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SOCIO-ECONOMIC REQUIREMENTS
A REVIEW OF INTERNATIONAL AND VIETNAMESE EXPERIENCES

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

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For more information on UNIDO's work on eco-industrial parks in Viet Nam, please visit https://eipvn.org/.

ABBREVIATIONS

EIA	Environmental impact assessment
EMS	Environmental management system
EIP	Eco-industrial park
EPZ	Export processing zone
EVN	Vietnam Electricity
FDI	Foreign direct investment
GSO	General Statistics Office of Viet Nam
HR	Human resources
IE	Industrial ecology
IEAT	Industrial Estate Authority of Thailand
IS	Industrial symbiosis
IP	Industrial park
IPC	Industrial Promotion Limited Company
ISO	International Organization for Standardization
JSC	Joint Stock Company
MONRE	Ministry of Natural Resources and Environment
NPEIPP	National Pilot EIP Program
NPCEZP	National Economic Regeneration Program
QCVN	National technical regulation of Vietnam
SEPA	State Environmental Protection Administration of China
SWTP	Solid waste treatment plant
USD	United States Dollar
VND	Viet Nam Dong
WWTP	Wastewater treatment plant

I. AN OVERVIEW OF INDUSTRIAL ECOLOGY

Industrial ecology (IE) is the study of the sustainability of man-made, industrial ecosystems compared to natural ecosystems (Ehrenfeld, 1994; Nakamura and Kondo, 2009). Industrial processes traditionally function as open ecosystems, exploiting natural resources and returning waste. Final consumption is a small proportion of an industrial ecosystem's environmental impact: its greatest output is waste. This imbalance creates a burden on natural absorption (O'Rourke et al., 1996). To minimize waste and to increase an ecosystem's capacity, IE recommends the development of closed systems, in which one sector's waste products are another's resources.

IE provides an integrated systems framework for managing the environmental impact of energy, materials and capital use in the industrial system (Frosch and Uenohara, 1994). Under this framework, companies are urged to redistribute waste and resources in a manner similar to structures found in natural ecosystems, such as the food chain. To be environmentally sustainable, company practices must consider how their actions affect other companies within their industrial ecosystem (Lowe and Evans, 1995).

The IE's closed system approach supports the development of eco-industrial parks (EIPs). Initially, the parks were created to reduce the environmental impact of increased industrialization and mass production in industrial parks (IPs). Various measures are required to reduce environmental pollution, such as lowering emissions, installing pollution reduction equipment, recycling waste, and applying cleaner production technologies.

The EIP allows the involvement of individual industries through "systematic industrial change" including the physical exchange of materials and products; management, shared utility and infrastructure (Tibbs, 1992; Chertow, 2000; van Berkel, 2006). The EIP connects different processes such as manufacturing waste, factories, and consumers, allowing not only tangible exchanges but also non-material exchanges such as knowledge, human resources, and technology (Mirata and Emtairah, 2005; Chertow, 2007). Community collaboration between EIP businesses forms the "industrial ecosystem". From there, it is possible to find comparative advantage in partnership between business, government, community, and other groups (Lowe, 2001; Veiga and Magrini, 2009).

To reduce IPs' environmental impact, eco-industrial parks promote energy efficiency, a closed loop system and industrial symbiosis (Conticelli and Tondelli, 2014). The parks are a manufacturing and service community in which businesses seek to enhance environmental and economic performance through collaboration in the management of environmental and resource issues, including energy, water, and materials. The energy and materials produced by one industry are absorbed by another industry or business. Industries and processes of exchange are considered systemic interaction rather than isolated in a linear flow system. The idea is to create a network of collaborating companies that function as an ecosystem through the recovery of resource and manufacturing waste through symbiotic relationships to improve environmental performance and promote regional economic development (UNC, 2008). By working together, the business community works towards collective benefits greater than the combined benefits of each company (Lowe et al., 1996; Veiga and Magrini, 2009).

