

# Chapter 9. Supporting Industry Awareness and Change

***More than 50 million companies are now operating in Asia, but few have been leaders in environmental performance. Many remain oblivious that their competitiveness is at stake. Countries must develop sector-specific programs for industry if they wish to promote more efficient resource use. Environment authorities will need to actively engage with the regulated community, including small and medium-sized enterprises, to agree on clear and fair targets for resource efficiency improvement.***

This chapter focuses first on ways that governments can stimulate the adoption of appropriate practices on the part of industry. These include capacity-building programs, voluntary initiatives, and eco-industrial park development. The second focus is on tools and methodologies that industries can use to improve their resource efficiency.

## Government Policies and Programs Targeted at Industry

A number of actions can help industrial and public facility managers understand the real costs of waste and the benefits they can gain from changing practices and technologies in their facilities. This will involve finding the optimal mix of environmental policy instruments, from conventional regulatory approaches and market-based instruments to new forms of public-private partnerships.

Some specific actions that governments can take are:

- Allow for market-based prices of commodities and other production inputs.
- Develop resource-based policies that set measurable goals for resource efficiency for each industrial sector and for government's own operations.
- Determine the appropriate level and mode of government agency involvement in assisting industry efforts, including the right balance between regulatory and voluntary programs.
- Formulate a cleaner production policy and/or law and voluntary programs for its implementation. This should include developing or strengthening the role of cleaner production centers and industrial associations in improving industrial resource efficiency through capacity development, outreach programs, and accumulation of lessons learned by peer networks. Support for SMEs should be a priority.
- Develop the physical and social infrastructure for resource recovery within and among companies, including eco-industrial parks and business incubators. At the same time, reframe waste management regulations to enable companies to exchange byproducts, with appropriate safeguards.
- Assist companies to integrate environmental management systems, green procurement, strategic R&D, customer relationships, supply chain management, and stakeholder dialogues.
- Develop government procurement policies that reward resource efficiency in supplier companies. This can be done by establishing new organizations, such as the Republic of Korea's "Green Product Promotion Association," or ecolabeling and certification schemes that guide both government and business procurement.
- Require companies or public facility managers to provide financial reporting on the costs of waste, the volumes of each type of waste, and the returns from resource optimization and recovery.
- Coordinate research by government, university, and private research institutes to advance the

technologies required.

- Set prices for utility energy and services on a quota basis, increasing costs for excess consumption rather than lowering them for high-volume use.
- Provide financial and social incentives to companies that excel in resource efficiency. These may be tax breaks, preference in government procurement, and recognition programs.
- Offer incentives and promotional programs for private investment institutions, encouraging them to make loans for facility retrofitting and high-performance design of new buildings and facilities.
- Create revolving loan funds (as public-private partnerships) to support the same types of loans, particularly for SMEs.

A number of the actions listed above were described in Chapter 4 on broad national policies. The following sections discuss four possible government actions specifically targeted at industry: capacity-building programs, voluntary initiatives, informational measures, and eco-industrial park development.

### Raising Awareness and Capacity of Businesses

Persuading industries to improve their environmental performance can be difficult. Managers may believe improvements will simply add to the costs of production. They may have no accounting tools to identify the costs of waste and pollution because they are hidden in overhead. Or they may be simply unaware of new approaches, particularly if they run SMEs. Therefore, increasing resource efficiency depends on management awareness, capacity, and definition of responsibilities.

Disseminating best industry practices provide firms with both useful information that they can use to alter their own practices, and a reference point as to how they are doing relative to the industry. The practices may be defined by a government agency, or the government may provide assistance to industry sector institutes to identify and disseminate the practices.

Management tools made freely available to firms can be of major assistance in understanding how to pursue greater resource efficiency and build systems

awareness (Box 9.1) within the primary mandate of business survival.

Similarly, disseminating environmental performance of different technologies helps firms to identify the best technology to choose to meet their requirements. While technology vendors are the most common source of detailed information on technology, they are not impartial in comparing technologies, and it is important to the buyer concerned with environmental efficiency to have a neutral reference point. The performance information may be developed by a government agency, or the government may provide assistance and incentives to independent research institutes or to industry sector institutes to develop and disseminate the performance data.

Different types of organizations can help disseminate and showcase best practice, management tools, and technologies.

### Information clearinghouses and networks

develop and maintain databases on production techniques and environmental impacts of materials in different stages of their life cycle. They also create a forum for the exchange of practical experience and data, putting individuals with information directly in touch with those seeking it.

**Extension services and technical assistance systems** bring useful technical and management information directly to firms that are too small or cannot spare the management time to seek the information themselves. They may not have sought information also because they are simply not motivated to change, and a representative of an extension service or other assistance network on site in the enterprise may be able to interest the manager in practical terms of his own facility. The



Source: AFP.

### Box 9.1: Building Systems Awareness

One goal of capacity-building programs should be to build systems awareness: the ability to perceive the dynamic interconnections among the elements of an issue or proposal. Systems awareness seeks to answer the following questions: How is the system of interest influenced by other systems? What impacts does it have on other systems? What are the needs one system fills for others?

There are simple process steps that can help groups think and work in a more integrative way.

- Begin by acknowledging that common sense is the basis of integrative systems planning. It is not high science to lay out a building in terms of the sun's path and the amount of exposure to solar rays in different seasons.
- Learn how other participants in a working group gather and process information. Inventory the sources of information each uses and what values they use in evaluating data.
- Assign a group member the role of remembering the larger context and looking for interactions with other systems. S/he can simply ask questions that broaden the view of the whole group.
- Exchange roles for a period of open exploration of the system under review. The economic development manager takes on the role of environmental protection. The investment analyst becomes the manager of a large sustainable farm. Each sees the world through the other's eyes.

Formal capacity-building programs for integrative thinking and planning might include the following activities:

- Contract university faculty and graduate students to study systems thinking and methods and adapt them to your culture's style of learning.
- Conduct workshops with international experts in such methods as transition planning and integrative regional planning.
- Highly participative workshops led by skilled facilitators can build capacity and at the same time advance understanding of a system. Some bilateral aid agencies,<sup>a</sup> nongovernment organizations, universities, and consulting companies have this sort of expertise.
- Assign key staff members to study the literature of systems thinking and planning and the websites applying it to sustainable development. They should attend workshops to develop skills in facilitating groups to work in an integrative way.
- Use information technology to support integrative planning.<sup>b</sup> For instance, simulation software supports "learning before doing" and geographic information systems allow one to view a region and overlay industrial, farming, water, soil condition, pollution sources, population and other data sets on it.
- Organize conferences in which participants play the key roles and agencies in a system of critical interest (like climate change or resource shortages) and simulate planning and decision making over one to two decades.

These process innovations can all be tried in the context of normal policy making and planning processes. They allow people to learn by doing what they normally do with a few modest changes.

<sup>a</sup> e.g., International Development Research Centre (Canada) and German Agency for Technical Cooperation (GTZ).

<sup>b</sup> Rejeski, David. 1998. Learning before Doing: Simulation and Modeling in Industrial Ecology. *Journal of Industrial Ecology* 2(4). Cambridge: MIT Press.

information provider could be part of an extension service offered through the ministry of industry or ministry of environment or it could be part of an industry sector program based in the sector institute or industry association. It could also use existing networks of technical assistance to business, such as may be operated by the electric power company.

