Chapter 5

Green industry concept and practices

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5.1 SUSTAINABLE DEVELOPMENT GOALS AND SUSTAINABLE INDUSTRY

Urbanization and industrialization are inevitable processes that enhance the quality of life. Urbanization is a process in which the natural cover is transformed into an artificial one with the aim of providing a foundation for human activities and living spaces. Unfortunately, in the course of the urbanization process, the environment becomes polluted and the ecosystem is damaged. Highly impermeable surfaces, such as roads, buildings, parking lots, etc., in urban areas cause a wide array of problems, including alteration of the natural water circulation, increased pollutant discharge, increased urban flooding, lowered groundwater level, heat island effect, and habitat destruction resulting from reduced green spaces. Meanwhile, industrialization is a process in which the goods and services required in our lives are produced and provided; this process poses an even greater threat to the environment and to our ecosystem than urbanization does.

Today, many developing countries are continuously pursuing industrialization as a way to overcome poverty and increase the standard of living so as to achieve a decent and quality way of life, while the developed countries are also expanding their industrialized platforms to further increase the quality of life of their people. Due to

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the ever-growing thirst for industrialization in the world, however, many countries are faced with serious environmental degradation and resource depletion issues. In an effort to solve such problems, United Nations (UN) members started discussions on Sustainable Development Goals (SDGs) in Rio +20, which was held in Brazil in 2012; the SDGs were finally adopted by the UN General Assembly in September 2015. The SDGs are a way of development that suits the current generation's needs while not harming the potential to meet the needs of the next generation.

'Social development', 'Economic growth', and 'Environmental protection' are the key elements of SDGs. Currently, there are 17 goals and 169 targets set during the period of 2016–2030 (UN, 2016). Most of the SDGs are related to *industry*, *economy*, and the *environment* and in order to achieve the three key elements, green industry must be established. The purpose of SDGs is to both achieve environmental protection and economic growth at the same time which can be described as *sustainable industry*. Many businesses are now shifting from their conventional ways, focused on resource consumption and maximization of production, to a new paradigm in which production, environmental protection, and circulation of resources considering the limitations of nature can coexist. The idea of sustainable industry is important in that it can provide a comprehensive, industry-wide approach to environmental problems as well as helping individual businesses tackle environmental issues on their own. In other words, many individual companies can apply the lessons they have learned from the system of circulation in nature to the building of an interconnected production system under the framework of sustainable industry. This perspective, which aims to establish an industrial complex that has characteristics similar to those of an ecosystem, is now being vigorously promoted by both the developed and developing countries, along with the SDGs.

5.2 GREEN INDUSTRY CONCEPT

Green industry means a type of industry based on an eco-friendly system in which the existing industrial structure, kept intact, is restructured into a more environmentally-friendly system. Green industry pursues sustainable production and consumption patterns, considering elements such as resource and energy efficiency, low carbon and waste emission, and non-polluting and safe industry through lifecycle management. The green industry agenda includes the 'greening' of industry meaning resource production and environmental efficiency for all types of industries which is enhanced on a continuous basis. In addition, green industry generates environment-related goods and services, such as waste management and recycling services, renewable energy technologies, and environmental analysis and advisory services (United Nations Industrial Development Organization [UNIDO], 2011).

Green industry guarantees a consistent improvement in environmental performance in all industries, regardless of sector, size, or location. It includes efficient use of resources in processes and production, phased reduction in toxic substance discharge, replacement of fossil fuels with renewable energy sources,

enhanced occupational health and safety, and commitment to and action toward fewer environmental impacts, along with increased liability of manufacturers and overall risk reduction efforts (Figure 5.1).

