Eco-Industrial Park (EIP) Initiatives Toward Green Growth: Lessons from Korean Experience

Suk-Chan Ko

Abstract The purpose of this article is to provide a more systematic understanding of supporting mechanisms for Green Growth based on the experiences of Eco-Industrial Park (EIP) development in South Korea. Since the enactment of "the Act to Promote Environmentally Friendly Industrial Structure" in 1995, the central government tried to establish a system for cleaner production and environmental management system. In 2005, Korea had also launched an ambitious EIP initiative under the leadership of the Ministry of Commerce, Industry, and Energy. The cases of several pilot projects for EIP in Korea indicate that inappropriate selection of the target industrial parks, conflicts of interests among stakeholders, poor planning, and lack of financial support from the government deteriorated the vitality of the project as a whole. The experience of EIP development in Korea shows that the spontaneous and active participation through training programs for citizens and government officials and the cooperation between the central and local government can guarantee the success of EIP project in the future.

1 Introduction

In March 2005, the 5th Ministerial Conference on Environmental and Development in Asia and the Pacific held in Seoul, Korea. Approximately 340 delegates participated and embraced the approach of environmentally sustainable economic growth. The conference endorsed 'Green Growth' as a policy focus and a powerful strategy to promote 'win–win' approaches in reconciling the conflict between the goal of poverty reduction and the goal of environmental sustainability (ESCAP 2006).

The 'Green Growth' approach seeks to harmonize the two imperatives of economic growth and environmental sustainability by promoting "fundamental

S.-C. Ko (✉)
Prof. Urban Planning & Real Estate Studies Dankook University, Yongin-si, South Korea
e-mail: sukchan@dankook.ac.kr

D.-S. Oh and F. Phillips (eds.), *Technopolis*,
DOI: 10.1007/978-1-4471-5508-9_19,

changes" in the way societies produce and consume. The Green Growth requires the introduction of concept and system changes. Across the world, corporations and small and medium-sized enterprises are becoming agents of change for sustainability. They acknowledge the issues of global warming and green growth and their relevance to businesses. Eco-efficiency and eco-innovation can be good for business and it is becoming widely held view in the business community that solving environmental and social problems is essential for the future growth of firms.

The current economic crisis and negotiations to tackle climate change should be seen as an opportunity to shift to a greener economy. Incremental improvement is not enough. Industry must be restructured and existing and breakthrough technologies must be more innovatively applied to realize green growth.

Industries have traditionally addressed pollution concerns at the point of discharge. Since 'this end-of-pipe' approach is often costly and ineffective, industry has increasingly adopted cleaner production by reducing the amount of energy and material used in the production process. Many firms are paying more attention to the product's lifecycle and are integrating environmental strategies and practices into their own management systems (OECD June 2009 Policy Brief). Some pioneers have been working to establish a closed-loop production system that eliminates final disposal by recovering wastes and turning them into new resources for production. Eco-Industrial Park (EIP) and Eco-innovation help to make possible this kind of evolution in industry practices.

There have been diverse government policy initiatives and programs that promote eco-efficient and eco-innovation. These include both supply-side and demand-side measures. As most countries recognize the need for more collaborative approaches to innovation, many initiatives involve creating networks, platforms, or partnerships that engage different industry and non-industry stakeholders.

The purpose of this chapter is to provide a more systematic understanding of supporting mechanisms for Green Growth such as Eco-Industrial Park (EIP) and Eco-Innovation. First, I would like to introduce the concepts of Eco-Industrial Park and Eco-Innovation, and then I will review the process of EIP development strategies in Korea and their policy implications. Third, I will discuss how these concepts and principles can be applied to the development and management of science park projects in many countries in the future.

2 Industrial Ecology and Eco-Industrial Parks

2.1 Industrial Ecology and the Role of Government

Industrial ecology is a strategic approach attempting to reduce environmental impacts by applying the principles of natural ecosystems to the industrial processes (Deutz and Gibbs 2004). Although similar concepts circulated in the 1970s, the concept was systematized by research on 'industrial metabolism' by Ayres (1989).