More broadly, eco-industrial parks are business communities that work with the local community to effectively share resources, such as information, materials, energy, infrastructure and the environment. Together, the EIP and the local community target economic interests, improve the quality of the environment, increase job opportunities, promote the use of shared resources and improve socio-economic standards for surrounding communities (PCSD, 1996; Cote 1998). An EIP works to improve the economic interests of participating businesses while minimizing

environmental harm. They adopt environmentally conscious practices, including environmentally friendly infrastructure, cleaner production, pollution prevention, energy efficiency, and partnership building.

Cote and Hall (1995) expanded the concept of an EIP, defining the parks as an industrial system that:

- conserves natural and economic resources
- reduces production, material, energy, insurance and treatments costs, and
- improves operational efficiency, product quality, the companies' public image, and their workers' health and safety.

With EIPs, governments, businesses, and the public can find uses for recycled waste and emissions. This approach benefits the neighboring communities, and includes the green design of the IP and plant infrastructure, cleaner production, energy efficiency, and the prevention of environmental pollution (Roberts, 2004, Lowe, 2014).

On 22 May 2018, Decree 82/2018/ND-CP defined EIP for the purposes of Vietnamese laws and government policies. Article 2 states:

> Eco-industrial park means an industrial park in which enterprises get involved in cleaner production, make effective use of natural resources and enter into manufacturing cooperation and affiliation in order to tighten industrial symbiosis to promote economic, environmental and social efficiency in these enterprises.

Decree 82/2018/ND-CP requires EIPs to:

- (i) comply with the laws on production and business, environmental protection and labor
- (ii) provide adequate essential infrastructure services (electricity, water, information, fire prevention and fighting...) and related services in the industrial park in accordance with the laws
- (iii) ensure that at least 90% of enterprises are aware of efficient use of resources and cleaner production; at least 20% of enterprises apply solutions to efficient use of resources and cleaner production, improved management methods and production technologies to reduce waste, pollutants and reuse wastes and scrap;
- (iv) ensure that at least 25% of the park land area is used for greenery, traffic, and shared service infrastructure
- (v) ensure at least one industrial symbiosis is effected and that at least 10% of businesses plan to join industrial symbiosis
- (vi) have solutions to ensure housing and social, cultural and sports facilities for workers working in industrial zones
- (vii) have coordinated mechanism to monitor the input and output of industrial zones on the use of energy, water, essential production materials, hazardous chemical management, and submit annual reports.

Companies within an EIP share management and/or ownership of infrastructure and services (Lowe, 2001). However, compared with IPs, EIPs have a more comprehensive, explicit concept of sustainability (Murray, 2009), as detailed above

Chertow (2000) divides the EIPs into five types by geographic regions and the quality and level of the transaction: (1) exchange of waste; (2) exchange within an enterprise; (3) exchange in an industrial park; (4) Exchanges in enterprises close to each other but not in the same industrial park; and (5) exchange in large areas.

According to UNIDO (2015: 39), the objectives and functions of the EIP include the following.

(1) Identify communities that share the same interests and bring them into the IP.

(2) Minimize environmental impacts and ecological footprints by replacing toxic substances, absorbing CO_2, exchanging materials and treating waste.

(3) Maximize energy efficiency through design and construction of facilities, cogeneration, and interconnection.

(4) Saving materials through design and construction of facilities, reuse, restoration, and recycling.

(5) Connect or create networks between companies and suppliers and customers in a larger community with an EIP.

(6) Increasingly improving the environmental performance of individual businesses and the entire community.

(7) Having a flexible regulatory system that encourages businesses to achieve their goals.

(8) Use economic tools in environmental protection to prevent waste and pollution.

(9) Use information management system to facilitate the flow of energy and materials in the more closed production process.

(10) Create a mechanism for training managers and employees on new strategies, tools, and technologies to improve the system.

(11) Arrange advertising activities to attract customers to increase the occupancy rate of the IP and add other business areas.

According to Lowe et al. (1996), there are three ways to form EIPs:

- (1) design for and construct at a new location
- (2) conversion from traditional IPs; and renovate contaminated areas, and
- (3) redevelop and expand existing production areas.

Each option presents challenges throughout the formation, construction and operation phases. There should always be a balance between benefits and costs, and determine whether the challenge can be overcome or not.