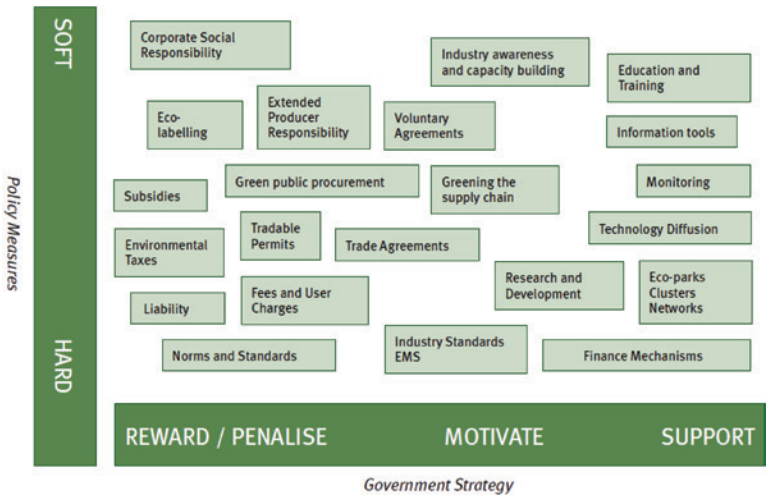

Figure 5.1 Policy Matrix for Green Industry (UNEP/CSCP, 2007; UNIDO, 2011).

In order to achieve sustainable performance in the green industries, systematic and comprehensive methods must be adopted; these methods will also serve as the foundation for a new business model. Efforts to establish a closed-loop circular production system look to the recycling of disposed products and to new resources for production (Figure 5.2).

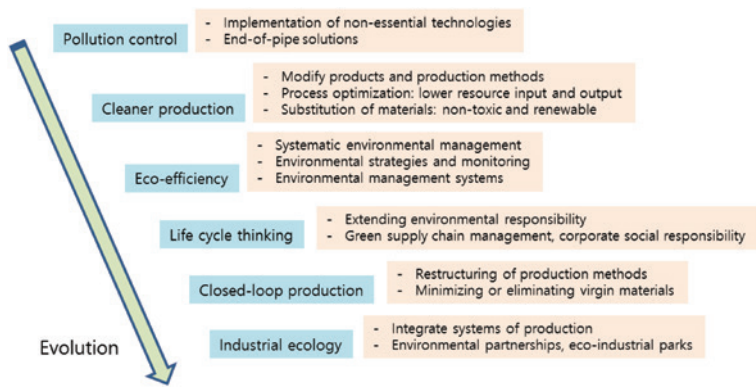

Figure 5.2 Evolution of sustainable manufacturing concepts and practices (Organisation for Economic Co-operation and Development [OECD], 2010).

5.3 GREEN INDUSTRY PRACTICES

The ecosystem consists of biotics and the environment, and is run by mass circulation and energy flow. An industrial complex has mechanisms similar to that of the ecosystem, since it is a venue for business activities in which goods are produced using raw materials; this system resembles the mass circulation and energy flow of nature. Based on this perspective, the notion of industrial ecology is introduced. Industrial ecology is a field of study systematically exploring the use and flow of substances and energy in manufacturing and its processes, in industries, and in the economy as a whole at local, regional, and global levels (Gibbs & Deutz, 2005). Industrial ecology is focused on potential roles of businesses in reducing environmental pollutant loads, which are created during the lifecycle of product manufacture, and which range from the export of raw materials and manufactured goods to the use of products and on to waste management (Figure 5.3).

Figure 5.3 Green economy as an integrated framework for policies on material use (European Environment Agency [EEA], 2016).

5.3.1 Environmental accounting (EA)

Environmental accounting (EA) is a useful tool that can help in the decision-making process of private sectors. Whether a business seeks pollution prevention or sustainability of its operation, EA can help in the realization of financially feasible environmental innovations. Environmental management accounting (EMA) is a concrete application of environmental management for identification, analysis, and use of key physical and monetary information during the internal decision-making process. Physical information includes information on the use and flow of energy, water, and materials, and also on the final products; monetary information refers to information on costs, revenues, and cost-reduction methods regarding the environment (Jasch, 2001). Material flow cost accounting (MFCA) is one of the EMA methods designated by the ISO standard; it focuses on the

discharge of waste and pollutants by businesses and the tracking of their non-products. This method can contribute to reducing the use of materials, energy, and water while improving the productive use of materials, thereby helping to improve the economic and environmental effects of a nation (Figure 5.4). In a country with a relatively low labor cost, use and loss of materials and energy is a vital factor in cost-effectiveness improvement. Thus, MFCA is an important tool to increase resource efficiency in developing and emerging economies (Kokubu *et al.* 2009).