Industrial ecology studies construction of a 'closed-loop production system' which is analogous to natural ecosystems. The closed-loop system assumes the re-input of wastes and by-products into the production system. Existing industrial systems suppose unlimited inputs and outputs of resources by considering resource flows as linear (Korhonen et al., 2004). In industrial ecology, the resource networking between plants is called 'industrial symbiosis', as in symbiosis between species in the natural system.

The systematic approach to industrial ecology results in the treatment of individual companies' economic interests in decreasing input resources and wastes in addition to the social benefit of reducing the load on the environment. The approach is thought to be the realization of the concept of sustainability in terms of considering economic growth and environmental concern simultaneously. The EIP project is to actualize this principle of industrial ecology.

The concept of EIPs was first made known when Indigo Development introduced it to EPA officials in 1993 (Lowe 2001). After that, the President's Council on Sustainable Development (1997) chose the EIP project as a model project in the Clinton Administration. The EIPs located in Fairfield, MD, Cape Charles, VA, Chattanooga, TN, and Brownsville, TX, are the outcomes of such US government initiatives. The US cases are examples of intentional policy efforts promoted by the government, while the spontaneous appearance of an EIP is found in the industrial park in Kalunborg, Denmark (Ehrenfeld and Gertler 1997).

An EIP 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. Lowe (1997) pointed out that "EIP conjoins the principles of mixed use development, recycling business and by-product exchange in coordination with green technology companies that makes eco-friendly products."

The intention behind the EIP is the formation of a corporate network where pertinent companies cooperate with each other and neighboring communities to accomplish the common goals related to economic interests, the improvement of environmental quality and the fair use of human resources (Cohen-Rosenthal 2003). The EIP provides a participating corporation with the various advantages of curtailing costs of supplying input resources and treating wastes, and publicity of an environmentally friendly corporate image. In addition, there are great social benefits from the construction of environmentally friendly communities that namely reduced energy and resource consumption, and sustainable treatment of wastes, and the reduction of social costs created by conflicts between companies and local communities. The government also enjoys a few advantages, reducing some regulation costs thanks to corporations spontaneously joining in 'green business' and accomplishing social integration with small expenses (von Malmborg 2004). As mentioned, many governments of the world have enthusiastically been promoting EIP projects for these reasons.

However, there are some opposing views about the government's involvement in promoting EIP projects. The question is whether or not the public sector should actively lead the EIP project. Some insist on a government-led approach while others advocate a market-led approach. The American and Korean cases are typical examples representing the active role of the public sector, while the case of Kalundborg, Denmark, is a representative example of a spontaneous project promoted by the private sector. Both approaches have strengths and weaknesses. The government-led approach has the advantage of being able to easily initiate the project. Meanwhile, it has the disadvantage of not being able to guarantee the persistence of the project. The market-driven approach's strength is in the EIP's firm persistence once the project begins, while its weakness is in the difficulty encountered for the project to begin. Therefore, it is hard to assess which acknowledges the role of public authorities in the development of EIP projects, while others such as Ehrenfeld and Gertler (1997), Bass (1998) and Waller (1999) emphasize corporate spontaneity and the role of the market mechanism in the project.

2.2 Eco-Industrial Park Management and Support Services

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

An EIP encompasses two distinct but overlapping business entities. It is a real estate development property that must be managed to provide a competitive return to its owners. At the same time, an eco-park is a community of companies that must manage itself to gain common benefits for its individual members. The full range of management functions to be performed by the combination of business community and park management systems include the followings:

- Maintain the values, culture, and identity of the eco-industrial park as a community.
- Resolve conflicts between companies, between park management and tenants, and between the needs for future viability and present efficiency.
- Facilitate the self-organizing community development process among tenants.
- Recruit firms to keep the park fully leased and maintain the mix of companies needed to best use by-products as companies change.
- Coordinate recruitment with local and state economic development agencies.