It is argued that because traditional IPs provide economic benefits but do not consider the so-called costs of environmental degradation, the merger of existing IPs into EIPs is expected to reduce pollution and create a path to sustainable development. For this reason, it is further argued that the EIP industrial model addresses all three aspects of economic, social and environmental sustainability (Veiga and Magrini, 2009). However, there are challenges. Industrial symbiosis requires getting many parties to agree, especially the infrastructure business and the enterprises in the industrial park. Additionally, existing pollution problems must be addressed (Lowe et al., 1996).

Similarly, Conticelli and Tondelli (2014) claim that the development of EIPs is most successful among enterprises that are already in a given area. According to their analysis, self-organization among companies is the key to success rather than the planning of IPs: there are no contradictions between the need to reduce land consumption, the need to provide good conditions to attract investment, and the need to reduce negative impacts on local ecosystems. Therefore, it is not necessary to locate and plan IPs on new land. Instead, it is necessary to consider opportunities in existing IPs, although this trend is still unclear. This direction creates a dual advantage – it promotes innovation of the sustainable industrial park model and encourages reuse of existing urbanised land without affecting new lands and ecosystems.

However, creating an EIP through construction and development on new sites has certain advantages. This approach allows for trials to determine well-tailored solutions. Site identification and EIP development will be well designed, with a clearer rationale (Lowe et al., 1996). In addition, enterprises can choose an optimal production site, with infrastructure, required services and closely related business groups in the area (UNIDO, 2017a).

The planning of existing EIPs demonstrates how to place an IP in a location that is favorable to both the business environment and the existing ecological infrastructure. However, policies that prioritize economic benefits ignore natural land protection while increasing traffic and creating an unsustainable use of land resources. In the short term, this favors short-term business profits. However, over time this approach hamrs the economy and the environment (Lowe et al., 1996).

To succeed, EIPs must:

- (1) develop policies to support EIPs
- (2) establish procedures for monitoring and evaluating EIPs on a regular basis
- (3) implement sector development strategies, and
- (4) encourage stakeholder engagement or start with pilot models

(Sertyesilisik and Sertyesilisik, 2016).

An EIP will be more likely to succeed if it is part of a broader community initiative. Topics of community concern can include the following.

- Housing for workers
- Reducing total waste (residential, commercial, public and industrial)
- Developing an area where parties can exchange by-products efficiently
- On-selling materials discarded as waste to other IPs
- Strengthening economic development planning to encourage appropriate businesses
- Mobilizing educational resources to help businesses and government operations increase energy efficiency and prevent pollution
- Reducing greenhouse gas emissions through a community-based programme (Lowe, 2001).

EIPs can also provide other socio-economic benefits, as summarised in table 1.

Table 1. Potential socio-economic benefits of the EIP

Economic benefits	Social benefits
• Direct employment creation and income generation • Export growth and export diversification • Foreign exchange earnings • Reduce the cost of waste management • Improved industrial and residential infrastructure • Access to investment capital • Foreign Direct Investment • Increased tax revenue • Increased competitiveness of enterprises • Integration with regional, national and international markets • Access to environmental credit lines • Reduced resources costs • More efficient material use • Increased sales through green marketing and improved corporate image • Reduced water consumption costs • Mixed land use planning • Access to environmental certifications • Avoidance of regulatory penalties due to waste charges • Increased income per capita • Meeting customers' requirements • Reduced transportation costs • Improved business and investment climate	• Vocational training • Skills training for women • Awareness outreach • Environmental education • Occupational health and safety • Breastfeeding program • School and kindergartens facilities • Customer services to clients • Financial institutions • Recreational space • Personnel transport • Pharmacy • Residential units • Roads to surrounding areas • Transition to more sustainable land forms • Projects to improve the wellbeing of slum dwellers

Source: UNIDO (2016).

In 2018, on behalf of the Ministry of Planning and Investment (MIP), the International Finance Corporation (IFC) developed the *Eco-Industrial Park Technical Guidelines for Viet Nam*. Focusing primarily on the environmental and technical aspects of EIPs, the guidelines provide a framework for assessing and ranking EIPs in Viet Nam. The guidelines consider the participation of enterprises in the EIP programme (one criterion), the activities of the zone (six criteria), and initiatives at the enterprise level (13 criteria). The guidelines do not assess economic and social factors, which are important aspects of the definition of EIPs under the laws of Viet Nam.

