) and what materials and wastes resulted.

Historical uses can be determined through interviews and document reviews. Aerial photographs will also be helpful. Determine how the waste was handled if possible. This method won't give you a complete picture, but will give you an idea of possible contamination concerns.

**Hazardous Materials:** Where were hazardous materials stored? Are there or were there underground or surface tanks or abandoned equipment that could have leaked materials? Is there any radioactive contamination (important on military bases)? Were pesticides used or stored?

**Extent of contamination:** If hazardous materials were used it is likely that some contamination has occurred, especially if hazardous materials were used before waste management laws were implemented in the mid-seventies. You will need to do sampling on the site to determine the extent of contamination.

**Existing Structures:** Is there asbestos piping or insulation in any of the buildings. Do the transformers on site contain PCBs? Is there lead paint?

**Remediation of Contamination**

In cases where the contamination poses a health or environmental hazard, there is no alternative to remediation of the site. In some cases, particularly in the early phases of the remediation, it will be impossible to develop the site until investigation is completed and the cleanup process is in place.

In other cases, the risk may be sufficiently low that there is no threat either to human health or to the environment. "No threat" means that construction and future land-use will not cause environmental releases or human exposure. Once immediate hazards are removed or contained activities can resume at the site. Many facilities have on-going remediation systems in place while industrial activities continue.

In some cases, relatively long-term, passive remediation technologies, generally involving bioremediation, can be implemented at relatively low cost.

The first step in utilizing these new technologies is a thorough, technically credible hazard evaluation and risk analysis. The second, and probably more difficult step is creating the regulatory, financial, and legal context for a project to move forward. In many jurisdictions, regulations are still in place that require expensive site remediation regardless of true environmental or health risk.

**Derelict Buildings/Facilities**

In many cases, the buildings and facilities from the prior industrial occupation have been removed or are in a state of such dilapidation that they must be razed.

In some older industrial areas, abandoned building sites occupy valuable land. The owner of these sites may have gone out of business leaving the site along with the associated contamination-related liabilities. Because of their location within the industrial area, these sites would have considerable value as locations...
for new companies that can be recruited to fill niches within the emerging industrial ecosystem. The unsightliness of the buildings in and of itself can often have a negative impact on the perceived desirability of the park to a prospective tenant.

When existing buildings can be used by new tenants this generally costs less than razing the old and building new structures.

Design for Environment

We introduced the industrial ecology method called design for environment in Chapter 8. The following is a specific DFE matrix two industrial ecology pioneers have developed to support facility design. Typically design teams develop more specific matrices for each of the interactions. Judgments from the lower level matrices then feed into the master matrix.

The Environmentally Responsible Facility Assessment Matrix

<table>
<thead>
<tr>
<th>Environmental Concern</th>
<th>Facility Activity</th>
<th>Ecological Impacts</th>
<th>Energy Use</th>
<th>Solid Residues</th>
<th>Liquid Residues</th>
<th>Gaseous Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site Selection and Development</td>
<td>1,1</td>
<td>1,2</td>
<td>1,3</td>
<td>1,4</td>
<td>1,5</td>
</tr>
<tr>
<td></td>
<td>Infrastructure Interactions</td>
<td>2,1</td>
<td>2,2</td>
<td>2,3</td>
<td>2,4</td>
<td>2,5</td>
</tr>
<tr>
<td></td>
<td>Principal Business Activity - Products</td>
<td>3,1</td>
<td>3,2</td>
<td>3,3</td>
<td>3,4</td>
<td>3,5</td>
</tr>
<tr>
<td></td>
<td>Principal Business Activity - Processes</td>
<td>4,1</td>
<td>4,2</td>
<td>4,3</td>
<td>4,4</td>
<td>4,5</td>
</tr>
<tr>
<td></td>
<td>Facility Operations</td>
<td>5,1</td>
<td>5,2</td>
<td>5,3</td>
<td>5,4</td>
<td>5,5</td>
</tr>
<tr>
<td></td>
<td>Facility Refurbishment/ Closure/transfer</td>
<td>6,1</td>
<td>6,2</td>
<td>6,3</td>
<td>6,4</td>
<td>6,5</td>
</tr>
</tbody>
</table>

The number in each cell corresponds to the relevant question set for that cell, as laid out below.

_EIP design teams will need to create checklists specific to each site and facility, guided by the performance objectives and goals they have developed earlier._

Eco-Industrial Park Handbook

Appendix 2 Supplementary Content

DFE Checklists, coded to the matrix above

Matrix Element 1.1
Facility Activity: Site Selection and Development
Environmental Concern: Ecological Impacts
- Has the proposed site previously been used for similar activities? If not, have any such sites been surveyed for availability?
- Is necessary development activity, if any, planned to avoid disruption of existing biological communities?
- Is the biota of the site compatible with all planned process emission, including possible exceedances?
- Does the siting decision impose disproportionate environmental burdens on minority, poor, or politically less powerful elements of society?

Matrix Element 1.2
Facility Activity: Site Selection and Development
Environmental Concern: Energy Use
- Is the site such that it can be made operational with only minimal energy expenditures?
- Has the site been selected so as to avoid any energy emission impacts on existing biota?
- Does the site allow delivery and installation of construction or renovation materials with minimal use of energy?

Matrix Element 1.3
Facility Activity: Site Selection and Development
Environmental Concern: Solid Residues
- Is the site such that it can be made operational with only minimal production of solid residues?
- Have plans been made to ensure that any solid residues generated in the process of developing the side are managed so as to minimize their impacts on biota and human health?
- If any solid residues generated in the process of developing the site may be hazardous or toxic to biota or humans, have plans been made to minimize releases and exposures?

Matrix Element 1.4
Facility Activity: Site Selection and Development
Environmental Concern: Liquid Residues
- Is the site such that it can be made operational with only minimal production of liquid residues?
- Have plans been made to ensure that any liquid residues generated in the process of developing the side are managed so as to minimize their impacts on biota and human health?
- If any liquid residues generated in the process of developing the site may be hazardous or toxic to biota or humans, have plans been made to minimize releases and exposures?

Matrix Element 1.5
Facility Activity: Site Selection and Development
Environmental Concern: Gaseous Residues
- Is the site such that it can be made operational with only minimal production of gaseous residues?
- Have plans been made to ensure that any gaseous residues generated in the process of developing the site are managed so as to minimize their impacts on biota and human health?
- If any gaseous residues generated in the process of developing the site may be hazardous or toxic to biota or humans, have plans been made to minimize releases and exposures?

Matrix Element 2.1
Facility Activity: Infrastructure Interaction
Environmental Concern: Ecological Impacts

- Has site been chosen to minimize the need for new on-site infrastructure (buildings, roads, etc.)?
- If new infrastructure must be created, are plans in place to minimize any resultant impacts on biota?
- Have provisions been made for orderly growth of infrastructure as facility operations expand in order to avoid unnecessary health or environmental impacts?