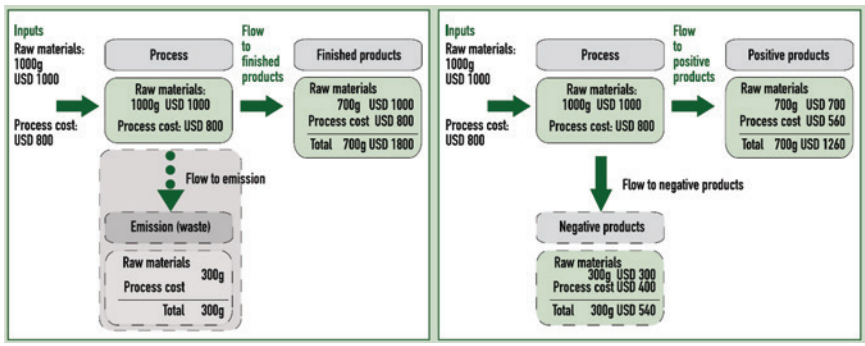

Figure 5.4 Comparative example of conventional cost accounting (*above left*) and material flow cost accounting (*above right*) (Kokubu *et al.* 2009).

5.3.2 Eco-industrial park (EIP)

To develop industrial parks that use a huge quantity of energy and industrial water and also generate waste by-products into sustainable industrial parks, it is necessary to form an eco-friendly eco-industrial park (EIP). EIPs are industrial parks designed, developed and operated for a cleaner production by means of adopting the concept of industrial ecology. The EIP was first presented in the United Nations Conference on Environment and Development at Rio de Janeiro, Brazil in 1992. The universal concept of EIP used internationally is the concept first proposed by the Indigo Development Team in 1992 and this concept was expanded by the United States Environmental Protection Agency (US EPA) in 1995. The concept of EIP was improved as depicted by Ernest Lowe in the Eco Industrial Handbook published by the Asian Development Bank in 2001.

5.3.2.1 Planning the new industrial park

The EIP is an industrial complex composed of the mechanisms of the ecosystem that is based on organic relations that minimize the use of materials and energy, and the amount of pollutants generated via ecological interconnectedness among businesses. In such a complex, more efficient environmental improvement activities and increase in productivity can be expected when compared to a single business

attempting to do such jobs alone. The support that a nation can provide to such a complex activity can bring more achievements than any help given to a single company. The most distinctive difference between the conventional industrial complex and the EIP is that while the network formed in the conventional industrial complex focuses on raw materials and products, businesses in the EIP forge a network based on by-products and wastes (Figure 5.5). The EIP can be called an industrial symbiosis, virtual EIP, or eco-industrial network depending on the content or the type of connectedness forged among businesses (Leuenberger, 2015).

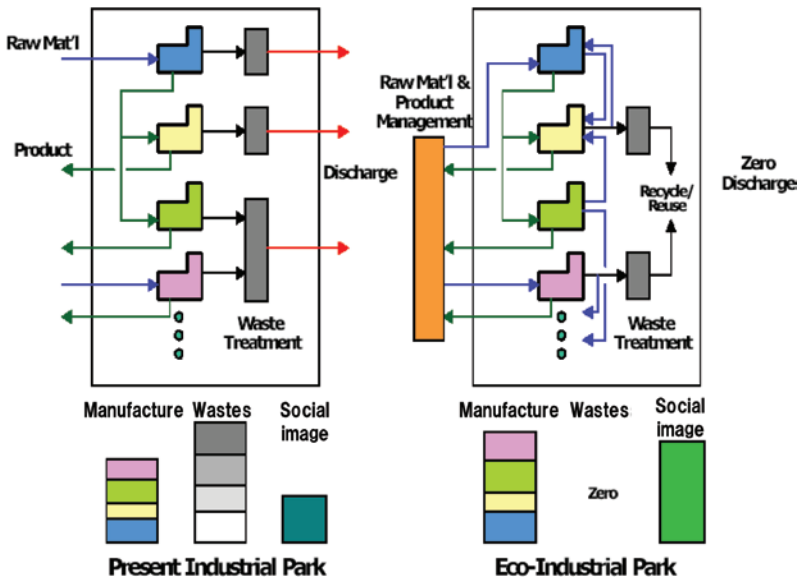

Figure 5.5 Schematic diagram of eco-industrial park (EIP, 2005).