**Industry clubs or associations** are a form of networking and are an effective means of promoting resource-efficient practices. They can be encouraged by providing the right regulatory incentives, usually at local government level, for establishing industry sector clubs and circles. The membership may be primarily representatives of firms, but it may also

include a wider circle of parties concerned, especially when an industry has a significant effect on the welfare of a community. Government should provide grants and other incentives to these associations to develop practical management tools promoting resource efficiency, specially prepared for SMEs and as specific as needed to the issues and operations of a particular industry sector.

**Demonstration projects** showcase the techniques and cost-saving opportunities associated with various approaches to greater resource efficiency in selected plants. Government can promote targeted, high-profile demonstration projects in firms whose success will be credible to other firms in the sector. It is essential that effective mechanisms be built into the demonstration for the publication of the results within the sector, and that the host of the demonstration be chosen appropriately to the intended market (i.e., a large multinational company is not a credible demonstration for local SMEs).

In Malaysia, for instance, the Government is leading by example. In 2004, the Ministry of Energy, Water and Communications moved into the Low Energy Office Building, the first large government office building to be specifically designed as an integrated energy-efficient building and fitted with cost-effective features. The building provides a showcase for local professionals, academics, and industries for how to integrate EE into buildings. Another project is the Zero Energy Office Building which will consume less energy than it generates. The building, which will house Pusat Tenaga Malaysia (Malaysia's "one-stop energy center"), will be used as a demonstration project for building-integrated photovoltaics and will also be fitted with many cutting-edge EE features.<sup>258</sup>

**Training facilities** create the skilled human resources needed to implement resource efficiency strategies in firms. Government should promote effective training initiatives by establishing them in government institutes or by providing incentives to private training institutions and to industry sector organizations to do so.

There are good examples of government-funded

capacity-building programs that have outreach programs serving the interests of constituent corporations (e.g., the Cleaner Production Centers that have been developed in many Asian countries). The best programs will facilitate industry-initiated activity rather than try to start change themselves. In addition, experience has shown that to be effective, such programs must be firmly grounded in an understanding of applicable market forces and thoroughly blended with other complementary policy measures.

One challenge that capacity building programs must overcome is that many companies are not aligned with an industry association. Few associations have adequate resources to actively seek out the many small companies in their sectors, and most commercially available tools are written to the level of sophistication and available resources of a large

#### Box 9.2: Targeting Small and Medium-Sized Enterprises in India

According to the Indian Ministry of Environment and Forests, small and medium-sized enterprises (SMEs) account for 40% of industrial production and are responsible for an estimated 70% of the total industrial pollution load nationwide. Thus, by expanding targeted monitoring and compliance assistance efforts to SMEs and clusters of small-scale industries, central and state boards could address a significant and growing pollution source.

As strongly advocated by the World Bank in its India Country Environment Analysis, a whole regulatory package should be put together by the central and state pollution control boards to target SMEs at the state and local levels, including

- a comprehensive inventory (to identify units that currently operate without consents);
- simplified monitoring procedures;
- environmental awareness raising; and
- technical and financial assistance programs.

Close cooperation with industry associations is essential in developing user-friendly technical guidance documents and setting up economic incentive schemes based on best practices that already exist in some states. However, compliance assistance would be effective only if there is a credible threat of detection and enforcement action against violators.

Source: Asian Environmental Compliance and Enforcement Network. 2006, November. *Environmental Compliance and Enforcement in India: Rapid Assessment*. Available: <http://www.aecen.org/document.htm>

<sup>258</sup> APEC. 2005. *APEC Energy Overview*. Tokyo: Asia Pacific Energy Research Centre/Institute of Energy Economics.

enterprise. Thus, capacity-building programs need to target SMEs (Box 9.2).

### Self-Regulatory and Co-Regulatory Policy Instruments

With the growing appreciation of the limits of conventional policy instruments, many governments are encouraging the adoption of self-regulatory and co-regulatory policy instruments. The basic concept of voluntary initiatives is that more can be accomplished through a negotiated partnership than through enforcement of regulation alone. The government has the threat of regulatory enforcement, and the leverage of the firm is the need of government to achieve broad change in behavior.

Most voluntary programs take the form of partnerships between governments and the private sector. They come in an infinite variety of forms and include any relationship in which the government and a firm or business sector agree to mutually beneficial terms. As a result, the behavior of the firm changes toward greater resource efficiency. Examples include negotiated agreements between the firm and the regulatory body, auditable environmental management systems (e.g., ISO 14001), and public-private partnerships between industry and government or industry and civil society to achieve agreed objectives and self-enforced industry codes of practice.

### Negotiated Compliance

In contrast to a specified compliance approach, negotiated compliance adopts a more cooperative approach between the regulators and the regulated in setting and enforcing standards. This shared responsibility between government and industry enhances the likelihood of a more open exchange of information between the parties and allows greater flexibility regarding the means of meeting a standard.

Moreover, a number of countries have started to develop regulations where attainment of certain targets (e.g., recycling targets) is required, while concrete means of achieving such targets are left in the hands of industries (nonprescriptive regulations). This, in turn, may increase the economic efficiency of the regulation and may be conducive to the adoption of innovative, preventative approaches to achieving the same environmental objective.

Negotiated agreements are between regulatory agencies and private sector enterprises. An enterprise either agrees to meet certain standards in return for specified incentives, or the mix of regulatory discharge limitations is negotiated, in which the firm may exceed one or more discharge limitations in return for better performance on others, the total being in the best overall interest of the environment and public health.

For instance, in the Philippines, DENR has recently put greater emphasis on encouraging industry groups to police their own ranks and come up with self-monitoring programs. Programs facilitate partnership with industry groups as well as regulations to require self-monitoring reports. The Philippine Environmental Partnership Program (PEPP) was designed to promote industry self-regulation. DENR provides technical assistance to help industries comply with regulations. For companies that have a strong compliance record, DENR provides incentives by relaxing reporting requirements or easing requirements for environmental compliance certificates, recommending preferential credit rating with partner government banks, and even providing financial incentives, such as tax credits, where allowed by law. For companies that are not in compliance but are committed to comply, DENR enters into an agreement with them, laying down a concrete plan and timetable to follow to come into compliance. According to representatives of a sugar mill that has had problems complying with water and air standards, participation in the PEPP helps them not only set a clear direction toward compliance but also projects a good image for the company, which makes it easier for them to deal with creditors and investors as they undergo financial rehabilitation.<sup>259</sup>

### Auditable Environmental Management Systems

Resource efficiency in a company can be significantly improved by establishing an environmental management system (EMS) with challenging and comprehensive objectives, effective indicators, and structures assuring rapid learning and response. Managers should see ISO 14001 or any other EMS structure as the outline in which the team defines

<sup>259</sup> AECEN. 2004. October. *Environmental Compliance and Enforcement in Philippines: Rapid Assessment*. Available: <http://www.aecen.org/document.htm>

significant objectives and strategies relevant for the industry and its social and environmental setting. ISO 14001 is increasingly important in international trade.