Matrix Element 2,2
Facility Activity: Infrastructure Interactions
Environmental Concern: Energy Use

- Does the existing energy infrastructure (gas pipelines, electric power cables) reduce or eliminate the need to build new systems?
- Is it possible to use heat residues from within the plant or from nearby facilities owned by others to provide heat or power?
- Is it possible to use gaseous residues from within the plant or from nearby facilities owned by others to provide heat or power?

Matrix Element 2,3
Facility Activity: Infrastructure Interactions
Environmental Concern: Solid Residues

- Is it possible to use as feedstocks solid residues from nearby facilities owned by others?
- Is it possible to use solid residues from the proposed facility as feedstocks for nearby facilities owned by others?
- Can solid residue transport and disposal operations be shared with nearby facilities owned by others?

Matrix Element 2,4
Facility Activity: Infrastructure Interactions
Environmental Concern: Liquid Residues

- Is it possible to use as feedstocks liquid residues from nearby facilities owned by others?
- Is it possible to use liquid residues from the proposed facility as feedstocks for nearby facilities owned by others?
- Can liquid residue transport and disposal operations be shared with nearby facilities owned by others?

Matrix Element 2,5
Facility Activity: Infrastructure Interactions
Environmental Concern: Gaseous Residues

- Is it possible to use gaseous residues from the proposed facility to provide heat or power for nearby facilities owned by others?
- Is it possible to share employee transportation infrastructure with nearby facilities owned by others to minimize air pollution by private vehicles?

Matrix Element 3,1
Facility Activity: Principal Business Activity: Products
Environmental Concern: Ecological Impacts
- If the activity at this site involves extraction of virgin materials, is the extraction planned so as to minimize ecological impacts?
- Do all outputs from the site have high ratings as environmentally responsible products?
- Are products designed to use recycled materials?

Matrix Element 3.2
Facility Activity: Principal Business Activity - Products
Environmental Concern: Energy Use
- Are products designed to require minimal consumption of energy in manufacture?
- Are products designed to require minimal consumption of energy in use?
- Are products designed to require minimal consumption of energy in recycling or disposal?

Matrix Element 3.3
Facility Activity: Principal Business Activity - Products
Environmental Concern: Solid Residues
- Are products designed to generate minimal and nontoxic solid residues in manufacture?
- Are products designed to generate minimal and nontoxic residues in use?
- Are products designed to generate minimal and nontoxic solid residues in recycling or disposal?

Matrix Element 3.4
Facility Activity: Principal Business Activity - Products
Environmental Concern: Liquid Residues
- Are products designed to generate minimal and nontoxic liquid residues in manufacture?
- Are products designed to generate minimal and nontoxic liquid residues in use?
- Are products designed to generate minimal and nontoxic liquid residues in recycling or disposal?

Matrix Element 3.5
Facility Activity: Principal Business Activity - Products
Environmental Concern: Gaseous Residues
- Are products designed to generate minimal and nontoxic gaseous residues in manufacture?
- Are products designed to generate minimal and non-toxic gaseous residues in use?
- Are products designed to generate minimal and nontoxic gaseous residues in recycling or disposal?

Matrix Element 4.1
Facility Activity: Principal Business Activity - Processes
Environmental Concern: Ecological Impacts
- Have all process materials been optimized from a Design for Environment standpoint?
- Have processes been dematerialized (evaluated to ensure that they have minimum resource requirements and that no unnecessary process steps are required?)
- Do processes generate waste heat or emission of residues that have the potential to harm local or regional biological communities?

Matrix Element 4.2
Facility Activity: Principal Business Activity - Processes
Environmental Concern: Energy Use
- Have all process materials been evaluated to ensure that they use as little energy as possible?
- Are processes monitored and maintained on a regular basis to ensure that they retain their energy efficiency as designed?
- Do process equipment specifications and standards require the use of energy efficient components and subassemblies?

**Matrix Element 4.3**
Facility Activity: Principal Business Activity - Processes
Environmental Concern: Solid Residues
- Are processes designed to generate minimal and nontoxic solid residues?
- Where solid materials are used as process inputs, have attempts been made to use recycled material?
- Are processes designed to produce usable byproducts, rather than byproducts suitable only for disposal?

**Matrix Element 4.4**
Facility Activity: Principal Business Activity - Processes
Environmental Concern: Liquid Residues
- Are processes designed to generate minimal and nontoxic liquid residues?
- Where liquid materials are used as process inputs, have attempts been made to use recycled materials?
- Are pumps, valves and pipes inspected regularly to minimize leaks?

**Matrix Element 4.5**
Facility Activity: Principal business Activity - Processes
Environmental Concern: Gaseous Residues
- Are processes designed to generate minimal and nontoxic gaseous residues?
- Are processes designed to avoid the production and release of odorants?
- If VOCs are utilized in any processes, are they selected so that any releases will have minimal photochemical smog impact?

**Matrix Element 5.1**
Facility Activity: Facility Operations
Environmental Concern: Ecological Impacts
- Is the maximum possible portion of the facility allowed to remain in its natural state?
- Is the use of pesticides and herbicides on the property minimized?
- Is noise pollution from the site minimized?
Matrix Element 5,2
Facility Activity: Facility Operations
Environmental Concern: Energy Use
- Is the energy needed for heating and cooling the buildings minimized?
- Is the energy needed for lighting the buildings minimized?
- Is energy efficiency a consideration when buying or leasing facility equipment: copiers, computers, fan motors, etc.?

Matrix Element 5,3
Facility Activity: Facility Operations
Environmental Concern: Solid Residues
- Is the facility designed to minimize the comingling of solid waste streams?
- Are solid residues reused or recycled to the extent possible?
- Are unusable solid residues from (including food service) disposed of in an environmentally responsible manner?

Matrix Element 5,4
Facility Activity: Facility Operations
Environmental Concern: Liquid Residues
- Is the facility designed to minimize the comingling of liquid waste streams?
- Are liquid treatment plants monitored to ensure that they operate at peak efficiency?
- Are unusable liquid residues disposed of in an environmentally responsible manner?

Matrix Element 5,5
Facility Activity: Facility Operations
Environmental Concern: Gaseous Residues
- Is operations-related transportation to and from the facility minimized?
- Are furnaces, incinerators, and other combustion processes and their related air pollution control devices monitored to ensure operation at peak efficiency?
- Is employee commuting minimized by job sharing, telecommuting and similar programs?