Table 1 Environmental management continuum for industrial parks

Standard Industrial Park	Concentrated industrial and business activity within a defined planning boundary with organized infrastructure
Eco-labeled Industrial Park	A labeling scheme developed in France to recognize an organizational set of enhanced environmental practices and amenities in industrial parks and zones
Environmental Industrial Park	Clusters of manufacturers of environmental products providers of environmental services and developers of environmental technologies
Eco-efficient Park	Cluster of companies working to reduce resource intensity, control pollution and minimize collective waste outputs
Environmentally balanced industrial cluster	Clusters of industries co-located such that the by-products of one become the inputs or materials for other businesses or industries to minimize waste and dissipation of resources
Eco-Industrial Park	Clusters of companies taking into account of ecological limits, using resource-efficient infrastructure, buildings and processes, networking purchases and a balance of producers, scavengers and decomposers

- Track present trends and emerging challenges and opportunities, including: patterns of inter-company collaboration, technologies, and firms that support by-product exchange, changes in regulations at all levels of government.
- Support continuous evolution of economic and environmental performance for individual companies and the park as a whole by managing a learning center and designing new inter-firm initiative.
- Conduct audits of successes as well as failures in EIP performance to assure learning and improvement.
- Coordinate provision of shared support services.
- Set up a project operations room to support effective work by the park management company and the community self-management system or tenants association (Lowe 2001).

EIP requires an ecological or systematic approach and must be more comprehensive involving more aspects and both management and tenants. EIP can be a part of environmental management continuum for industrial parks as shown in Table 1.

3 Eco-Industrial Park Development in Korea

Industrial policies in Korea have been changed drastically since the Ministry of Commerce, Industry, and Energy MOCIE(currently the Ministry of Trade, Industry, and Energy) since February, 2013 enacted 'the Act to Promote Environmental Friendly Industrial Structure' in December 1995. Based on this Act, the ministry established an institutional system for cleaner production (CP) and

environmental management system based on ISO 14001 as an implementing tool. The first comprehensive master plan for environment friendly industrial development was made and operated based on this Act. The plan includes: streamlining the supporting system, cleaner production transfer and dissemination, promoting environmental industry, and stimulating environmental management. The cleaner production transfer and dissemination deal with technology transfer, international collaborative projects, supply chain environmental management, and eco-industrial park development (Park et al. 2008).

More recently, Korea has launched an ambitious EIP initiative in 2005, under the leadership of the Korea National Cleaner Production Center (KNCPC) and the Korea Institute of Industrial Technology (KITECH). Six industrial parks or complexes out of 35 large national parks were designated as EIP projects, and some of these projects are actually clusters of several industrial parks. Eventually, this initiative would encourage all 504 industrial parks in Korea to achieve the transition to become EIPs. The six industrial complexes that are pilot projects in the EIP initiative are listed in Table 2.

Table 2 Six industrial complexes selected as EIP projects in Korea

Name of Complex	Land Area (hectare)	Number of Companies	Major Industries and Characteristics
Banwol and Siwha	3,180	5,400	Located in the southern part of Seoul metropolitan area Typical industries include textile, dying, pulp, chemical plants, small manufacturers, and waste incinerators
Mipo and Onsan	5,557	700	Located in Ulsan city, industries are automobile manufacturing, ship building, and one of the world's largest petrochemical complexes; Nonferrous metals, steel, and metal manufacturers are the major industries
Yeousu	3,130	149	Located in the southern part of Korea and is primarily a petrochemical complex and refinery with 149 companies
Cheongju	410	200	Major industries are textile, paper-mill, petrochemical, electronics, nonferrous metals, metal manufacturing and assembly
Machun, Chilso, Sangpyeng	581	550	Three clusters of smaller industrial parks include Machun Industrial Complex at Jinhae, Chilso Industrial Complex in Hanam, and Sangpyeing Industrial Complex at Junju. The three clusters are around 50 km apart. Most of the companies in these locally managed parks are small and medium enterprises. Industries at Jinhae include nonferrous metal, steel, and machinery and at Jinju, food, textile, pulp, and chemical
Pohang	2,010	220	Located in Pohang city, major industries include cement, steel, metal processing, fine chemical, and waste disposal

The Korean EIP initiative is notable for the potential impact on all industrial parks in Korea, because this initiative is a 20-year, 3-phase long-term project. Korea has a total of 504 industrial parks, with 35 large national parks or complexes on two-thirds of the total industrial land (about 66,635 ha) and the government intends to transform the major industrial complexes into EIPs in the long run.