To support monitoring and enforcement efforts, the state of Gujarat in India has introduced an environmental audit scheme aiming at ascertaining the performance of environmental management systems in various industries in the state. One objective of the program is to arm the Gujarat PCB and the association of industries with necessary performance information to support compliance monitoring.<sup>260</sup> Introduced under the directions of the High Court of Gujarat and implemented under the direction of a technical committee consisting of experts from the National Institute of Occupational Health, Central PCB and the government of Gujarat, the scheme requires industries to submit an annual environmental audit report through designated auditors recognized by the board. If a specified industry does not submit its audit report according to the prescribed time schedule, the board issues a notice of direction to the defaulting unit, failing which, the Gujarat PCB can request the concerned authority to disconnect water or electricity services. According to the Gujarat PCB, the environmental audit scheme has resulted in improved compliance and enforcement of environmental laws, creating an effective mechanism for supplementing legal monitoring of industries with a third-party audit.<sup>261</sup>

Major multinational companies require their suppliers to develop a certified EMS through supply chain relationships, often called greening the supply chain (section below). For many Asian suppliers, it has become a basic condition of doing business. Government also has a potential role in promoting EMS, by linking EMS adoption with permit requirements, introducing related flexible penalty systems, and/or ensuring that future updates of EMS standards have an increased emphasis on resource efficiency and enhanced environmental performance.

EMS should be more than just an administrative exercise. Without an overriding goal of improving resource efficiency (going beyond regulations), an EMS may result in a formal system that, while matching the requirements for certification, may

simply define performance objectives and indicators that do no more than keep operations in compliance with regulations.

### Greening the Supply Chain

Greening the supply chain (GSC) means looking not only at the environmental practices of a particular company, but also at those of its associated suppliers and vendors. In this way, buyer companies seek to ensure that the environmental standards they have adopted internally are consistently maintained by their suppliers. Even without government regulation, this sort of inter-firm compliance regime gives advantages to supplying companies that adopt greener practices.

Currently, many large multinational corporations have adopted green supply chain standards and enforce them through inspection and compliance regimes, but they also offer assistance to suppliers to help them achieve the more rigorous standards. Interest in green supply chain management and its implications for industry suppliers is growing in Southeast Asia and the PRC, as large companies seek to protect themselves from increased liability while protecting the environment. Some NGOs are also promoting this practice (Box 9.3).

In addition to helping spread EMS throughout the region, DfE is also spreading through the region through supply chains. In response to RoHS legislation (page 64), many Japanese electronics corporations and Japan-based foreign multinational corporations have issued public statements or policies reflecting the companies' commitments to incorporating DfE elements in their product design systems. These voluntary industrial standards are spreading by supply chain relationships, such as Sony's "Chemical Substances Management Standards" and Matsushita's "Green Procurement Standards" and "Chemical Substances Management Rank Guidelines."

### Voluntary Agreements

Voluntary agreements involve companies agreeing to achieve significant goals in waste reduction and other aspects of resource efficiency in exchange for improved public recognition, access to governmental technical assistance, and cost savings. Most voluntary instruments are funded through partnerships

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<sup>260</sup> AECEN. 2006, November. *Environmental Compliance and Enforcement in India: Rapid Assessment*. Available: <http://www.aecen.org/document.htm>

<sup>261</sup> Ibid.

### Box 9.3: A Philippine NGO Supports Green Supply Chain Management

Recognizing that buyer companies are increasingly concerned with their suppliers' social and environmental performance, the nongovernment organization Philippine Business for Social Progress initiated the Green Supply Chain Project. The project has identified environmental benefits as well as cost savings and strategic and competitive advantages for greening the supply chain as described below.

- **Economic benefits from increased efficiency.** Reduced wastes means decreased handling expenses, fines, and even costly inputs. Suppliers' savings may be passed along to buyer companies.
- **Competitive advantage through innovation.** Efficient production is enhanced through use of cleaner technologies, process innovation, and waste reduction. Reduction in wastes equals money earned.
- **Improved product quality.** Supply chain partnerships help maintain relationships between buyers and suppliers leading to increased control over product quality.
- **Consistent corporate environmental goals.** Companies enjoin suppliers and business partners to practice good environmental management to address corporate environmental goals.
- **Improved public image.** Consumers, investors, and employees respond positively to companies with a reputation for good environmental performance.
- **Risk management.** Decreases the liability and risk of interrupted service due to supplier's environmental practice.

Source: Philippine Business for Social Progress. Available: [http://www.pbsp.org.ph/greening\\_the\\_supply\\_chain\\_business\\_case.htm](http://www.pbsp.org.ph/greening_the_supply_chain_business_case.htm)

between governments and the private sector. In some cases, and particularly with capital-intensive projects in developing countries, multilateral donors or international organizations are major financial contributors.

Voluntary agreements are almost nonexistent in Asian countries, even though they are quite common in other regions, especially Europe and North America. The PRC uses voluntary agreements as a policy tool to increase industrial EE. The first agreements were signed with Jinan Iron and Steel Company and Laiyang Iron and Steel Company in April 2003. Both plants agreed to increase their efficiency efforts to achieve by 2005 a level of efficiency equal to the advanced international level in 2000. A recent performance review showed that both plants were well on their way to achieving these targets. The experience in this pilot laid the foundation for the expansion of the approach to the national iron and steel sector, as well as to the petrochemical sector, with support from the GEF.<sup>260</sup>

Some voluntary instruments are now becoming mandatory policies. This applies specifically to energy-efficient equipment

labeling, standards, and various emission targets. In Asia, however, this shift has had less impact because these voluntary instruments are not yet widespread.<sup>263</sup>

### Industry Codes of Practice

Industry codes of practice provide broad guidelines to firms for a management approach that addresses issues of environmental sustainability as part of core business decision making. Examples include the International Chamber of Commerce's Business Charter for Sustainable Development, the chemical industry's Responsible Care Program, and the Japanese business sector's Keidanren Global Environmental Charter. For these codes to be effective, mechanisms need to be in place to promote members' implementation of the code, to monitor and publicly report on adherence, and to have meaningful business sanctions in addition to peer pressure.

Japanese manufacturers have established the Japan Article Management Promotion-consortium (JAMP) to help them comply with REACH and other chemical-related regulations, such as RoHs and

<sup>262</sup> Lawrence Berkely National Laboratory, China Energy Group. 2005. Available: [http://china.lbl.gov/china\\_industry-iee-va.html](http://china.lbl.gov/china_industry-iee-va.html)

<sup>263</sup> UNEP. 2006. *Improving Energy Efficiency in Industry in Asia: A Policy Review*. Bangkok, Thailand.

WEEE. JAMP provides a practical means of orderly management and the smooth disclosure and transfer of information on chemical substances and other data contained in components and products. JAMP tries to establish common forms of substance information to share among manufacturers and suppliers to help them reduce their costs and burdens. Along the increasingly globalized supply chain, voluntary initiatives for information sharing and harmonization, such as JAMP, are also likely to expand beyond borders (page 161).<sup>264</sup>

Moreover, the Japan Electrical Manufacturers' Association Environmental Action Plan highlights industry efforts to create "a resource-circulating society," and the Association for Electric Home Appliances has recently begun making public on its Japanese website the voluntary DfE initiatives that its members are undertaking.<sup>265</sup>

In India, one voluntary initiative aimed at reducing industrial pollution is the Charter on Corporate Responsibility for Environmental Protection. In 2003, the Ministry of Environment and Forests (MOEF), and the Central Pollution Control Board (CPCB), in consultation with industry, launched the charter to promote waste minimization and adoption of clean technologies. Eight task forces comprising representatives of the MOEF, CPCB, state pollution control boards, industry associations, and experts monitor implementation of the charter. The charter recognizes that some of the 17 category sources were not in compliance with all requirements and set new industry sector-specific compliance dates. As part of this process, noncomplying facilities submitted bank guarantees with their action plans.<sup>266</sup>

### Informational Measures Targeting Industry

Governments can further stimulate the adoption of appropriate industrial practices through informational measures. Action can be taken in a variety of areas, including ecolabeling schemes, public disclosure of

firms' environmental performance, energy audits, and environmental accounting systems, as described below.