Matrix Element 6,1
Facility Activity: Facility Refurbishment, Closure or Transfer
Environmental Concern: Ecological Impacts
- Will activities necessary to refurbish, close, or transfer the facility to alternate uses cause any ecological impacts, and if so, has planning been done to minimize such impacts?
- When refurbishment, closure or transfer activities are undertaken, can the materials required be supplied, and the materials surplus be recycled, with a minimum of ecological impact?
- Has a “facility life extension” review been undertaken to optimize the life and service of the existing facility, therefore minimizing the need to construct new “greenfield” facilities with their attendant environment impacts?
Matrix Element 6.2
Facility Activity: Facility Refurbishment, Closure or Transfer
Environmental Concern: Energy Use

- Can the facility be closed or transferred with a minimum expenditure of energy (including any necessary site clean-up and decontamination)?
- Can the facility be modernized, and converted to other uses easily?
- When the facility is refurbished, closed or transferred, has it been designed, and are plans in place, to recapture as much of the energy embedded in it as possible?

Matrix 6.3
Facility Activity: Facility Refurbishment, Closure or Transfer
Environmental Concern: Solid Residues

- Can the facility be refurbished, closed or transferred with a minimum generation of solid residues, including those generated by any necessary site clean-up and decontamination?
- At closure, can the materials in the facility, including all structural material and capital stock remaining at closure, be reused or recycled with a minimal generation of solid residues?
- Have plans been made to minimize the toxicity of, and exposures to, any solid residues resulting from clean-up and decontamination of the facility and its environs upon refurbishment, transfer or closure of the facility?

Matrix 6.4
Facility Activity: Facility Refurbishment, Closure or Transfer
Environmental Concern: Liquid Residues

- Can the facility be refurbished, closed or transferred with a minimum generation of liquid residues, including those generated by any necessary site clean-up and decontamination?
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Environmental Concern: Gaseous Residues

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- Have plans been made to minimize the toxicity of, and exposures to, any gaseous residues resulting from clean-up and decontamination of the facility and its environs upon refurbishment, transfer or closure of the facility?

This new application of Design for Environment is still evolving. Perhaps your EIP design team could improve your decision processes while participating in the creation of valuable new tools. Similar matrices and question sets could be developed for EIP site design and physical infrastructure or even non-tangible components like forming of Covenants, Conditions, and Restrictions for the property.

High Performance, Socio-Technical Systems, and Viable Systems

*In Chapter 10 we suggested that Socio-Technical Systems (STS) methods could be very valuable to plant design teams. In Chapter 10 we outlined EIP management functions in terms of the Viable System Model*
Eco-Industrial Park Handbook

Appendix 2 Supplementary Content

(VSM). The following overview of the two methods discusses the strong synergy between them in creating high performance total quality organizations.

Major corporations in North America and Europe have applied STS methods to engage line employees in the design of manufacturing operations. Applications include the design of new industrial facilities (greenfield plants), where design of the total work process is tightly integrated with design of the physical plant. The result is a high performance system, optimizing both social and technical design. STS design methods easily incorporate environmental performance objectives and goals into standard practice.

Integrating the two methods in the design and management of EIPs could contribute strongly to a project’s economic and environmental performance.

VSM x STS = Structure for Total Quality Management


Introduction

This paper offers preliminary insights into the synergy between The Viable System Model and Socio-Technical Systems in support of Total Quality Management. It is based on working together with the partners of STS Associates (Carolyn Ordowich, Audrey Bean and Andre Montclair) in a week-long seminar on change management and a joint presentation in the first ICOD/Goal-QPC TQM conference.

In Japan Total Quality Management operates through a systemic view of the organization, closely linked internally and with its customers and suppliers. In North America TQM often operates as a grab bag of tools applied piecemeal in a traditional fragmented management structure. In some companies it competes with other change initiatives as one more special function. The quality effort may be poorly integrated with the strategic planning process. The challenge in such companies is to align TQM with a systemic view grounded in our own culture.

Together, Socio-Technical Systems (STS) and the Viable System Model (VSM) offer American companies a chance to match and possibly surpass Japanese management’s holistic approach to TQM.

- Both look at organizations as living whole systems of closely related sub-systems.
- They strongly emphasize building autonomy and self-management into operations, placing decision-making close to the action.
- Both create close ties to the environment of the organization.
- Both emphasize design of strong feedback loops to insure that each level of the system remains self-regulating.

The two technologies, in team, offer a deep foundation for managing TQM as a transformation of the whole organization.

Socio-Technical Systems contribution to total quality

STS focuses most strongly on detailed design of the value producing operating units of the organization—the stream of work creating goods and services for the business environment.

This technology includes powerful methods for design of inter-related social and technical systems of production that insure both high product quality and quality of work life.

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3 A few of these companies include Hoescht-Cellanese, Volkswagen Canada, Esso Canada, and Proctor and Gamble.
STS variance control sets a systemic context for applying classic TQM tools in the realm of daily process control.

The environmental scan is a potent STS tool that supports the VSM development function. A scan is executed by a team drawn from a diagonal slice of the organization to survey the company as a whole in its business environment. The scan helps use the voice of the customer to guide the work design process.

**Variance control and self-management**

A strong feature of STS work design, central to total quality, is the identification and control of variances. A variance is a deviation from standard that has an impact on the quality of final output. Variances need to be controlled as close to their sources as possible. A work group responsible for its own testing, for example, assures that its outputs to the next stage meet quality requirements. As workers at each stage receive quality goods, any variances will be ones they can address in their own process.

A work process designed to control variances at the source implies consideration of the boundaries between the stages of the process. STS enables workers to create meaningful boundaries so that responsibilities do not overlap, all relevant information is close to hand, and changes and coordination can take place within the work team. Such work design requires substantially less managerial oversight.

Self-managing operating units responsible for any given output need similar responsibility for the way they use resources and the flow and timing of needed materials. STS design aims for this level of work authority in the production team.

**STS principles of organization design provide a powerful basis for total quality.**

For instance, the principle of compatibility demands that people in an organization ‘walk the talk’. If a philosophy of continuous improvement and participation is to be introduced on the shop floor, this must be done with real worker participation, not by command.

The principle of Minimal Critical Specification calls for management to specify output goals and get out of the way. Give the people who do the work ample room to design the means of achieving the goals.

Another principle, Bridging the Transition, acknowledges stresses and dislocations likely in any change process. When going through work re-design, teams must have some respite from tight production quotas and other usual demands. (The VSM supports these and all other STS principles.)

The worker involvement in all work design processes enabled by STS results in a powerful commitment to total quality on the shop floor. The design of jobs itself is done with quality in mind. Units are designed to be multi-functional, to make work more challenging, and to allow workers to develop a larger skill base. Quality products are a natural output from workers whose roles and responsibilities have been defined with as much consideration as is given to technical factors such as plant layout and machine integration.