The first phase (2006–2010) of the developmental plan strives to perform trial projects for two industrial parks in order to shift them to EIPs, with prior understanding of the material and energy flow analysis, input and output of raw materials, products, by-products, and wastes. An energy efficient by-product exchange network would be created using the basic concepts of industrial ecology. Pollution monitoring systems are installed to envisage the existing wastewater and waste treatment systems. Additionally, an integrated environmental management system would emerge together with detailed analysis of the infrastructure. Sustainable education and awareness campaign has been conducted. The development so far has envisioned for further phases that would upgrade the existing manpower resources in conjunction with an organizing group that manages the operation on a timely basis (Park et al. 2008).

The second phase (2011–2015) would provide conceptual ideas and disseminate understanding of the designed concept to twenty other industrial parks. It would also help in spreading the environmental management system and sustain a balance between the different key factors that are likely to influence economic growth. A system of common sharing and practice, common purchase and common transportation system would be organized to establish an enlarged infrastructure that is capable of handling joint ventures.

The third phase (2016–2025) would overview the flaws and constraints envisioned in the earlier phases and strive to rework and reinvent the existing system of practice. The performance indicators would be analyzed and evaluated by an expert committee to redesign any missing components and infrastructure. The ultimate aim would realize and pave the way to provide zero discharge in all process industries within the EIPs.

The Korean EIP Model is characterized as a cluster of inter-networking businesses, which perform individual and collective cleaner production program prior to by-products exchange network within an environmental management system (Chiu 2005). Under such framework, the KNCPC and Korea Industrial Complex Corporation will be the main actors in implementing the different phases and strategically supervising the development and implementation programs.

In November 2004 the KNCPC organized the 2nd International Conference on Industrial Ecology and Eco-Industrial Park in Seoul, with Indigo Development providing presentations on a system view of EIPs. Indigo also led two workshops with delegates from 5 of 6 pilot complexes. On the basis of these experiences, Lowe and Chiu (2005) developed the following critical success factors for the transition from industrial park to EIP in Korea. These critical success factors emerged from Indigo's consulting and research in Korea but are generally applied to the EIP projects in other countries.

These can be highlighted as follows:

- Good cooperation among the national agencies with responsibility for EIPs.
- Each pilot industrial park requires an adequate management structure for coordination and cooperation supporting the transition to an EIP.
- Both public management authorities and business associations require capacity development and education so they can participate effectively in the EIP initiative.
- Businesses in the park need to be involved from the beginning of the planning process. They are the ultimate actors in the system.
- The high level planning process for the transition to EIPs must be supported by a strong bottom up planning process, i.e., a dialog between top down and bottom up.
- An evolving long-term vision of the whole system is required to make effective decisions about the specific strategies used in each phase of the transition.
- An EIP is much more than an exchange of by-products among companies.
- Strong support to the growth of the environmental technology and services cluster will provide Korean industrial parks with many of the solutions they require.
- Green chemistry is an important field for petrochemical EIPs as well as customers using chemicals.
- Resource-based policies.
- Policy in support of the EIP initiative should take an integrated view of all aspects of cleaner production as complementary to eco-industrial strategies.
- National policy should support excellent management of the eco-industrial park initiative and individual industrial parks (Indigo Development 2005).

The Korean EIP initiative is relatively new and participants are still learning the basics of eco-industrial park development. Recently, there have been a few efforts to evaluate the outcomes of EIP demonstration projects. Several researches found that the total of 45 pilot projects were successfully implemented and resulted in $14 million of economic benefits mainly from energy exchange and recycling by-products. Most of pilot EIPs could establish resource circulation networks (Ban 2008).

4 The CMS EIP Development Case in Gyeongnam Province, Korea

The Gyeongnam Regional Environmental Technology Development Center suggested that building a ‘resource-symbiotic network’ unifying a few industrial complexes in the exchange of by-products is relatively easy, as local industrial parks in Gyeongnam province consist of various types of industries. The Center investigated nine industrial parks in the province from the viewpoint of material flows and proposed the construction of the Chilseo-Macheon-Sangpyung (CMS) resource symbiotic network.