### Ecolabeling

Product labeling is most significant in international trade with industrialized markets, but is having a slowly increasing effect as well on domestic purchasing choices. There are various such schemes worldwide and the ISO 14000 series of guidelines is trying to bring some coherence to the many definitions. There is a proliferation of ecolabeling schemes in Asia and the Pacific (Table 9.1). For a discussion of EE labeling, please see page 78.

There is also a growing movement to harmonize environmental label programs within the region with the help of the Global Eco-labeling Network. As of 2003, Japan; Republic of Korea; Taipei, China; and Thailand had joined the Common Core Criteria for Asia Countries. Currently, the mutual recognition system is done on a project basis, such as the common core criteria for paints and toner cartridges. Certification standards will be unified step by step from the national to the regional and eventually to the international level.<sup>267</sup> While this prospect is still far off, harmonization could one day help make ecolabeling a powerful global tool to encourage sustainable consumption.

Another important trend is the strong relationships that are beginning to form between ecolabeling organizations and procurement programs. For instance, the Japanese Government established guidelines for green procurement and referenced the Eco Mark as one possible source of information. Subsequently, many local governments in Japan established green procurement guidelines that also referenced the Eco Mark.

For the most part, however, the implementation of ecolabeling schemes has been a challenge in the region. Some are seen to distort the market and conditions for fair competition, especially in product groups where national producers compete with foreign products. Another challenge is the verification of the environmental features of a labeled product.<sup>268</sup>

<sup>264</sup> International Symposium on Chemicals Management in the context of Global Trends "EU REACH and Japan's Response," Japan Article Management Promotion Consortium website

<sup>265</sup> EcoTrack. Available: [http://www.eco-track.com/regions/region\\_detail.php?id=1](http://www.eco-track.com/regions/region_detail.php?id=1)

<sup>266</sup> AECEN. 2006, November. *Environmental Compliance and Enforcement in India: Rapid Assessment*. Available: <http://www.aecen.org/document.htm>

<sup>267</sup> Green Council. 2003, 15 Feb. The Seminar of "Common Core Criteria of Eco-labelling Scheme." Available: [http://www.greencouncil.org/web/publications\\_articles.php?id=1&art\\_id=227](http://www.greencouncil.org/web/publications_articles.php?id=1&art_id=227)

<sup>268</sup> ADB. 2005. *Asian Environmental Outlook: Making Profits, Protecting Our Planet*. Manila.

Table 9.1: Ecolabels in Asia

Country	Organization	Ecolabel	Summary
<b>Australia</b>	The Australian Environmental Labelling Association Inc.	The Australian Eco-label	<ul style="list-style-type: none"> <li>Launched in November 2001</li> <li>26 companies certified; standards developed for 30 types of product categories<sup>a</sup></li> </ul>
<b>China, People's Republic of</b>	China Certification Committee for Environmental Labeling Products <sup>b</sup>	Ten-ring Mark	<ul style="list-style-type: none"> <li>Established in May 1994</li> <li>As of May 2003, 527 Chinese enterprises and a total of 3,426 products had been certified<sup>c</sup></li> </ul>
<b>Hong Kong, China</b>	Green Council and Hong Kong Productivity Council	Green Label Scheme	<ul style="list-style-type: none"> <li>Green Council formed in 2000</li> <li>9 categories comprising 37 products open for application<sup>d</sup></li> </ul>
<b>India</b>	Central Pollution Control Board	Ecomark Scheme	<ul style="list-style-type: none"> <li>Launched in 1991</li> <li>16 product categories</li> </ul>
<b>Japan</b>	Japan Environment Association	Eco Mark	<ul style="list-style-type: none"> <li>Second oldest program, established in 1989</li> </ul>
<b>Republic of Korea</b>	Korea Environmental Labeling Association, Korean Ministry of Environment	Environmental Labeling Program	<ul style="list-style-type: none"> <li>Launched in June 1992</li> <li>2,041 certified products (506 companies) in over 100 product categories</li> </ul>
<b>Malaysia</b>	Product Certification Program	SIRIM <sup>e</sup> Quality Assurance Services	<ul style="list-style-type: none"> <li>Launched in 1996</li> </ul>
<b>New Zealand</b>	Environmental Choice New Zealand	Environmental Choice New Zealand	<ul style="list-style-type: none"> <li>Over 200 products in 29 product categories<sup>f</sup></li> </ul>
<b>Singapore</b>	Singapore Environment Council	Singapore Green Labeling Scheme	<ul style="list-style-type: none"> <li>Launched in May 1982</li> <li>About 300 products in 32 categories<sup>g</sup></li> </ul>
<b>Taipei, China</b>	Environment and Development Foundation	Green Mark Program	<ul style="list-style-type: none"> <li>Launched in August 1992</li> <li>Nearly 1,400 products certified in 87 product categories<sup>h</sup></li> </ul>
<b>Thailand</b>	Thailand Environment Institute	Green Label Program	<ul style="list-style-type: none"> <li>Launched in August 1994</li> <li>About 144 products (and 29 companies) in 16 categories<sup>i</sup></li> </ul>

<sup>a</sup> Australia Environmental Choice. Australian Environmental Labelling Association, Inc. Canberra. Available: <http://www.aela.org.au/homefront.htm>

<sup>b</sup> Third-party certification program under the direction of the China State Bureau of Technology Supervision and the National Environmental Protection Agency.

<sup>c</sup> Qing, Xia and Yu Jie. 2003. China's Environmental Labeling Program. Presentation at Challenges Ahead on the Road to Cancun, World Trade Organization, 16–18 June.

<sup>d</sup> Law, Ir Nelson. 2003, August. Green Label : *HK Green Label - A Product Certification Scheme using Green Criteria*. N. Law and Associates Management Consultancy. Available: [http://www.nlaw.com.hk/articles\\_detail.asp?Article\\_id=35](http://www.nlaw.com.hk/articles_detail.asp?Article_id=35)

<sup>e</sup> Standards and Industrial Research Institute of Malaysia.

<sup>f</sup> Environmental Choice New Zealand. Available: <http://www.enviro-choice.org.nz/>

<sup>g</sup> United Nations Environment Programme. 2004. *Regional Sustainable Consumption and Production Report: Asia and the Pacific*. Paris.

<sup>h</sup> Greenmark. Environmental Protection Administration. Hsinchu, Taipei, China. Available: <http://greenmark.epa.gov.tw/english/index.asp>

<sup>i</sup> Bunyagidji, Chaiyod. 2004. Presentation on Green Procurement in Thailand: Challenges and Opportunities for *APO Workshop on Green Procurement*. Kuala Lumpur, Malaysia. 3 September.

### Publicizing Environmental Performance

The widely accepted idea of citizens' right to know has both paved the way for the use of public disclosure programs that publicize compliance information of individual polluters. Another important aspect is that information collection is a first step toward the possible introduction of other policies at a later stage. A feature that has made disclosure schemes very attractive to policy makers is their low cost. A properly managed and relatively small infrastructure for collecting and disseminating information is generally sufficient for implementation.