**The Viable System Model contribution to total quality**

The VSM complements STS by designing management roles, responsibilities and processes so they naturally support self-managing work teams. (It’s distinctions also inform the structuring of self-managing work teams themselves.)

This technology provides explicit work design at middle and upper levels of organizations—a process that creates a dynamic infrastructure for integrating all other streams of change with the total quality effort. It enables the organization to evaluate and select proposed quality and change initiatives in terms of corporate identity and culture. Such a change management organization consciously balances change with the stability needed to maintain viability in day-to-day operations. The VSM also offers powerful techniques for designing robust communication channels internally and between the organization and its environment.
The Viable System Model identifies five basic functions existing in any successful organization. These distinctions support change management and total quality in the following ways:

**Operating units (System 1)** create value for the environment, producing the goods and services that it delivers to customers. This is the level of organization where daily process control tools of TQM are applied. It is also the prime focus for STS design of the core process, self-managing work teams, and variance control. Each self-contained operating unit is itself organized in terms of these five basic VSM functions.

*(We describe this as “Operate the Production Units” in Chapter 10.)*

**The coordinating function (System 2)** supports operating units by smoothing their demands on common resources, and communicating and monitoring standards that apply across all units. Many basic administrative functions are found here. Once quality breakthroughs are achieved, this function insures their conversion into operating standards.

*(This is “Coordinate Administrative and Support Functions” in Chapter 10.)*

**The synergy function (System 3)** supports day to day operations with the aim of multiplying their combined output through creative allocation of common resources. This function plays a central, stabilizing role in the Change Management Organization. When managers are wearing this hat, they must assess the feasibility of proposed quality or change initiatives, with input from their operating units. This is the VSM system that provides the cross-functional management called for in TQM. The focus here on the viability of present operations provides an essential counter-balance to the drive for change emerging from the development function.

*(We title this “Manage the Present Operations of the EIP” in Chapter 10.)*

**The audit function (System 3*)** conducts sporadic inquiries into operations to investigate either negative or positive variances. Why is one operating unit surpassing quality targets? Is worker morale being undermined by too many change initiatives? Management, worker teams, or external consultants may carry out such audits.

*(This is “Audit EIP Operations” in Chapter 10.)*

**The development or change function (System 4)** creates the future of the organization, scanning for trends and surprises in its total business environment. When performing this function managers are evaluating both the changes imposed by the environment (new regulations, shifts in competitive situation) and the methods of change that will enable the company to continue adapting and evolving (TQM, STS, new manufacturing technologies, just in time supply, concurrent engineering). A basic, often neglected, need here is to coordinate all change initiatives to build a coherent, synergistic change effort. Total Quality is the strongest focus for organization wide change and it should inform strategic planning, human resource development, and the basic design of organizational structure.

*In Chapter 10, we describe the task as, “Assure the Future Viability of the EIP”.)*

People in the development and synergy functions, Systems 3 and 4, must maintain an intense dialogue to keep balance between the short-term and long-term interests of the organization as a whole.

**The coherence function (System 5)** sustains and evolves the identity and culture of the company. Ideally people fulfilling this responsibility reflect all stakeholders in the organization. Change initiatives proposed by the development function are evaluated here against the basic identity of the organization as a whole. Does a particular approach to total quality match our principles and values? Does our reward system support our personnel in making the changes demanded? And, most important, are we maintaining a viable balance between change and stability as we transform. System 5 intervenes, when needed, in the dialogue between the future and present functions to bring closure.
(We title this function "Maintain the Community of Companies" in Chapter 10.)

Six distinct internal communication channels connect these functions. Operations and the Development Function have direct channels to the relevant business environments. Communications may also flow from one part of the organization, through the environment, to another part.

Each operating unit is itself a viable system, with the full set of functions and channels active within it. This nesting of the full model within System 1 operations (called recursion) provides a coherent picture of an organization across levels. The explicit design of communication channels supports rapid movement of information concerning the quality effort throughout the company: as in the TQM catchball process. A company's balance and clarity in performing these functions is fundamental to total quality management.

Conclusion

Applied separately, Socio-Technical Systems and the Viable System Model offer powerful support to achieving total quality in an organization. The combination of the two methods offers a unique synergy. Together they fill major gaps in present TQM practice:

- Strengthening horizontal and vertical management;
- Clarifying channels of communication within a company and with its environment;
- Creating high performance work design for self-managing workers and management alike.

This synergy can make a notable contribution to focusing a whole company (and its various change initiatives) around a core identity of full commitment to total quality.

Sources


Plant Surveys

A very comprehensive survey form can be downloaded from the web site for Triangle Joint Council of Governments (TJCOG) a by-product exchange project in North Carolina, US. This also offers extensive documentation on mapping of existing exchange patterns, and an extensive project report. The Triangle Joint Council of Governments in surveyed material by-products available in a six county area of North Carolina and built a geographic information system with the resulting data. [www.tjcog.dst.nc.us](http://www.tjcog.dst.nc.us)

Plant Survey Form Used in 1995 Brownsville Case Study

Our project team used this form in initial screening of plants for the Brownsville case study that focused on by-product exchange. It may suggest useful questions to begin exploring the potential for creating a network of by-product exchanges. A next step would require a more detailed level of inquiry, including questions about energy efficiency, pollution prevention, and management of environmental performance.

Introduction

The residents of Brownsville, Texas and Matamoros, Mexico are currently engaged in an important experiment in the application of a new strategy for organizing business relationships. This new strategy, based on the principles of industrial ecology, can be profitable for the businesses involved because it develops markets for byproducts. By turning a waste into a source of revenue, the application of industrial ecology can improve the environmental performance of businesses while also improving their bottom line. Similarly, by taking advantage of the opportunity to add value to the manufacturing in the Brownsville/Matamoros area, the application of industrial ecology can stimulate entrepreneurial business development. These new businesses would serve as brokers and technical linkages, enabling the existing business to take full advantage of the potential benefits of industrial ecology.

There are three major types of inputs and outputs that must be analyzed to determine what applications of industrial ecology might be viable in a specific instance: water, energy, and other materials. Companies may be able to use wastewater from other companies when the requirements for purity and temperature “match up” between the potential supplier and the potential user. Similarly, energy cascading might be possible when waste heat from one company is created at a temperature similar to what is needed by a proximate company. Materials exchange is often possible when the byproducts of one company are of sufficient quantity and quality to be substituted for a virgin material currently being used by another company. These three waste streams in any company - water, energy, and materials - could represent potential profit that is not being exploited. The accompanying document provides concrete examples of how some companies in Kalundborg, Denmark are applying “industrial symbiosis” to take advantage of that profit potential.