Barriers to symbiosis include technical, economic, informational, organizational, and legal matters. Overcoming these barriers requires diverse strategies, such as (Saikku, 2006):

- attracting companies that meet EIP targets
- strengthening the trust, involvement and commitment of companies in the industrial ecological network
- information sharing
- improving organizational structures
- properly assessing the role of key enterprises in the network, and
- building the vision and management system of the EIP.

EIPs should not be created for purely economic purposes. They should not be considered as merely a strategy to increase corporate profits through waste reduction and resource saving. EIPs should be considered a model for effective enterprise management. EIPs are new development strategies, especially at the regional and local levels. To assess the sustainability of this strategy, it is necessary to identify and pursue specific objectives, including outcomes and management. These must demonstrate consistency and can be measured by indicators, including economic, social and environmental indicators. Conversely, the formation and development of EIPs must be considered a long-term strategy that may not produce immediate results (Tarantini et al., 2007).

II. THE DEVELOPMENT AND ASSESSMENT OF INDUSTRIAL ECOLOGICAL PARKS: INTERNATIONAL PRACTICE

2.1. CHINA'S EXPERIENCE

The Chinese government actively encourages the development of a circular economy based on the core principles of industrial ecology. The government first promoted the circular economy concept in 2005. Notably, the country's 11th Five Year Plan (2006–2010) set the target of establishing circular economies at the enterprise, IP, city, and province level. The government passed laws and adopted action plans to support the development of a circular economy. These included the *Law on Promotion of Cleaner Production* (2002) and the *Air Pollution Prevention and Control Action Plan* (2013). In 2018, China and the EU signed a joint Memorandum of Understanding on Circular Economy Cooperation.

China first built IPs in the 1980s (1984–1988). These included IPs developed in Tianjin, Yantai, Shanghai and Guangzhou. By 2011, there were at least 1,568 IPs. The IPs significantly contributed to China's economic growth. In 2011, the GDP growth rate of IPs was 30.3%, substantially higher than the average of 9.2% nationwide. However, although China adopted environmental management regulations, the IPs caused considerable environmental damage. The Chinese government adopted the EIP programme to minimize environmental harm while maintaining economic growth (Yu et al., 2014).

EIPs were first proposed by the State Environmental Protection Agency (SEPA) as an environmental strategy, but over time came to be valued more as an economic strategy (Yuan et al., 2006). In 2001, SEPA was responsible for both EIPs and the circular economy programme, respectively called the National Pilot EIPs Program (NPEIPP) and the National Economic Regeneration Program (NPCEZP).

At the IP level, the NPCEZP can be considered a nationwide EIP pilot. In 2004, as EIPs came to be seen less as a means of environmental protection, the National Development and Reform Commission was appointed to take over the duty of promoting the circular economy (Zhang et al., 2009). By contrast, the NPEIPP continued to be coordinated by SEPA (Zhang et al., 2009), which assumed the lead role, with the Ministry of Science and Technology and the Ministry of Commerce assisting the agency in managing high technology and economic and technological development zones – the main kinds of IP in China.

To improve waste utilization and to reduce industrial pollution, NPEIPP management strategies were refined across 2001–2007. To standardize the planning process, SEPA issued a national EIP planning manual in 2003. The manual outlines central elements of EIP planning, noting key industrial and environmental challenges. It also

details the process of establishing EIP networks and requires IPs to develop integrated management plans for solid waste, water and energy. However, the manual does not provide details on EIP standards. This prevented some IPs from moving towards the EIP model (Geng et al., 2008a).

Accordingly, SEPA developed a comprehensive guide in June 2006. The guide defined EIP and detailed assessment and evaluation criteria. SEPA issued the guide in September 2006. It is considered the first national EIP standard (Duan et al. 2006). The guide directs that to participate in the NPEIPP an IP must meet certain criteria, including the following:

(1) The strict implementation of all national environmental laws and regional environmental regulations in the three years prior to forming an EIP, with no environmental incidents or ecological damage events.