Governments can publicize environmental performance to encourage (or discourage) certain industry behavior in various ways. Four of these are described below.

**Toxic release inventories and pollutant release and transfer registries.** These create a public record of the environmentally threatening raw materials used by a firm and of the discharges by the firm to the environment. They have been successful in the Australia, Canada, United Kingdom, and US, and through mandatory environmental reporting in Denmark. Requiring public disclosure of information on environmental performance by any means, including establishing a pollutant release and transfer register, stimulates greater voluntary corporate reporting. While originally intended as a means of public monitoring of corporate performance, reporting procedures have also brought about substantial voluntary change in firm behavior by managers who, before being required to report their discharges, often did not realize how inefficient their processes were.

**Corporate reporting.** Corporate reporting of general environmental performance should be encouraged by government, both to inform the affected public and to force firms to focus on their performance. One lever available to government is to require audits of environmental performance as part of the permitting requirements. Firms may be mandated to undertake audits of their plants and to implement some of the audit findings. In terms of integrated permit conditions, firms may be required to implement a structured environmental management system and to make public information

on their environmental performance. Government can also achieve this end through a combination of requirements and tax rewards for compliance or exceeding requirement.

**Public recognition and awards.** Recognition is an effective means to reward accomplishment by business, giving them visibility and a valuable public relations asset. Issuing high-profile awards for enterprises that have effectively achieved greater resource efficiency may be carried out by a government agency, such as the ministry of industry, a regulatory agency, an industry association, or a prestigious neutral body, such as a foundation. In any case, the government can offer incentives associated with the reward, such as fast track licensing or less frequent compliance monitoring.

**Corporate environmental performance ratings.** These ratings provide a forum in which firms can compete for recognition for their accomplishments toward environmental or sustainability performance, and in which firms that do not take the issue seriously can receive a poor rating and risk public embarrassment. Public disclosure programs in some Asian countries (PRC, Indonesia, Philippines, and Viet Nam) have introduced a rating system for the most important industrial polluters based on self-reported and inspection data. Such systems can offer a compliance incentive and benchmarking tool for industry, an information source and accountability vehicle for the public, and priority setting aide for environmental agencies.<sup>269</sup> For instance, the PROPER initiative in Indonesia selected the firms to be rated (Box 9.4). An alternative approach is to have firms volunteer to be in the rating system because they want the public recognition of a good rating.

### Environmental Accounting Systems

Standard management accounting usually buries waste costs in overhead costs where they are not visible to management. Usually no one is responsible for more than disposal or pickup of wastes by recycling companies. Thus, capacity-building

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<sup>269</sup> AECEN. 2006, Nov. *Environmental Compliance and Enforcement in India: Rapid Assessment*. Available: <http://www.aecen.org/document.htm>

**Box 9.4: Indonesia's PROPER—Pollution Control Evaluation and Rating**

Launched in June 1995, Indonesia's Program for Pollution Control Evaluation and Rating (PROPER) was the first major public disclosure program in the developing world. Although it collapsed in 1998 with the Asian financial crisis, it is currently being revived, this time on a larger scale.

The PROPER scheme targeted major industrial water polluters and used a five-color scale to grade the environmental performance of different facilities. Four rounds of evaluations were released to the media over the 3 years that the program ran.

Indonesia's environmental authority, BAPEDAL, went to great lengths not to alienate or provoke industry but to be constructive and provide accurate and timely advice about what firms had to do to improve their ratings. Since industrial leaders were very influential during this period, there was also a conscious media strategy for the release of information and other aspects of public relations related to the program

A 2004 assessment of the program by Resources for the Future showed that there was a strong, positive response to the scheme, in particular among firms with poor environmental compliance records. These firms cut their emissions intensity by approximately a third. The response was immediate, and firms pursued further reductions in the following months.

Source: Lopez, Jorge Garcia, Thomas Sterner, and Shakeb Afsah. 2004 October. *Public Disclosure of Industrial Pollution: The PROPER Approach for Indonesia? Resources for the Future*. Washington, D.C. Available: <http://www.rff.org/documents/RFF-DP-04-34.pdf>

programs should stress environmental accounting systems and useful management approaches to support improvement in source reduction and by-product utilization, such as<sup>270</sup>

- developing database inventory of every unmarketed by-product (waste);
- giving every by-product flow a product number and a line in the cost-accounting books (material, energy, or water);
- assigning a manager the responsibility of managing by-products and encouraging innovations to eliminate them, finding internal uses, and/or marketing them externally; and
- seeking the highest and best use for the unmarketed products, internally or externally.

With these changes in organization, plant managers can see the real costs of producing unmarketed products and someone has the job of dealing with them so as to add to the bottom line. This person is looking at the overall picture of by-product mass, energy, and money flows, and balancing revenues and costs to discover the highest

value use of these products. His or her assignment is: either find a way to stop making unmarketed products or find a way to use them, internally or externally.

Environmental management accounting provides the firm with an understanding within its overall corporate accounting system of the cost of regulatory compliance and of otherwise managing its environmental issues. Only with such information can the business decision maker compare the cost of a particular process improvement or environmental management action with the cost reductions or other benefits that will be gained. Governments may promote the use of environmental management accounting through education and awareness programs directed to business; in certain circumstances it may require an environmental management accounting report by the firm.

### Eco-Industrial Park (EIP) Development

PRC, India, Japan, Republic of Korea, Thailand, and other Asian countries have established programs to transform existing industrial parks or estates into eco-industrial parks (EIPs). In a few instances, these programs aim at developing new parks, but most have started by implementing industrial symbiosis, seeking exchange of by-products among companies. Location in an EIP can provide business opportunities and support for new or expanding environmental

<sup>270</sup> Lowe, Ernest. 2001 and 2005. Interviews with Douglas Holmes, chemical engineer and co-author of the first *Eco-industrial Park Handbook*, and with Aldrin Bayer, strategic consultant in by-product utilization for the steel industry, former manager at Suprachem, a South African steel by-product recycling subsidiary.

enterprises, as well as standard manufacturing and service companies.

The definition of an EIP from the ADB Handbook<sup>271</sup> is as follows:

“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.”

This systems understanding implies a mission for EIPs:

“An eco-industrial park will achieve profitable return on investment while demonstrating an environmentally and socially sound form of industrial real estate development (or redevelopment). This model of industrial development will be a major hub for sustainable regional development.

“Profit for public authorities includes local ventures developed, foreign direct investment attracted, new jobs created, and environmental and social benefits. Nevertheless, publicly-owned EIPs should

generate sufficient revenue to pay their own operating costs.”<sup>272</sup>

To achieve this mission, EIPs may create by-product exchanges among companies as one of many strategies to optimize resource consumption and reduce pollution in an industrial park or region. Some projects emphasize this approach over all others. EIP teams benefit from seeing the overall EIP system as one for optimizing all resource flows in an industrial park while reducing all environmental and social impacts. The system includes:

- implementation of cleaner production within plants and utilities and promotion of eco-efficiency through source reduction, reuse, internal recycling, and product and process design;
- company-to-company by-product exchanges to handle a share of their unused by-products; and
- an integrated resource recovery system to optimize use of all external resource flows and of all by-product resource flows.