The purpose of this interview is to conduct a preliminary assessment of the potential for incorporating your firm in a prototype application of industrial ecology in the Brownsville/Matamoros area. Your cooperation will help us to determine how your plant’s production process might benefit through cooperation with other companies in the area. Once we determine, through analysis of preliminary information on a number of plants, that your plant might fit in such a plan, we will, with your permission, work with one of your plant engineers or plant managers to work out the technical details.
Preliminary Information

1. What products are produced at this plant, in approximate order of value?

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<tr>
<th>Rank</th>
<th>Product Description</th>
<th>SIC Code (if known)</th>
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2. What are the top 10 materials (by value) used by your company in producing these products? Note: Be as descriptive as possible. Note any technical requirements (i.e. water temperature or purity, form of material, etc.) offered by the interviewee.

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3. Is your production process particularly water-intensive or energy intensive?

4. What is your source of water?

5. What is your source of energy?

6. What byproducts are produced as a result of the manufacturing process?
   
   Note: include byproducts that are disposed of as solid waste, are emitted into the air or water, or are recycled, either on premises or off-premises. If offered, pay special attention to describing the form the byproduct is in, i.e. purity of wastewater, form of solid waste.

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7. How important is controlling the cost of environmental management and compliance to the competitiveness of your product?  
(Note: These costs include: tipping fees for solid wastes; air, water, underground storage tank permits; hazardous waste transportation and storage permits, etc. and the time to do paperwork)

Below are some suggested choices to give the interviewees:

Very important - Cost containment in this area is essential to our competitiveness
Important - We aggressively seek ways to control these cost
Not particularly important - We would like to control these costs, but other components of cost have a much higher priority
Not important at all - Our environmental costs are so small we give them little consideration

8. Would you be interested in participating in a project that might help you find ways to purchase inputs more cheaply, generate revenues from your byproducts, or reduce your environmental management and compliance costs?

9. If so, is there an engineer or plant manager who would be helpful in working out the more technical aspects of such an arrangement, including estimation of cost implications?

Additional data to gather:

In designing a plant survey for your project you may find it useful to also include questions about energy wastes that could be re-used in the plant or by neighboring facilities, energy needs that might be met by outputs from other firms, and other opportunities for increasing the efficiency of energy use. Has there been an energy audit of the facility?

Other useful questions include: To what extent are employees aware of and practicing pollution prevention measures? How are environmental and energy issues integrated into the plant's management structure?

A Sampling of By-Product Exchanges

We offer several lists of industrial by-product trades developed by businesses, both spontaneously and as the result of an organized effort. It is useful to browse such lists to find viable reuse and recycling opportunities for industrial by-products.

Examples of by-product utilization from the Philippines

PRIME Project staff created this listing in 1999, based upon the materials exchange developed by the a Philippine business and environment NGO.

Supreme Baby Wear Inc. (SBWI)

SBWI is a 100 percent clothing exporter whose main market is the US. Its product lines include children and infant's wear, ladies' dresses, men's cotton trousers, jackets and shorts. The company has received one of the highest factory evaluation ratings from J.C. Penney, its number one customer.

SBWI generates 300 kg of scrap textiles a day. SBWI gives the scrap textiles for free as a source of livelihood for the relocated squatters of the resettlement program of the Pasig River Rehabilitation Program (PRRP). A major component of the PRRP is the relocation of the squatter communities living along the riverbanks. By giving the PRRP resettlement program their scrap textiles, SBWI has not only found an alternative to the landfilling of their waste but is also helping the families rebuild their lives. SBWI now saves P3,000 a month it used to dish out for getting the scrap hauling to a landfill. PRRP has ceased shelling out P24,000 a month for buying 3,000 kilos of scrap textiles priced at P8 per kilo.

Republic Asahi Glass Corp. (RGAC) and Antiques As Accents (AAA)

Republic Asahi Glass Corp, a joint venture of Republic Glass Corp. and Asahi Glass Corp., is a manufacturer of flat glass in the Philippines. RAGC uses raw materials such as silica sand, soda ash, salt cake, dolomite, limestone, and feldspar. To minimize costs, RAGC also uses glass cullets in its production processes. Glass cullets are scrap glass generated mainly by manufacturers of incandescent and fluorescent lamps. RGAC requires 300 tons of glass cullets per month.

Antiques As Accessories or AAA, on the other hand, manufactures and exports mirrors and other glass products. The company generates waste glass sheets during production at a rate of 2-3 jeeploads per week. Initially, the total quantity of glass sheets supplied by AAA to RAGC is five jeeploads. Every week, sometimes twice a week, AAA collects and hauls what they once considered as wastes. The total volume collected has already reached three tons.

Another firm, the Philippine Electrical Manufacturing Company (PEMCO), provides RAGC's glass cullet requirements of 300 tons per month.

Texas Instruments Phils., Inc. and Bacnotan Cement

Texas Instruments Philippines, Inc. operating at the Philippine Export Zone Authority in Baguio City, is a manufacturer of integrated circuits. It generates a significant amount of mold runner wastes, including thermoplastic materials. These have a heating value of up to 1,500 kcal/kg and contain 60% ash by weight.

On the average, Texas Instruments produces around 20 tons of mold runners per month. These mold runners usually end up in a landfill inside the company's compound. Realizing the limited space the company has, Texas Instruments expressed its need to dispose the mold runners. Bacnotan Cement Corp. responded to the call.

Mold runner waste possesses certain characteristics that make it a good cement additive. Mold runner has high heating value, grindability, ignition temperature, ash content, and density.
A group of researchers from Texas Instruments and Bacnotan Cement has made a study to find out the exact ratio of the mold runners that will be introduced to the system such that the resulting cement will not be of inferior quality. The finding was that if they introduced the mold runners at a rate of only 1% by weight, the quality of the resulting cement will not be affected at all.

**Pacific Glass Products Manufacturing Corp. and Arms Corp. of the Philippines (Armscor)**

Formerly known as Pacific Enamel and Glass Manufacturing Corporation, Pacific Glass is primarily involved in manufacturing glass bottles. Its glass-melting furnace has a production capacity of 90 MT/day.

Armscor on the other hand, formerly under the Squires Bingham Manufacturing Co., is a maker of quality firearms and ammunition. Armscor generates a lot of sawdust in the manufacturing gun stocks. Pacific Glass, meanwhile, regularly uses large quantities of sawdust in cleaning up oil spillage in its bottle-forming section and fuel oil delivery area.

Armscor used to solve the problem of disposing sawdust by paying haulers to dump the waste to landfills. The previous problem of Pacific Glass was where to get enough supply of sawdust on a regular basis. It used to buy sawdust at P4-P5 from a supplier. Now, they're getting it for free. It collects the waste from Armscor's plant in Marikina, collecting a total of 200 sacks.

**Sterling Products International Inc.**

Sterling Products International Inc. is a manufacturer of pharmaceutical and consumer products. The company shows its commitment to environmental protection in several ways. Sterling has succeeded in recovering waste heat generated by its 40-hp air conditioning system. This heat is used to supply the hot water needed by the company's canteen and boiler stations.