From the beginning, however, the project has not been carried out following EIP principles. The three industrial parks are as far as 80 km away from each other. This fact is contrary to the EIP principle of short commuting distance between plants (Lowi 2001; Deutz and Gibbs 2004). Also, the principle of an EIP is to basically build a resource-symbiotic network within an industrial park. Therefore, the network between the industrial parks has some problems in that it has weak economic feasibility and can cause secondary pollution in the transport process of wastes and by-products. The Center's initial plan was to promote the project in Chilseo Industrial Park alone. Then, Macheon and Sangpyung asked to be involved in the project for several reasons. The MCIE accepted their requests and the project in Gyeongnam Province developed this unusual form as a result. It is clear that the unreasonable structure continues to threaten the rationality and justification for the existence of the project (Kim 2007).

Macheon Industrial Park (MIP) is a local industrial complex officially approved by the MCIE in 1993. The main type of business is small foundries. These small businesses moved to the outskirts of Jinhae, Gyeongnam, from the border of Busan City in the late 1980s due to expansion of the residential district and civil complaints. The area of MIP belongs to the Busan-Jinhae Free Economic Zone (BJFEZ), and the BJFEZ authority takes charge of the area's environmental and industrial affairs.

MIP has generated civil complaints concerning the stench created by the combustion process of molds made of sand. Ammonia and phenol gases are the main source of the stench, produced when melted iron combusts sand molds. The stench might be partially treated through pollution prevention facilities, but complete treatment is impossible because a great deal of the work is carried out in the open air. The stench and air pollution are serious in the summer season when the south-southwestern wind tends to concentrate pollutants in the basin area. Residents complained of administrative irresponsibility in placing the residential area beside the industrial complex, which generates a large quantity of pollutants and demanded strict supervision and even the removal of MIP.

In addition to the unfavorable quality of life of the residents, the issue was also related to fiscal matters. Due to the stench problem, the housing development project promoted near MIP did not pass the environmental impact assessment twice, in 2002 and 2005. If the quality of a site does not sufficiently meet the standards of the environmental impact assessment, the inevitable use of the land will be as a factory site. The residents are discontented with this notion because this affects the property value of the residents' houses. The BJFEZ has feared that the MIP problem could ruin the master plan of the entire free economic zone and has come up with two alternatives to resolve the problem.

The first alternative is to convert MIP into an EIP. The managerial board of MIP felt that the EIP approach promoted by MCIE could settle its stench problem. The chief manager strongly requested the BJFEZ and MCIE to involve the industrial park in the project. The BJFEZ sympathized with the view of MIP and requested the involvement of MIP in the pilot project to MCIE. However, this happened because of their conceptual misunderstanding of EIPs (Kim 2007).

In principle, the EIP is a resource-symbiotic network constructing a food-web of resources and wastes, creating a closed loop. However, the stench is not a resource in which the project is interested. A zero-emission approach which is popular in Japan, can be considered in this case, but the governing ministry is the MCIE and not the Ministry of Environment. MCIE is more interested in recycling and energy-efficiency issues than environmental ones. This implies that MIP and BJFEZ began the project with poor assumptions.

The cooperation between businesses and local authority in the EIP project is essential for the successful promotion of the project. Despite this need the attitude of the public officials was not only passive but skeptical due to sectionalism and display administration which are prevalent in the Korean administrative culture. MCIE was in charge of the pilot project to construct the EIP. However, the post of environmental affairs in the local authority manages the project. Due to sectionalism, the EIP project is considered an extra duty by the local environmental post. In this situation, the pertinent post has been rarely interested in the EIP project and cooperation with MCIE has not been effective. Particularly, the City of Jinhae and Gyeongnam Province seems passive in developing the project (Kim 2007).

After the central government launched the pilot EIP project in 2005, the central government created relevant policies and directed local authorities to promote the project substantially. Since then, local governments have developed very few ideas about the project or policy means to promote it. In addition, government authorities, regardless of their level, have not secured the budget to support the project. Local authorities do not concentrate efforts on securing extra funds because the project is considered an extra duty.

Previous studies on EIP in other countries indicate that the EIP project requires more funds than ordinary industrial park management costs. Therefore, the financial support from the public sector is necessary considering the social benefits. However, in the case of Macheon Industrial Park, there is no substantial support plan for funds from central government or the local government. There is no financial support program because the basis of environmental policy is the polluter-pays principle.