EIP planners apply principles and practices of industrial ecology to the park infrastructure and buildings. Effectively, this organization provides opportunities for cleaner production, technologies for renewable energy, advanced water management strategies, and ecological landscaping. Thus, resource efficiency is embodied in the physical plant itself. A good example, based on water recycling in an EIP in Thailand, is given in Box 9.5.

Development of EIPs offers business opportunities in real estate development.<sup>273</sup> In Asian countries structured to allow private land development, such as in India, Philippines, and Thailand, this infrastructure for business operation enables developers to profit from the appreciation of land, tenant leases or purchases, and business environmental services. In the PRC, industrial zones are generally owned and managed by the government so the returns are from sale or leases, foreign direct investment, and the social goods of new enterprise development and employment opportunities.

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<sup>271</sup> Lowe, Ernest A. 2001. *Eco-Industrial Park Handbook for Asian Developing Countries*. Prepared for the Environment Department, Asian Development Bank. Available: [www.indigodev.com/Handbook.html](http://www.indigodev.com/Handbook.html).

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<sup>272</sup> Ibid.

<sup>273</sup> Ibid.

### Box 9.5: A Closed-Loop Water System in Thailand

Management at the Eastern Seaboard Industrial Estate has created a closed-loop water system at this site southeast of Bangkok. The estate manager, Hemaraj Land and Development, initiated the system design from the beginning of the planning process. It was essential to invest early in capacity and alternative piping so that the water infrastructure could accommodate all necessary processing for reuse.

The estate's companies use a total of 36,000 cubic meters (m<sup>3</sup>) 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 pretreatment plant, after which their wastewater flows to primary and secondary aerated lagoons. (The estate maintains an inorganic waste-water treatment plant and an emergency pretreatment plant in case of breakdown of the factories' plants.) A constructed wetland provides tertiary treatment and a holding pond (600,000 m<sup>3</sup>) which cleans the water to higher than the Industrial Estate Authority standard. Plants in this wetland are selected to remove residual heavy metals remaining after earlier treatment.

The 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 that the estate uses for landscaping and to supply several factories using 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 cannot be marketed for human consumption because they contain significant amounts of heavy metals, but management is exploring the possibility of supplying them to an alligator farm in the Rayong region. During the winter, migratory water fowls 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 wastewater, 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.

Source: Lowe, Ernest A. 2001. *Eco-Industrial Park Handbook for Asian Developing Countries*. Prepared for the Environment Department. Manila: Asian Development Bank. Available: [www.indigodev.com/Handbook.html](http://www.indigodev.com/Handbook.html)

A specific source of sustainable investment is emerging around the need for reductions in GHG emissions. Management of an EIP could coordinate GHG credit trading for resident companies and others in the region, sharing in the financial returns. Another potential source of return to the continuing management team is fees for supporting exchange of by-products among tenants.

EIPs yield both 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 nongovernment funds) sources. The balance between the two will vary by project.

- An EIP project may benefit from finance from public and civic sources in its predevelopment and design phase. The park may fully qualify for private sector funding in the actual development of the site; 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, although the public sector may provide environmental industry investment funds, development bonds, or other forms of public support.
- Support structures like the incubator and training center generally qualify for funding from government or international banks and/or bilateral development agencies. Because 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 suggests that the EIP developer should form a number of overlapping public-private partnerships with members appropriate to each level of the project. For instance, the developer could seek support for feasibility planning of the EIP from development banks, multilateral 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 creates a joint venture 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 government owns and develops the land, the investment picture is usually quite different. The high priority benefits are attraction of foreign direct investment, development of new local enterprises and expansion of existing ones, and creation of jobs. As an EIP achieves these goals, along with improvement of the industrial and agricultural environmental performance, the public agency may not be required to achieve the usual financial returns on investment. This is especially true when the park management offers tenants low rent, tax holidays, and other incentives. A publicly developed enterprise can generate the same variety of revenues as a private one; thus, a useful policy is to require management to calculate a bottom line, showing total financial, environmental, and social return on investment.

## Resource-Efficient Tools and Methodologies

Various approaches to reducing industrial pollution and resource use—such as cleaner production, eco-efficiency, and industrial ecology—have been developed and pursued by different organizations, each targeting some aspect of improving the resource efficiency of the production of goods and services. Many of these approaches share the common goal of reducing risks and fostering the sustainability of

economies and the environment. In this they also share the goal of achieving maximum efficiency in the way economic processes use natural resources.

Perhaps the biggest contributions of these approaches is that, together, they have provided a suite of methods and tools to help companies and utilities take responsibility for their products and services over their full life cycles. Such methodologies include industrial metabolism, material flow analysis, DfE, dynamic input-output analysis, industrial symbiosis and by-product exchange, systems engineering, and logistics engineering. This section describes some of these methodologies.

Proactive corporations and agencies that adopt these resource-efficient methodologies and invest in new technologies have the opportunity to turn environmental problems and constraints into profitable or financially beneficial outcomes. Increased productivity of resource use, product differentiation, and risk reduction are essential strengths for operating in a global economy.

The benefits of investment in resource efficiency are demonstrated by the experience of developed countries over the last 35 years. Whether the product is electricity, steel, paper, chemicals, or other commodities, industry has developed new and improved manufacturing and processing systems that make products using fewer natural resources and generating less pollution per unit of output. Through these changes, companies have complied with regulations and met or exceeded internal performance targets at a lower gross cost (e.g., operating, maintenance, disposal, and penalties).

## Product-Life Extension and the Service Economy

The concepts of product-life extension and the service economy go beyond all other industrial ecology approaches to closing the loop in industrial or consumer systems. Companies can realize cost-savings in materials, energy, transportation, consumables, and the need to manage the eventual disposal and/or recycling of a physical product through various strategies.

Product-life extension implies a fundamental shift from selling products themselves to selling the use of products, the customer value they yield. This change in the source of economic value to firms depends on

### Box 9.6: Dematerialization and Recycling in Building Construction

Construction waste recycling is the separation and recycling of recoverable waste materials generated during construction, remodeling, and demolition. Packaging, new material scraps, and old materials and debris all constitute potentially recoverable materials. In renovation, appliances, masonry materials, doors and windows are recyclable.

Some materials can be recycled directly into the same product for reuse. Others can be reconstituted into other usable products. Unfortunately, because of a combination of processing costs and transportation costs, recycling that requires reprocessing is often not economically feasible unless a user of the recycled resources is located near the material source. Many construction waste materials (such as dimensional lumber scraps) that are still usable can be donated to nonprofit organizations, keeping the material out of the landfill and supporting a good cause.

The most important initial step in a strategy to reduce construction waste is to reduce the amount of waste through good planning. Design should be based on standard sizes and materials and should be ordered accurately. The use of high-quality materials will reduce rejects. A good waste reduction strategy can reduce the amount of material needing to be recycled while increasing profitability and economy for the builder and the customer and reducing the demand for landfill volume.

Recycling of construction waste requires on-site separation. Initially, this requires some extra effort and training of construction personnel, but once separation habits are established, on-site separation can be done at little or no additional cost.

Other components of a waste reuse and recycling plan may include contracts with customers requiring regular pick-ups, use of reusable and standardized construction forms to avoid waste generated by single-use wooden forms, and placing marked bins and staging areas for different materials, with segregation of some materials for on-site reuse.