(2) The quality of the on-site environment must meet national environmental standards. No enterprise may exceed the allowable pollution and overall emissions limits set by SEPA and its regional representations.

(3) EIP plans of IP managers must be evaluated and approved by SEPA and local authorities.

The guide divides EIPs into three sector-related groups:

- the sector-integrated group – IPs that work across many industry sectors
- the venous group – IPs with resource recovery functions where environmental technology companies and so-called green product companies coexist, and
- the sector-specific group – IPs operating within one industry sector or across several related sectors.

Following the guide's release, China issued draft standards for the remaining types of IPs, including: HJ/T274-2006 for Tentative Standard for Sector-Integrated Eco-Industrial Parks and HJ/T275-2006 for Tentative Standard Venous Industry Based Eco-Industrial Parks. These have three main categories of economics, environment, and management such as HJ/T273-2006. The difference between the standards mainly lies in the compositional indicator of the environmental group, especially regarding raw material reduction and recycling (Geng et al., 2008a).

The EIP test standards for sector-specific IPs (HJ/T273-2006: Tentative Standard for Sector-Specific Eco-Industrial Parks) included 21 indicators with evaluation thresholds. These were divided into three parts: economy, environment, and administration and management.

As of January 2009, SEPA had funded 33 pilot EIPs. Of these, 23 were in the sector-integrated group, 1 was in the venous group, and 9 were in the sector-specific group. Most of the approved EIPs were located in Southeast China, where the economy is more developed (Geng et al., 2008b; Zhang et al., 2009).

In 2009, China issued new standards for sector-integrated IPs (HJ/T274-2009: Standard for Sector-integrated Eco-Industrial Parks). HJ/T274-2009 added the following five indicators: industrial value added per unit area, recycled water reuse rate, energy consumption elasticity, clean water consumption elasticity, and cleaner production rate in key enterprises. Additionally, the thresholds for multiple indicators were increased to better compare the performance of IPs (Huang et al., 2019).

At the start of 2010, 5 of 33 EIPs had passed all tests and were approved by the NPEIPP: the Suzhou China-Singapore Industrial Park, the Suzhou Hi-tech Park, the Economic and Technological Development Zone Tan, the Wuxi and the Yantai (Zhang et al., 2009). The 2012 revised Standard for Sector-Integrated Eco-Industrial Parks

(HJ/T274-2009) removed the per capita industrial value added criterion and the reuse rate of reclaimed water criterion.

In 2015, the Standard for National Demonstration Eco-Industrial Parks substantially changed the regulatory system. The standard introduced seven significant changes:

(1) IPs are no longer divided into three groups.

(2) Added a new indicator to evaluate industrial symbiosis.

(3) Added indicators to assess on environmental risk control.

(4) Strengthened the environmental indicators by adding the indicator elasticity coefficient of main pollution emissions.

(5) Moved away from a system based on compulsory indicators by adding optional indicators.

(6) Allows flexibility when setting targets so that IPs can better accommodate economic conditions.

(7) Replaces the administration and management indicator with an information disclosure indicator.

(Huang et al., 2019.)

However, the HJ/T274-2015 standard has several shortcomings (Huang et al., 2019). Notably, these include the following:

(1) Industrial symbiosis is limited to solid or renewable resources.

(2) Industrial symbiosis outside the IP is not evaluated or encouraged.

(3) New indicators are needed to demonstrate how IPs link to other areas and how industrial symbiosis acts within and outside the EIP to promote local sustainable development.

(4) There is no social benefit indicator. Therefore, social indicators such as occupational health and safety, employment rate, average employee salary and level of community recognition and involvement are needed.

(5) Indicators mainly focus on the assessment of energy and water consumption per unit of industrial value added. Indicators should be added to measure the reduction of consumption at source, integrated into product design and production. It is crucial to require systematic monitoring of material flow, such as measuring material flow and resource productivity and boosting the market for secondary resources.

(6) Incentives to promote EIPs, such as land incentives, tax reductions for EIPs and related businesses, and administrative support for businesses in the EIP, are needed.