The existing support program suggested by the public sector requires some modification to draw more businesses into the EIP project. Businesses want substantial subsidies but the government does not have any specific support program. The reality is that just emphasizing the conceptual superiority of the EIP cannot realize the project without any support in Korea. Structured display administration and the absence of concrete policy measures generate administrative lethargy and risk-averse behavior. The EIP project in the view of local public employees is nothing but a mere fad, and thus given a low priority.

Because the long-distance network between the pertinent industrial complexes makes the original concept of EIPs unclear, the project manager tried to exclude MIP from the entire project. MIP has not been excluded from the project yet, but the fact is the manager tried to launch a separate project targeting MIP. The interim assessing group of MCIE pointed out that the pilot project in Gyeongnam Province is not feasible economically due to the long-distance transport of wastes

and by-products between industrial parks. KNCPC knew that the idea of the long-distance network was theoretically and practically unreasonable from the beginning, but they accepted the present structure because of the local politics. The Center could not refuse the local authority's requirement to include MIP in the project, and subsequently the poor initial selection of the target industrial park deteriorated the vitality of the project as a whole.

5 Lessons and Policy Implications for Science Parks

This chapter discussed the promotion process of the EIP project in Korea through the case of MIP. The need for the EIP project is mainly found in the pollution and civil complaints in Korea. The conceptual understanding of the EIP in Korea is quite different from the original idea. That is, the EIP primarily aims to construct organic material flows and a resource-symbiotic network within an industrial complex. However, the approach was adopted to deal with environmental complaints from residents caused by the industrial plants in the case of MIP. This might pervert the aim of the project and finally threaten the sustainability of the project itself. Therefore, a re-conceptualization or a training program for ordinary citizens is needed for the successful promotion of the park.

The EIP initiative in Korea is in its early stage and is experiencing trial and error. There are sharp gaps between the expectation of the interested parties and those actually benefitting from it. This problem mainly results from a conceptual misunderstanding of the project. The public sector should play a more active role for the environment and economies in connection with the EIP project. Furthermore, private companies seem too passive in the promotion of the project. They have tendency to wait for governmental action and to simply want to get a free ride on the support. This passive stance of businesses makes the future of the EIP project gloomy. Only the spontaneous and active participation of businesses guarantees the success of the project. Businesses need to realize that the project is an effective solution for the environmental regulation, which is becoming strict. The active participation in and accurate understanding of the project by the local residents is also essential for the success of the project.

The experience from the EIP initiative in Korea can be applied to make our science and technology parks more eco-friendly and greener science parks.

First, it is necessary to gather accurate data for environmental and industrial fields as well as material balance from the activities in science parks. We also need to review the experience of existing and technology parks and identify their institutional and/or organizational structure; and estimate what fraction of the activities might be considered relevant to eco-innovation for sustainable development. From these analyses, the experience garnered in previous science/technology park efforts can be utilized to help establish a new arrangement for green growth.

Second, while a wide range of technologies might be appropriate for green growth efforts, it may be appropriate for the science and technology park to be become more focused on the specific area of eco-innovation. It may be appropriate for the proposed entity to focus on clean energy technologies, eco-environment protection, cleaner production technologies, water efficiency technologies, agriculture and health issues, or other topics of immediate concern to each society. The selection of technologies and the area of eco-innovation can be done effectively by establishing governance system with interested parties.

Third, networks between science-parks and eco-industrial parks should be established to explore potential opportunities for new business. Public sector can facilitate the establishment of these networks by providing incentives to encourage park entities and businesses to participate.

Fourth, when a potential institutional arrangement for the network has been developed, the next step will be to estimate the financial needs necessary to establish the project, and to sustain its future efforts.

A more comprehensive understanding of the interaction between supply and demand for eco-innovation will be a pre-requisite for creating successful eco-innovation policies. Eco-innovation has the potential to lead to significant economic opportunities. But the costs of some innovations may be very high initially, and government will have to share the risk of new technologies with the private sector in some circumstances.

A number of other measures are already being employed by countries to support environment-related R&D. An analysis of the results of the OECD survey on current government innovation policies reveals several areas for improvement among such measures: Supply-side measures include equity support, research and development, pre-commercialization, education and training, networks and partnership, and information services. Demand-side measures include regulations and standards, public procurement and demand support, technology transfer.