As part of its solid waste, used steel drums are donated to the Clean and Green Foundation which uses the drums as garbage cans. About 300 pieces of used steel drums are generated every month. These drums come from deliveries of glucose, a raw material used by the company in making its products. Since glucose is a non-toxic and non-hazardous substance, the drums used to store it are not corroded and not contaminated in any way by any harmful chemical.

These waste steel drums have also found a market in Hoechst Philippines, Inc. A multinational company, Hoechst manufactures pesticides, pharmaceutical products, surfactants and textile auxiliaries. On the average, Hoechst needs 200-500 steel drums per month. To meet this requirement, the company gathers the used steel drums from its other plants or buys from outside sources. The supply was often not enough. Hence, the acquisition from Sterling Philippines.

**Sinclair Philippines and O.M. Manufacturing Phils. Inc.**

Sinclair Philippines produces heat-resistant paints for smokestacks and boilers, mildew-resistant paints for the handicraft industry, and coatings for the transportation industry. From its operations, Sinclair is able to collect around 50 pieces of used drums a month. These drums come from deliveries, which originally contained solvents, mineral oils, and other raw materials, take up precious space in the company's manufacturing plant.

O.M. Manufacturing is a registered recycler of solder waste, a material classified as toxic and hazardous under RA 6969. The company, which recovers tin and lead from solder waste, needs used drums as storage containers in its recycling process. It has acquired a total of 75 used drums from Sinclair.

**Rhone-Poulenc Agro and San Miguel Packaging Products**

Rhone Poulenc Agro Philippines, Inc. is a manufacturer and distributor of agricultural pesticides. The company decontaminates, collects, and segregates all broken glasses it has accumulated in the past two years. Collecting and recycling glass can help extend the life of landfills, reduce energy consumption by 25 percent, reduce air pollution by 20 percent, reduce mining wastes by as much as 80 percent, and save water use by 50 percent.
For its part, Rhone Poulenc is able to collect a total of 2,008 kg of amber glass cullets, all of which are sold to the Manila Glass Plant of San Miguel Packaging Products (SMPP). The Manila Glass Plant uses glass cullets in manufacturing various glass bottles and containers. To broaden its cullets collection campaign and to maximize the use of its recycling technology, the company has already accredited a number of consolidators, whose job is to do the preliminary cleaning of the cullets before these are delivered to the plant.

Examples from Florida Power and Light

Scrap Wood as Fuel for Sugar Mills
Scrap Porcelain and Concrete as Road Fill
Conversion of scrap wire insulation to fuel for the solid waste authority through burning;
Conversion of used stretch wrap to a resource for a plastic lumber product made by Mobil Chemical;
Return of wire reels to manufacturers for reuse;
Refurbishment and reuse of hardware and equipment in lieu of scrapping;
Testing and resale to Third World countries of old street lights and sodium bulbs that still have additional life but no longer meet U.S. specifications, thereby avoiding expensive and unnecessary disposal;
Cleaning, granulizing, and sale of scrap PVC, polyethylene, and polycarbonate for reuse;
Consolidation and use of unwanted paint, solvents, and degreasers;
Harvesting and sale of aluminum and copper wiring from surplus transformers; and
Donation of usable wood poles to local farmers for fencing.

1995 Distribution/Power Delivery Recycling Totals

Source: This list is from the By-Product Synergy Primer (1997) produced by the Business Council for Sustainable Development-Gulf of Mexico entitled “By-Product Synergy: A Strategy for Sustainable Development”. The case study has been adapted for this site by Ron Duerksen IISD, 1998 with permission from the Business Council for Sustainable Development-Gulf of Mexico. [http://iisd.ca/business/synergy.htm](http://iisd.ca/business/synergy.htm)

Examples of by-product utilization from the early 90s.

The following are examples of waste exchanges grouped by industry type or waste exchanged.1 Scanning through these varied firm-to-firm flows of by-products may be useful to your team in identifying EIP recruitment candidates, once you know some of the materials needed by or available from companies in your park or region.

Paper Mills and Cement Companies

Champion International, a paper mill located in Hamilton, Ohio, sells 100% of its sludge (120 tons wet or 60 tons dry) as well as 50 tons of boiler ash per day, to Portland cement companies. Costs are $30-$35 per ton which is comparable to the cost of dumping it in a landfill. ([Pollution Prevention Review, Vol2, No. 4, Autumn 1992, p.453.](http://iisd.ca/business/synergy.htm))

Chemical, Pharmaceuticals and Coatings Industries


Chemical Company and Fertilizer Company

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1 This list was compiled by Nicholas Gertler, Graduate Student at MIT, from recent publications and waste exchange networks.
Huntsman Chemical Co. sells some of its wastes to Harmony Products, Inc. Harmony is a producer of organic fertilizer (In Business, March/April 1993, p31)

**Lumber**

Natural Products Corp. of Shippensburg, PA gets 75% of its raw materials through waste exchanges. Natural Products obtains, free of charge, scrap lumber from Quaker Maid (Leesport, PA) and produces products such as potpourri and bird houses. The cost for Quaker are $350 less per load than dumping would be. (Biocycle, Nov. 1990, P. 58-59 and Wall Street Journal, August 2, 1991, p.A5)

A TV antenna manufacturer in Danville, IA previously disposed of 1,000 2X4's each month until they found that they could send them to Design Engineering Management Co. who uses them to make shipping crates. (By-product and Waste Search Service (IA), 1994-5).

A pallet rebuilder and a nail gun maker have a mutually beneficial agreement. The nail gun maker gets scraps of wood for free from the pallet maker. It tests its nail guns on the scraps rather than on new wood, and then gives the scraps back to the pallet maker who burns the wood, and sells the nails as scrap metal (Garbage May/June 1991)

**Sewage Sludge**

Contra Costa Water District (Concord, CA) sends dried sludge to Port Costa Materials where it will be used in lightweight concrete bricks. About 700 tons of sludge will be exchanged annually. (Biocycle, March 1991, p. 15)

**Chemical and Petrochemical Industry**

DuPont will use polyester waste to replace p-xylene for use in making dimethylteraphthalate (DMT). It is expected to cost $12 million to convert the production unit at Cape Fear, NC. The facility is expected to open in 1995, and will produce 100 million lbs/yr. of DMT and 30 million lbs/yr. of ethyl glycol. This will supply 10% of Dupont’s polyester intermediates needs. (Chem Week, April 6, 1994 and Chemical and Engineering News, April 4, 1994)