China's experience shows that the state policy framework and the development of quantitative indicators are critical to the success of national pilot EIP programmes. Since 2006, the EIP standard has been revised several times to better suit China's environmental and economic conditions. Despite some shortcomings, the steps China has taken to develop EIPs provide valuable lessons for other countries.

Table 2. Evaluation indicators for National Eco-Industrial Parks in China (HJ/T274-2015)

Groups	NO.	Indicators	Units	Standard	Remarks
Economic development	1	The proportion of high tech enterprises output value of gross industrial output value	%	≥ 30	At least one indicator shall reach the standard
	2	Industrial added value per capita	10,000 RMB/ person	≥ 15	
	3	The average three-year growth rate of industrial added value	%	≥15	
	4	The proportion of remanufacturing industry added value of the gross industrial added value	%	≥30	
Industrial symbiosis	5	The added eco-industrial chain numbers after enforcing EIP demonstration program (EIPDP)	%	≥6	Required
	6	The comprehensive utilization rate of industrial solid waste	%	≥70	At least one indicator shall reach the standard
	7	The usage rate of renewable resources	%	≥80	
	8	Industrial added value per unit industrial land area	Hundred million/km²	≥9	
	9	The average three-year annual growth rate of industrial added value per unit industrial land area	%	≥6	
	10	Elastic coefficient of comprehensive energy consumption	-	- When annual growth rate of industrial added value in the EIP demonstration period is › 0: the value must be ≤0.6; - When the annual growth rate of industrial added value in the EIP demonstration period is ‹ 0: the value must be ≥0.6	Required
	11	Energy consumption per unit of industrial added value	Metric ton of standard coal/10,000 RMB	≥0,5	At least one indicator shall reach the standard
	12	Application ratio of Renewable energy	%	≥9	
	13	Elastic coefficient of fresh water consumption	-	- When annual growth rate of industrial added value in the EIP demonstration period is › 0: ≤0.55; - When annual growth rate of industrial added value in the EIP demonstration period is ‹ 0: ≥0.55	Required
	14	Freshwater consumption per unit industrial added value	m³/ 10,000 RMB	≤8	At least one indicator shall reach the standard
	15	Recycling rate of industrial water	%	≥ 75	
	16	Reuse rate of reclaimed water	%	- Water deficient cities › 20%; - Jing-Jin-Ji areas › 30%; - Other areas › 10%	

Groups	NO.	Indicators	Units	Standard	Remarks
Environmental protection	17	Rate of reaching the discharging standard for key pollution sources	%	Meet the standard	Required
	18	The conditions of national and local key pollutant emissions	-	Meet the standard	Required
	19	Frequency of severe environmental accidents	-	0	Required
	20	Completion degree of Environmental management strategies	%	100	Required
	21	Implementation rate of key enterprises' Clean production audit	%	100	Required
	22	Centralized sewage treatment facilities		Exist	Required
	23	The completion rate of environ-mental risk prevention and control system		100	Required
	24	Utilization rate of industrial solid waste (including hazardous wastes)		100	Required
	25	Elastic coefficient of main pollutant emissions	-	- When annual growth rate of industrial added value in the EIP demonstration period is › 0: the value must be ≤0.3; - When annual growth rate of industrial added value in the EIP demonstration period is ‹ 0: the value must be ≥0.3	Required
	26	The annual reduction rate of carbon dioxide emissions per unit industrial added value	%	≥ 3	Required
	27	Waste water emission per unit industrial added value	t/ 10,000 RMB	≤7	At least one indicator shall reach the standard
	28	Solid waste discharge per unit industrial added value	t/ 10,000 RMB	≤0,1	
	29	Green cover percentage	%	≥15	Required
Information disclosure	30	Environmental information disclosure of key enterprises	%	100	Required
	31	The completion degree of the ecological industry information platform	%	100	Required
	32	Number of public education campaigns	Number/year	2	Required

Source: Huang et al. (2019).