Technology is quickly developing for recycling of materials into reconstituted building materials and other products. The most widely used technology is the processing of asphalt and concrete debris into road building materials. Wood debris has been processed into a number of products, such as fuel pellets and composite board materials. Recycling of many waste materials requires only some additional effort and coordination with a salvage company or nonprofit organization to reuse them directly without reprocessing.

The potential for reduction, reuse, and recycling of such debris is very high. In a municipal program in the United States, it was found that 59.5% of the incoming debris volume was recyclable. Doing so would extend the life of their landfill approximately 4 years and generate \$1.5 million in revenue, sufficient to fund the cost of establishing an on-site construction and demolition waste-recycling center. Careful planning and effective management programs may achieve even higher levels of reduction, reuse, and recycling.

Any change in the present waste of such debris will benefit not only the profitability of the builder but also the municipality, which avoids the need for investment in additional landfill volume, and the global resource base, which is depleted by that much less materials.

Sources: Sustainable Sources. 2006, August. *A Sourcebook for Green and Sustainable Building*. Available: <http://www.greenbuilder.com/sourcebook/ConstructionWaste.html>

Shoou-Yuh Chang, and Rebecca Cramer. 2003. The Potential For Reduction of Landfill Waste by Recycling and Mining of Construction and Demolition Waste at the White Street Landfill, Greensboro, North Carolina. *Journal of Waste Technology and Management* 29(1). February.

enhancing product life through design strategies. Designers seek to optimize the following product qualities:

- durable and difficult to damage;
- modular;
- multifunctional;
- subcomponents standardized, self-repairing, or easy to repair;
- easy to upgrade;
- components can be reused in new systems; and
- units or systems can be easily reconditioned and remanufactured.

These design strategies are already part of the DfE toolkit. They can significantly cut demand on material and energy resources and reducing pollution from manufacturing. Product-life extension is highlighted in recent practices in the design of new buildings (Box 9.6). A huge volume of high

quality structural material becomes landfill waste, or is at best recycled (in the case of steel), during building demolition. To increase the ability to directly reuse building materials, buildings can be designed to make deconstruction an economical alternative to demolition. By providing standard design and detailing approaches, which make deconstruction more feasible, the market will be able to drive the move from demolition to deconstruction. To facilitate this, standards will need to be developed for structural members (e.g., structural steel beams, precast concrete planks, and heavy timbers), which are readily available in many markets. However, with current standards, it is difficult for an engineer to specify reuse without perceived exposure to increased liability.<sup>274</sup>

As a company moves from maximizing sales of material products to the delivery of customer satisfaction, its long-term source of competitive advantage will become the ability to provide the needed service. This idea is the basis of the service economy (also known as the functional economy).

Under a service economy, new ways of dealing with products at the end of their useful lives are related to increasing sales of services rather than products. Revenues could come from leasing of equipment with long life, continuing maintenance and service, major upgrading of systems, parts and supplies, service provider training, and licensing. Or the company might simplify the transaction by offering one, use-based fee.

However, it should be noted that leasing is not a guarantee of eco-efficiency. For instance, dealers of automobiles may still sell older vehicles to the poor and the cycle of deterioration may only be delayed, not ended. Some car hire companies in Australia compete on price with “rent-a-bomb” vehicles, which involves reusing secondhand cars that are well past their prime. This demonstrates the need to combine market-based approaches with effective regulation.

Implemented together, product-life extension and the service economy would help complement recycling by slowing the rapid unsustainable flow of materials and goods through the global, national, and local economies. By increasing the productivity

per unit of resource, they could help make very large reductions in materials and energy use needed to satisfy growing consumer needs.<sup>275</sup>

### Industrial Metabolism<sup>276</sup>

Industrial metabolism is a method used in the field of industrial ecology (IE), discussed in Chapter 1, to analyze resource flows through a given system and assess relative environmental impacts and critical points for intervention. Based on engineering’s mass balance analysis, it traces materials, water, and energy flows from initial extraction of resources through industrial and consumer systems to the final disposal of wastes.<sup>277</sup> This includes inputs into a socioeconomic system, internal flows within a system, flows between different socioeconomic systems, and outputs to the environment (Figure 9.1). It may be applied at the scale of a production line, factory, region, watershed, or even a nation. A few companies have conducted environmental audits based on this method. Regional application gives valuable insight into the sustainability of industry in natural units such as watersheds or atmospheric basins. Mapping sources, processes of transformation, and sinks in a region offers a systemic basis for public and corporate action.

Industrial metabolism analysis highlights the dramatic difference between natural and industrial metabolic processes: in natural systems materials flow in closed loops with near universal recycling. Industrial systems are often very dissipative, leading to materials concentrations too low to provide value but high enough to pollute. Dissipative use is where materials are degraded, dispersed, and lost in the course of usage. Any release to the environment in dissipative form (i.e., too diluted or chemically locked up to be of economic value) is unsustainable, because it moves material “out of reach” of the industrial cycles that depend on it.<sup>278</sup>

Below are some guidelines for improving the metabolic pathways of industrial processes and materials:

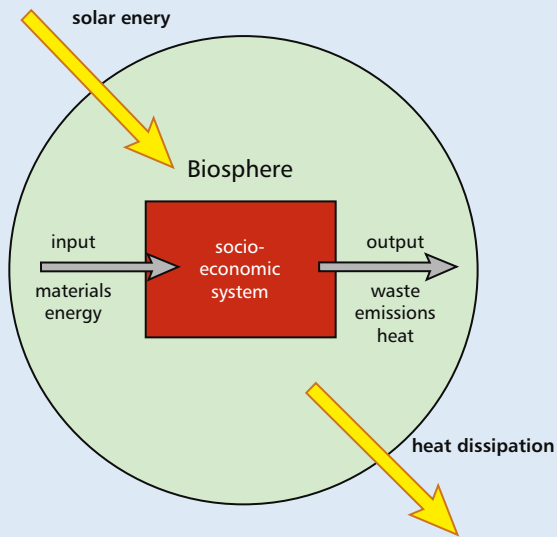
<sup>274</sup> American Society of Civil Engineers. 2005, 3 June. *Report on Forum on Technical Opportunities for Sustainable Infrastructure*. Available: <http://www.asce.org/files/pdf/instfound/june05report.pdf>

<sup>275</sup> Indigo Development. *Industrial Ecology Methods and Tools for Analysis and Design*. Available: <http://www.indigodev.com/Tools.html>

<sup>276</sup> Main source of the next three sections: Lowe, Ernest, John Warren, and Stephen Moran. 1997. *Discovering Industrial Ecology: An Executive Briefing and Sourcebook*. Cleveland, Ohio: Battelle Press.

<sup>277</sup> Footnote 275.

<sup>278</sup> Ibid.

**Figure 9.1: Flow of Materials and Energy**

Source: Weisz, Helga, and Heinz Schandl. 2005. *Material Flow Analysis: A Comparison Between Industrialized and Developing Economies*. Open lecture at Universitat Autònoma Barcelona. 26 April. Available: [http://www.iff.ac.at/socec/backdoor/sose05-barcelona-mssm/Open\\_lecture\\_MFA.pdf](http://www.iff.ac.at/socec/backdoor/sose05-barcelona-mssm/Open_lecture_MFA.pdf)

- Reduce dissipative uses of materials through change in product or process design, enhancement of reuse, and recycling.
- Change product design to eliminate toxic materials from being dissipated into the environment as a factor of use.
- Reduce the number of steps in processes to achieve greater energy and resource efficiencies.
- Create on-site, on-demand production of toxic materials.
- Emulate biological metabolism in temperature and pressure and in cyclic processes.
- Improve overall system efficiencies as a cooperative effort between suppliers and customers.