Mobil Chemical Company’s Joliet plant sells 22,000 gallons of styrene/ethylbenzene every 6 weeks to a recycler. Before, it cost Mobil over $1 per gallon to dispose of the wastes, but now they receive $.50 per gallon for it. (United Press International, April 24, 1989)

Lyondell Petrochemical Co. (Houston, TX) buys used lubricants from manufacturing plants, railroads, transportation fleets, and refines it to gasoline of a grade equal to that refined from crude. They started by recycling about 7.5 million gallons per year. This number is expected to rise to 30 million gal/yr. (Biocycle, May 1992, P. 80)

DuPont and Waste Management recycle plastics and produce resins to be used by DuPont as feedstock (Society for the Advancement of Management, June 22, 1992)

Ashland Chemical collects the ultra pure solvents it sells to semiconductor customers and then resells the used solvent to industrial customers. (Chemical Week, Aug. 1993)

Allied Chemical saved thousands of dollars when an exchange found a buyer for its alkali by-product (Chemical Week, May 16, 1984)

Witco sells/uses the “bottoms” left after production of detergent alkylate to companies that make high molecular weight sulfonates (Chemical Week, Feb. 4, 1981)

Unnamed company earns $300 each yr. by selling 1600 lbs of propylene glycol to another that saves $302 by buying it used (The Business Journal-Charlotte, Nov. 1, 1993)

Unnamed Co. bought 260,000 lbs of waste calcium oxide. It saved $10,400 and the seller gained $11,440 (The Business Journal-Charlotte, Nov. 1.)

Unnamed company that makes dashboards sold 4.1 tons of plastisol to a resin manufacturer (The Gazette (Montreal), Sept. 13, 1992)

Syntax Inc. in Springfield, MO, uses HBr in many processes. In 1993 they returned approximately 6.1 million gallons of used HBr to their supplier, for a total disposal savings of about $830,000 plus they gain revenue from resale of some of the HBr. They also sell 65 drums (55 gallons each) each quarter of acetic acid to a reclamer. This results in a yearly savings of $260,000. (Nancy Luxton of Syntax, Inc.)

DuPont also markets dytek A, another waste from nylon production (Gannet News Service, Nov. 8, 1990)
DuPont sells acetonitrile ACE, a derivative of acrylonitrile (used in some DuPont fabrics) to pharmaceutical companies. It is also used in the production of agricultural chemicals (Gannet News Service, Nov. 8, 1990)

Clorox Co. sold 120 tons of cat litter that would have been waste, to humane societies and to state highway department to clean up oil on highways (Business Week, September 17, 1990)

Arco refinery saves $2 million each year by selling spent alumina catalysts to Allied Chemical

**Metals Recovery**

Horsehead Resource Development Co. (PA), buys waste from steel foundries, metal finishers, electroplaters, and zinc diecasters for use in its metal recovery kilns. (The Business journal-Charlotte, Nov. 1, 1993)

Parker Hannifan Corp. (Cleveland, OH) ships 8,800 gallons of sludge every 90 days to Encycle Texas, Inc., a metal waste recycling company in Corpus Cristi, TX. This saves Parker Hannifan about $80,000 each year (Wall Street Journal, August 2, 1991, pA5)

A greeting card manufacturer sends metal contaminated nitric acid waste to a company that recovers the metals and reclaims the acid. This has reduced the card company's waste handling costs by one-third (Ontario Waste Exchange)

British Steel sends leaded steel by-products to a secondary lead smelter about 50 miles away. They break even on the deal. (Process Engineering, March 22, 1993)

**Wallboard Manufacturing**

Northern Indiana Public Service Co.'s Bailly Station installed a sulfer dioxide scrubber that is 95% effective in cleaning SO2 from waste streams derived from burning coal. The sulfur is converted to gypsum, which is sold to a nearby wallboard manufacturing plant, owned by US Gypsum Co. (Power Engineering, Oct. 1992, p. 10)

Trendway of Holland, MI, sells left over fiberglass, vinyl film and scrap gypsum to other companies. The gypsum gets turned into cat litter and chemical spill cleaning products. Trendway saves about $40,000 per year in disposal costs of gypsum (Grand Rapids Business Journal, Oct. 28, 1991)

New England gypsum plant in Windsor, VT, uses sheetrock waste from a NYC company and makes it into cat litter and an oil absorbent drying agent (Vermont Business Magazine, Sept. 1991)

**Aluminum Recycling**

IMCO Recycling, Inc. has developed aluminum recycling technology that produces fertilizer as a by-product (Business and the Environment, June 1994, p. 12)

Aluminum anodizers save money by selling aluminum hydroxide filter cake and aluminum trihydrate crystal. About 3,000 tons per year have been diverted from landfills. These products are used as raw materials in the production of aluminum sulfate (alum). This saves the alum producer purchasing costs, the anodizer saves on disposal costs, and it generates less waste than bauxite (the material replaced by this reuse). (Ontario Waste Exchange)

In Shandong, China, red/brown mud, a waste from alumina production at an aluminum plant is mixed with fly ash from a nearby coal-fired power station, and used to make bricks. Other potential uses for the red/brown mud include road construction and ceramics, cement, rubber and paint production and as a soil additive for agriculture (From Ideas to Action: Business and Sustainable Development, by Willsums and Goluke, p. 182)

Aluminum Waste Technologies, Inc. uses dross, a by-product of secondary aluminum smelting to make fine aluminum oxide, salts, and nonmetallic products. They use 160 tons of dross each day. (Biocycle, April 1994)

Eastalco Aluminum Co. of Frederick, MD sells flourspar, a powdery grey chemical waste from aluminum smelting to an industrial firm in Pittsburgh. It used to cost them $70 per ton to dump it, now they get $20 per ton for selling it. (Chicago Tribune, July 26, 1992)

**Iron Foundries and Asphalt/Cement Companies**

Ten iron foundries in Ontario are considering selling moulding sand to asphalt companies. It would be screened and washed and shipped to the asphalt companies. It would cost the foundries anywhere from $10-$40 per ton less than dumping it in a landfill (MacLean Hunter Ltd. (Canada) 1990, Canadian Machinery and Metalworking).

Hickson and Welch of Castleford (England?) sell 80 tons of iron oxide each week to a cement company (Process Engineering, Mar 22, 1993)

**Food Waste**

In Minnesota, restaurant food waste is delivered to pigs (Minneapolis-St. Paul CityBusiness, July 31, 1992)

Bakery leftovers sold to animal food makers (Financial Times, Mar. 20, 1991)

Sioux-Preme Packing Co. (Sioux Center, IA) sends 5,000 lbs of hog hair each day to Boyer Valley in Denison, IA. The hair is processed into a powdery substance, and added to livestock feed to serve as a nondigestable protein. Saves about $500-$600 per month in disposal fees (Choose to Reuse, By-product and Waste Search Service (IA), 1993-4.