With eco-innovation gaining ground within both industry and government as a way to tackle environmental degradation and to foster green growth, both developed and developing countries are intensifying its work in this area. But research on eco-innovation is still in its infancy, particularly concerning systemic eco-innovations, which have greater potential for overall environmental improvements but are also highly complex, involving non-technological changes. In this context, the management entities of science and technology parks need to intensify activities such as

- Develop a toolkit to help businesses benchmark their performance and improve their production processes and products.
- Gather examples of eco-innovations, particularly those of more integrated, systemic approaches, and conduct in-depth analyses of such innovations to deepen understanding and extract lessons for practitioners and policy makers.
- Identify promising policies that encourage eco-innovation by sharing best practices among countries with science and technology parks.

References

Ayres, R. U. (1989). Industrial Metabolism. In J. H. Ausubel (Ed.), *Technology and Environment*. Washington,DC: National Academy Press.

Ban, Yong-Un. (2008) Korean EIP Development Strategies Including Legal System Improvement Measures (http://www.wbginvestclimate.org/advisory-services/cross-cutting-issues).

Bass, L. (1998). Cleaner production and industrial ecosystems: A Dutch experience. *Journal of Cleaner Production*, *6*, 189–197.

Chiu, A. S. F. (2005). *Training package for NCPC on CP/environmental management of industrial estates*. Ver. 3.3. UNEP.inWENT, Paris. http://www.uneptie.org/pc/ind-estates/event

Cohen-Rosenthal, E. (2003) A Case study of the Louisiana Army Ammunition Plant Re-use. In Cohen-Rosenthal, E. & Musnikow J.(Eds.). *Eco-industrial Strategies Unleashing Synergy between Economic Development and the Environment* (pp. 330–340). Sheffield:Greenleaf Publishing Ltd.,

Deutz, P., & Gibbs, D. (2004). Eco-industrial development and economic development: Industrial ecology or place promotion? *Business Strategy and the Environment, 13*, 347–362.

Ehrenfeld, J., & Gertler, N. (1997). Industrial ecology in practice- the evolution of interdependence at Kalunborg. *Journal of Industrial Ecology, 1*, 67–79.

ESCAP (2006). *Green Growth at a Glance: The Way Forward for Asia and the Pacific*. U.N. Economic and Social Commission for Asia and the Pacific.

Indigo Development. (2005). South Korean EIP initiative.

Kim, H. (2007). Building an eco-industrial park as a public project in South Korea. The stakeholders' understanding of and involvement in the Project. *Sustainable Development, 15*, 357–369.

Korhonen, J., von Malmborg, F., Strachan, P.A., & Ehrenfeld Jr. (2004). Management and Policy Aspects of Industrial Ecology: An emerging research agenda. *Business Strategy and the Environment*. *13*, 289–305.

Lowe, E.A., (1997). Regional Resource Recovery, and Eco-Industrial Parks: An Integrated rategy. Prepared for the Symposium, Verwertungsnetz Obersteiermark Innovation durch regionale Recycling-Netzwerke at Karl-Franzens-Universität Graz. April 28–29, 1997. Available at:http://www.indigodev.com/Eipresrecov.html

Lowe, E. A. (2001). *Eco-industrial development in Japan*. Emeryville, C.A: Indigo Development.

Lowe, E. A., & Chiu, A. S. F. (2005). *Consultant's Report on Korean EIP Project*. Korea National Cleaner Production Center.

OECD. (2009). Sustainable manufacturing and eco-innovation: Towards a green economy.

Park, H. S., Rene, E. R., Choi, S. M., & Chiu, A. S. F. (2008). Strategies for sustainable development of industrial park in Ulsan, South Korea—from spontaneous evolution to systematic expansion of industrial symbiosis. *Journal of Environmental Management, 87*, 1–13.

Von Malmborg, F. (2004). Networking for knowledge transfer. *Business Strategy and Environment., 13*, 334–346.

Waller, H.P., (1999). Toward sustainable development of industry: Networking complexity and eco-clusters. *Journal of Cleaner Production*, *7*(1):49–58.