A comparison of the characteristics of conventional industrial parks and EIPs is shown in Table 5.1. In general, parks having only recycling and environmental technology-related firms, green product manufacturers, and a single environmental theme (e.g., parks with firms using solar energy) are not classified as EIPs. The most important aspect in building an EIP is that firms voluntarily participate in network formation, and the industrial park infrastructure is governed by low impact development (LID) that seeks to minimize impact on the environment. To this end, it is necessary to guarantee the mutual interests of the participating firms.

5.3.2.2 Transforming existing industrial parks

For the industrial parks that are already created, it is important to form an eco-industrial network among firms regarding matters, energy, and by-products.

Generally, in parks where firms in the same industry are gathered together, it is impossible to exchange by-products and is thus, not easy to build an eco-industrial network. The method of transforming existing industrial parks to EIPs is shown in Figure 5.6. The transformation process of existing industrial areas/parks/clusters into EIPs involves various aspects such as infrastructure development, planning, estate management and capacity building. To efficiently transform existing industrial parks to EIPs, it is necessary to apply green infrastructure. To this end, activities shown in Table 5.2 are needed.

Table 5.1 Characteristics of conventional industrial park and eco-industrial park (EIP).

Parameter	Conventional Industrial Park	Eco-industrial Park (EIP)
Selection criteria	Economic feasibility	Economic and environmental feasibility
Connectivity	Raw materials or products	Raw materials, products, by-products, wastes, etc.
Management of wastes	Individual or joint treatment	Reuse as resources
Management authority	Industrial complex corporation	Industrial complex corporation and independent organization
Waste generation	High	Low
Relationship with local communities	Many civil complaints	Participation of local communities
Social image	Pollution sources	Environmental and social harmony
Components	Request for quotation	Spontaneous participation
Storm drainage	Fast drainage by storm pipe	Natural water circulation system
Soil cover	Highly impermeable pavement	Highly permeable pavement
Public spaces	Low	High
LID application	Low	High

5.3.3 Stormwater management

The artificial environment, such as the industrial complex, causes serious air, water, and ground pollution due to the various types of wastes and pollutants it generates. In order to reduce the various environmental impacts, ecological engineering is being introduced to the industrial complex. The concept of ecological engineering was first introduced in 1963 by Howard Odum, an American ecologist. At the initial stage, ecological engineering suggests natural energy as a controlling factor to manage and control the environmental system

(Odum & Odum, 2003). The recent concept of ecological engineering is more about designing a sustainable ecosystem in which human society is integrated with nature so that benefits are brought to both humanity and the natural environment. The final goal of ecological engineering is to restore the ecosystem, long-disturbed by human activity, as well as to develop a sustainable eco-system in which human and ecological values go hand-in-hand. In the 21st century, landscaping, civil engineering, environmental, design, and energy technology are grafted with ecological engineering in a wide range of industrial complex and other social infrastructure development projects.