**Acids and Bases**

Unnamed pickle factory sells its waste brine solution to textile plant as a replacement for virgin acetic acid (Pollution Prevention Review, Vol. 1, No. 1, Winter 1990/91, p. 22)

Collis Tool Corp. generates black oxide sludge in their tool manufacturing operations. The sludge which is a base is used to neutralize an acidic material generated by a nearby manufacturer. This saves about $7,000 per year (By-product and Waste Search Service (IA), 1994-5).

GE Aircraft, Rutland, Vt, uses a high purity acid to etch metal to very specific tolerances. When it is no longer pure enough, the acid is sent to a nearby GE facility where it is used to wash engine parts (Pollution Prevention Review, Vol. 4, No.1, Winter 1993/94, p 57)

**Film**

Unnamed X-Ray manufacturer flakes and bales waste polyester coated film then sells it to another firm. Sells about 20 million lbs/yr., and saves $200,000 in collection fees, and revenues from former waste film are $150,000 per year. (Pollution Prevention Review, Vol. 1, No. 1, Winter 1990/91, p. 23)

**Textiles**

Unnamed textile manufacturer sold 900,000 lbs of waste for $9,000 plus saved $5,000 in dumping fees (The Business Journal-Charlotte, Nov. 1, 1993)

Cotton lint from a diaper service is delivered to paper making classes (Minneapolis-St. Paul City Business, July 31, 1992)

**Universities**

A pharmaceutical company gave 700 kg of pancreatic lipase enzyme to a university. Company saved $2750 in disposal fees, and the university saved $54,000 purchasing cost (Ontario Waste Exchange)

In MN, Surplus water treatment chemicals from a sewage plant are delivered to a university chemical lab (Minneapolis-St. Paul CityBusiness, July 31, 1992)
Solvent Recovery

A control valve manufacturer saves $21,000 a year by sending paint sludge waste to four different companies who reclaim the solvent from the sludge (Ontario Waste Exchange)

Planar Systems of Beaverton, OR, sells leftover isopropyl alcohol from its production of computer screens to Western Foundry of Tigard, OR which uses it to clean casts for steel products. Planar saves $300 per drum on isopropyl alcohol that it does not dispose of in a landfill (Chicago Tribune, July 26, 1992)

Audubon Society House: Sustainable Design and Construction

The National Audubon Society's renovation of a 19th century building for its headquarters put sustainable design and construction principles into practice.

The project enhanced energy efficiency, indoor air quality, pollution avoidance, solid waste management, water conservation, light quality, and thermal comfort. This was accomplished with substantial savings and an improved relationship with the natural environment--in the heart of New York City!

Project architects and designers used an integrated approach that relied on the cumulative effect of no-cost or low cost design solutions, in tandem with advanced technologies. The design team purchased only readily available “off-the-shelf” products and materials to ensure economic and environmental performance.

Retrofitting an existing building cost the environmental group $24 million versus new construction that would have cost $33 million. Operating costs are about $100,000 a year less than costs would be in a building that merely complied with code.

Economics, however, only begin to suggest the quality the Audubon House achieved. The goal of the planners and designers was to produce a “staff rejuvenated by their workplace instead of repelled by it.” The Audubon design team made decisions throughout the project based on user comfort and well-being.

Architects designed natural lighting and ventilation into the building: large floor-to-ceiling windows fill offices with sunlight, while operable windows allow fresh breezes. Builders installed material that helped guarantee good indoor air quality.

The design team mandated contractors to recycle construction wastes and to use recycled building materials with post-consumer content. Countertops are made from recycled detergent bottles, while floor tiles are composed of recycled light bulbs.

The project continues innovation in the day-to-day operations with long-term waste management and energy operational changes.

Audubon has a goal of recycling 80 percent of office wastes generated. Four recycling chutes (for mixed paper, aluminum cans, plastic bottles and food wastes) run the length of the building from the eighth floor to the sub-basement recycling room.

Designers boosted operational energy efficiency by using computer modeling. The Audubon design team used DOE-2, a computer software program developed by the U.S. Department of Energy, to demonstrate how cost-effective, energy saving design could perform far beyond code. The Audubon House now consumes 62 percent less energy than would a code-compliant building.

The design team used a standard five-year payback formula for all energy-related systems. Photovoltaic cells (which convert sunlight to electricity) were ruled out as an energy source, for instance, because payback in the New York climate was determined to be about 10 years.

The Audubon design team had to make compromises to reach completion: builders installed non-recycled flooring in one section of the building because of structural weakness; safety concerns forced the installation of carpeting with toxic glues on staircases (versus tacking carpets). The design team realized...
from the outset, however, such individual compromises are necessary to achieve a greater goal--what is
called a "90 percent solution."

Designers, architects, builders and contractors spent more time than usual in education and integration of
their working group. The project team, however, believes this higher level of integration across professions
will become standard practice.

(Based on--Audubon House, National Audubon Society, Croxton Collaborative, Architects; John Wiley &
Eco-Industrial Developments in Japan

By Mari Morikawa, industrial ecology graduate student at Yale University who served as intern to Indigo Development, RPP International during the Spring and Summer of 2000


Summary

Since the breakdown of the Bubble Economy in Japan, which had prospered on the basis of mass production and mass consumption, Japan has been struggling to find an alternate vision for development. Facing a negative heritage of unsustainable economic activities in recent decades, which caused environmental degradation and resource exhaustion, Japanese industry and society have been forced to go through changes in their mode of production. Recognizing an eco-industrial approach as a way to realize sustainable development, Japanese leaders have launched various types of eco-industrial projects around the country. Since the term “eco-industrial park/estate” is not commonly used in Japan, the exact number of projects are unknown, but one estimate indicates that there are currently about 60 eco-industrial projects operating or under development, including those that are still in the planning and consideration phases.

The following analysis of the driving factors behind the emergence of Japanese eco-industrial projects aims to provide a base of knowledge and insight for better understanding the framework of, and for promoting the future development of, eco-industrial projects. In the second part of this study, we analyze projects that could potentially be defined as eco-industrial parks or that possess many of the qualities typically associated with industrial symbiosis. These projects are grouped into the following categories:

- Eco-industrial parks
- Eco-Town Projects
- Industrial cluster and zero emissions efforts
For each project category, we describe the types of energy and material linkages that are typically present and appeared most attractive to industry. We examine the relationship between the factors that encouraged their development and their organizational structure and also evaluate the degree of success attained. We seek to provide insights that will support the development of more effective public policy for encouraging future eco-industrial projects. It should be noted that these categories are aimed at grouping similar types of projects emerging in Japan to characterize them for this study. This typology is not meant to serve for categorization of eco-industrial projects in general.

Download Word 97 file 95 kb http://www.indigodev.com/IndigoEco-Japan.doc