### Dynamic Input-Output Models

Faye Duchin, Director of New York University's Institute of Economic Analysis, created "what if" tools on the foundation of industrial metabolism and structural economics. These dynamic input-output models enable business and policy decision makers to perceive the broad business, economic, and environmental implications of systemic technical change. They can be applied to a regional or national economy or specific issues in it.

Input-output models add environmental resource accounts to economic information about the 100+ industrial sectors found in standard national input-output tables. By incorporating a time dimension, Duchin created a means of analyzing the total impacts of alternative scenarios of industrial change. How would the changes affect the environment, businesses in the target industry, and their major suppliers and customers?

Duchin's work provides "an analytic framework for considering the economic implications of complex webs of technical changes... Dynamic input-output models are used to develop a set of possible solutions rather than a single optimal one... (making it) possible to experiment with changes in input structures that might reduce water usage in production, for instance, or recover products of economic value... A more complex set of results, involving economic and environmental trade-offs, can be evaluated." Duchin has applied input-output modeling to issues of household consumption, an important first in IE. Most industrial ecologists focus on manufacturing.<sup>279</sup> An application to transportation is given in Box 9.7 (see page 158).

### Industrial Symbiosis and By-Product Exchange

The concept of industrial symbiosis, a key field of study and practice of industrial ecology, is based on this process of exchange and collaboration between or among firms, where one facility's waste (energy, water, or materials) becomes another facility's feedstock. Inherent to industrial symbiosis is a cooperative approach to competitive advantage among traditionally unrelated firms. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity.<sup>280</sup>

A by-product exchange is especially useful when managers in a plant reach the limits of cleaner production and still have major unusable wastes. The concept of industrial symbiosis broadens the mission of such a network to sharing other resources, as well as by-products, especially energy, water, and a wide range of services (Box 9.8). For instance, in

<sup>279</sup> Ibid.

<sup>280</sup> Chertow, M. R. 2000. Industrial Symbiosis: Literature and Taxonomy. *Annual Review of Energy and Environment*. 25:313-337.

### Box 9.7: Applying Input-Output Modeling to Transportation

#### From the Viewpoint of an Automobile Manufacturer

An automobile manufacturer might choose to study the impact on the environment and its own future of possible socio/technological changes such as:

- innovations in engine design resulting from much higher standards for emissions and fuel efficiency,
- systemic redesign of small vehicles as proposed by Amory Lovins,
- increase in the United States' fuel prices to the global average, and
- dramatic increase in short- to mid-distance rail transport and a resulting increase in demand for rolling stock and feeder motor vehicles.

In the input-output study, the auto manufacturer could build alternative scenarios, such as:

- remaining focused on traditional motor vehicle transport through technological innovation needed to meet the regulatory and economic changes;
- developing and marketing lines of alternative vehicles (electric, hybrid-electric, etc.); and
- possible diversification into railcar production through acquisition of a current manufacturer and retooling some of the company's auto parts plants.

Researchers would then go through these steps:

1. Create conceptual models to develop the most useful research questions and to guide next steps.
2. Build a database of relevant data in a form the dynamic input-output model can use:
  - o national accounts with industries selected for the study (if working in a model of the national economy);
  - o environmental accounts reflecting resources and sinks (as well as wastes and emissions) needed to analyze the environmental impact of the technological changes in question;
  - o the company's financial information, especially capital stocks, investments, etc.;
  - o data on capacity utilization and costs, stocks, and flows for energy and materials; and
  - o information on the technologies being evaluated, including projections of technical data for the future.
3. Use existing strategic and technology innovation plans to develop detailed scenarios about alternative future paths.
4. Evaluate each scenario from economic and environmental perspectives using the dynamic input-output model.

The final products for the manufacturer would be a set of scenarios with assessment of the impact of each possible course on its own economic interests and its impact on the environment. It would have a rationale to guide policy and public relations work around its decision. The modeling tool developed for transportation would continue to be useful for evaluation of new strategies as other environmental, technical, and social changes emerge.

#### From the Viewpoint of Government Ministries

The transportation and economic development ministries of a developing economy might use input-output modeling to evaluate alternative scenarios for creation of a transportation infrastructure and industry. Scenarios explored might include:

- auto-and-truck-based highway system,
- rail-based, intermodal system, and
- moderation of need for travel through application of information technologies.

Some key elements in the model are:

- vehicle efficiency and fuel use;
- emission characteristics and air pollution;
- demands on energy and material resources;
- economic and environmental implications of new roads, rail lines, telecommunications, and other infrastructure;
- congestion and travel times;
- choice among material processing technologies and the associated demand for material and energy resources;
- labor requirements and the capacity of the educational system; and
- information system requirements.

For instance, the leadership of the People's Republic of China is presently projecting an industrial development strategy based on automobile and truck manufacturing and infrastructure. An input-output study as outlined here could open an effective process for exploring alternative strategies.

Source: Lowe, Ernest, John Warren, and Stephen Moran. 1997. *Discovering Industrial Ecology: An Executive Briefing and Sourcebook*. Cleveland, OH: Battelle Press.

**Box 9.8: Industrial Symbiosis in Gujarat**

The Naroda Industrial Estate in Ahmedabad, Gujarat, which encompasses 30 square kilometers, includes approximately 700 companies from a diverse set of industries, such as bulk chemicals, pharmaceuticals, dyes, textiles, and food processing. The Naroda Industrial Association partnered with researchers from the University of Kaiserslautern, Germany, to identify potential inter-firm partnerships. One of these opportunities involved collecting spent sulfuric acid, a by-product by several different chemical companies, to produce ferrous sulfate, which has application in textiles, agriculture, and water purification. This production could take place at another company in the estate that had previously been forced to close, but which already owned much of the necessary production technology, drastically reducing the initial capital cost of the project. As a result of the project, chemical companies reduced costs associated with disposal by 50%, local buyers benefited from decreased production costs, and there were unquantified economic benefits to the region from the saving of landfill space and the reduction of environmental risk.

Source: Wilder, Martin Z. 2003. *Economic Growth, Environment and Development*. New Delhi: Manak Publications.

Kalundborg, Denmark, the primary partners—an oil refinery, power station, gypsum board facility, and a pharmaceutical company—share groundwater, surface water, wastewater, steam, and fuel, and also exchange a variety of by-products that become feedstocks in other processes (Figure 9.2). High levels of resource and economic efficiency have been achieved, which has led to many other less tangible benefits involving personnel, equipment, and information sharing.

An interesting debate is the relative extent to which industrial symbiosis emerges from the bottom-up among firms that find it mutually advantageous to make various exchanges or comes top-down through planning processes. Both processes are being used in Asia. As an example of a top-down approach, Japan has designated many ecotown projects, where industrial partners in a city are pursuing waste and material reuse across firms (page 126). One useful mechanism to initiate and expand intercompany collaboration is a coordinating council. In the PRC, “waste minimization clubs” have sprung up in the very large industrial areas of Tianjin and Nanjing.

**Figure 9.2: Industrial Symbiosis in Kalundborg, Denmark**