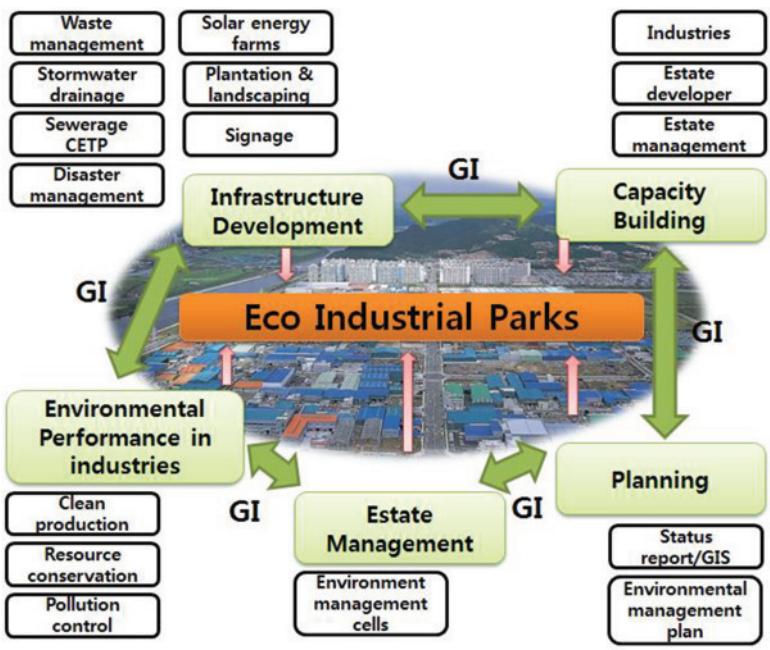

Figure 5.6 Transforming existing industrial parks to eco-industrial parks (EIPs) (CETP: common effluent treatment plants; GI: green infrastructure; GIS: geographic information system).

Recently, in some developed countries, including the United States, the adoption of ecological engineering onto the social infrastructure sector in such areas as landscaping, civil engineering, and design, and energy technology, instead of the conventional plan-based approach used in land-use planning, has been actively promoted. This is called 'green infrastructure', a concept in opposition to gray infrastructure, which is based on the conventional social infrastructure development methods that do not take into account ecology or the environment.

Table 5.2 Relevant activities for transforming existing industrial park to eco-industrial park (EIP).

Parameter	Content
Setting up of common effluent treatment plants (CETPs)	• Includes sewerage system, disposal system, recycle/reuse – Activities include undertaking feasibility studies • Prepare the project development module with relevant business model for setting up of CETP • Implement the optimal technology
Stormwater drainage system	• Assess and restore the natural water circulation system by increasing infiltration capacity and green spaces • Implement the possible green infrastructure technology
Plantation/green belts	• Identify the potential areas (block plantation, avenue plantation) by environment management cells (EMCs) at industrial parks • Implement the possible plantation/green belts technology
Solar energy farms	• Perform pre-feasibility studies • Prepare the project development module with relevant business model for setting up of CETP • Implement the possible technology
Disaster/hazard management systems	• Prepare the disaster management plans (on-site, off-site) for the identified industries and industrial parks • Design and specify the disaster management infrastructure • Implement the possible technology
Waste management	• Includes measures for clearing up wild dump sites and for management of hazardous wastes as well as solid wastes
Environment management cells (EMCs)	• Set environment management cells
Renovation of infrastructures	• Renovate gray infrastructures to green infrastructure (GI) • Install the natural water circulation system by applying LID/GI techniques

5.4 CONCLUSIONS

The key elements of SDGs include social development, economic growth, and environmental protection aimed to solve economic inequality on a global level, environmental degradation, and the severely damaged ecosystem. Green industry has been adapted as a worthy solution to achieve environmental protection and economic growth at the same time. Green industry is a type of industry based on an eco-friendly system that runs resource and energy efficiency, producing low carbon and waste emission, non-polluting and safe industry through integrated lifecycle management. The EIP is an industrial complex composed of the mechanisms of the ecosystem. EIPs are perceived as important alternatives to build sustainable industrial parks. Industrial ecology for EIPs, which resembles the mass circulation and energy flow of nature, is focused on potential roles of businesses in reducing environmental pollutant loads with managements of the lifecycle of

product manufacture. EA and EMA are useful tools that can help the decision-making process in the private sector and actual application of environmental management during the internal decision-making process. MFCA is one of the EMA methods, which is a tool to increase resource efficiency in developing and emerging economies. Ecological engineering is a technological approach for solving various environmental problems in the industrial complex. Recently, a variety of fields such as landscaping, civil engineering, environmental, design, and energy technology have been grafted with ecological engineering in a wide range of industrial complexes. Stormwater management using green infrastructures is one of several practices that can incorporate the ecological engineering concept applicable in industrial areas.

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