2.2. SOUTH KOREA'S EXPERIENCE

In the Republic of South Korea, IPs are a major source of CO_2 emissions. The country launched EIP programmes to encourage cleaner production and sustainable development (Ban et al., 2015). To improve efficiency and industry competition while minimizing environmental harm, in 1992 the Ministry of Commerce, Industry and Energy adopted a comprehensive strategy based on the concepts of cleaner production and EIP. In December 1995, South Korea enacted the *Act on the Promotion of the Conversion into Environment-Friendly Industrial Structure* (the 1995 Act). Article 21 of the 1995 Act established an institutional system for cleaner production and an environmental management system (EMS) that met the ISO 14001 standard. The Act promoted the development of an environmentally friendly industrial sector. For this reason, the 1995 Act is considered the catalyst in South Korea's move towards environmentally sustainable industry practice. (Park et al., 2008).

Since 2005, South Korea has been a leader in the development of industrial symbiosis strategies in the Asia Pacific. The country has invested in EPI programmes, creating symbiotic systems and converting IPs into EIPs. In the early pilot phase, the Korea National Cleaner Production Center oversaw the formation of EIPs. The center is a non-governmental organization that promotes resource saving and cleaner production. EIP oversight was transferred to the Korea Industrial Complex Corporation (KICOX), an organization under the Ministry of Knowledge Economy (formerly the Ministry of Commerce, Industry and Energy) (Park et al., 2016).

To implement the EIP programme, 8 regional EIP centers and 30 related industrial clusters were created. The regional centers are owned by KICOX (Behera et al., 2012), and manage the entire project development process, from mapping local context-based strategies to facilitating the development of ideas through to arranging forums and meetings. The regional centers also provide support for developing project proposals and funding for project evaluations in collaboration with local authorities and related organizations. Each regional EIP center has an advisory panel, which are comprised of representatives from local government, research institutes, and industry. The panels evaluate proposals and advise on the programme's overall direction. All projects approved for implementation at a regional EIP center are evaluated monthly by a KICOX Evaluation Committee staffed by relevant experts (Park et al., 2016).

According to Park et al. (2008), the Korean institutional system and policies provide a solid foundation for the development of the national EIP programme. The most influential policies include an environmental policy that promotes sustainable development, an environmentally friendly industrial policy, and a renewable energy policy.

A feasibility study is carried out for all proposed EIP projects. Interested IPs must submit a project proposal to the relevant regional EIP center, which then reviews the proposal with the KICOX Evaluation Committee. If the proposal is successful, regional EIP centers seek financial investments. Projects will be supported at a maximum of 75%; additional funding must be obtained from the private sector. Once the project is completed and commercialized, KICOX undertakes a final evaluation to determine whether the project has achieved anticipated economic and environmental benefits. It then determines the number of royalties for technology support to be paid back to the government; this is usually around 20–40% of the funded budget (Park et al., 2016).

The EIP programme in South Korea has achieved remarkable results in recent years. Ban et al. (2015) analyzed the reduction of direct CO_2 emissions through 41 EIP projects conducted in the period 2005–2012 in South Korea. They found that these projects lead to a 48% reduction in CO_2 emissions from industry compared to 2004. Most of these projects have been implemented effectively through energy and resources shared and exchange networks.

As of 2013, 116 EIPs were deployed, of which 47 were operational. Of these 47 EIPs, 14 began operating in the first stage of the EIP programme, and 33 began operation during the second phase of the EIP programme (NIER, 2014). The benefits of EIPs in the early stages of the program were very encouraging. The 47 EIPs generated benefits of USD 189 million, of which USD 97 million were derived from cost reductions; USD 92 million resulted from revenues generated (that is, revenue in excess of government funding). In terms of environmental benefits, the 47 EIPs collectively reduced waste by 477,633 metric tons, wastewater by 110,032 metric tons, energy by 176,781 ton of oil equivalent, and greenhouse gases by 668,198 metric tons of $CO_{2\text{-eq}}$. This is equivalent to 0.83% of waste generation, 0.008% of wastewater generation (NIER, 2014), and 0.14% of energy consumption in 2012 (KEEI, 2013, NIER, 2014).

Table 3. Some of the EIP programme benefits in South Korea 2007–2013

Indicator group		2013	Accumulation of 2007–2013
Economic benefits	Reduced costs for waste treatment and purchase of raw materials	34 billion KRW	134.9 billion KRW
	Sales of recycled and excess goods	20.3 billion KRW	180.5 billion KRW
Environmental benefits	Reduced energy use through reuse of heat from waste incineration	55,000 toe	243,000 toe
	Reduced greenhouse gas emissions	190,000 t	1,107,000 t
	Reduction of by-product residue through recycling scrap and metal scrap	45,000 t	828,000 t
	Reduced industrial water use through re-use	48,000 t	216,000 t
	Reduced waste to air, such as SO_x and NO_x	-	156,000 t
Social benefits	Demand for new investments in recycling facilities	117.3 billion KRW	376.5 billion KRW
	Created new employment	108	514

Source: MSF et al. (2014).

Reflecting on South Korea's experience, MSF et al. (2013) conclude that to be successful an EIP programme must adopt the following principles:

(1) Business participation is voluntarily; businesses expect to generate economic returns.

(2) Energy, by-product and industrial/wastewater exchanges between participating enterprises and existing IPs are established.

(3) The involvement of large-scale enterprises increases the likelihood of success.

(4) Geographic concentration is important as it impacts costs and safety when installing pipes. The applicability is easier if the EIP scale is not too large.

South Korea's EIP standard also contributed to the programme's success. The standard consists of the following main groups:

a) network (focus on raw materials, products and by-products, waste heat)

b) waste treatment (focus on reuse and recycling)

c) generation of waste (towards zero emissions)

d) social image, and

e) community.

(MSF et al., 2013).

Criteria vary between the five EIP groups. The guidelines for the development of the EIPs are provided by MSF et al. (2013):

> (1) The criteria to be considered for the selection of locations for clusters and cluster design should be identified.
>
> (2) For the part of environmental degradation, indicators should be assessed including air quality, odour, greenhouse gas emissions, water quality, land use, soil quality, physiology and topography, animal and plant life, noise and vibration, leisure and landscaping facilities, public hygiene and sanitation. These criteria may be added or reduced depending on the type of enterprise, the nature and ecology of the surrounding area.
>
> (3) EIPs should actively consult stakeholders.

2.3. DENMARK'S EXPERIENCE

Kalundborg is a small industrial park established in 1959. It is located on the coast of Denmark, 75 miles west of Copenhagen. Kalundborg's evolution from a series of independent product exchanges into a complex network of symbiotic interactions involving regional companies and local urban systems is a model of effective EIP development (Ehrenfeld and Gertler, 1997; Ehrenfeld and Chertow, 2002). Major companies involved in the industrial symbiosis include a 1,300 MW power plant (Asnæs), a refinery (Statoil A/S), a biotech and pharmaceutical company (Novo Nordisk A/S), a wallboard manufacturer (Gyproc) and a soil treatment company (Bioteknisk Jordrens Soilrem A/S) (Jacobsen, 2006; Chertow, 2007).

The energy and material exchange network was initially developed to reduce costs by using surplus product. For example, Gyproc located its plant to take advantage of the available butane gas from Statoil A/S. Managers and residents subsequently recognised that the exchange offered many environmental benefits. This led to the development of bilateral agreements (Lowe, 2001).

Resources available for exchange include water, solid waste, and energy. Wastewater and cooling water from refineries are reused at power plants, in which wastewater is used for secondary purposes. Cooling water is reused in boilers producing steam and electricity and is also used in desulfurization. The process of desulfurization, in turn, makes industrial gypsum, which is used in Gyproc production, thereby reducing the use of natural gypsum. The cogeneration plant also produces hot water for the town of Kalundborg and steam for Novo Nordisk A/S and Statoil A/S. Additionally, condensed water at the power plant is transferred to fish farms. Solid wastes, such as coal ash, sludge from wastewater treatment, and biomass from Novo Nordisk A/S, are recycled in many ways, both locally and further afield. In all, Kalundborg's industrial symbiosis incorporates roughly 20 product exchanges, the most important of which is the symbiotic exchange of water and steam demand between plants. Additional projects are proposed, while others have folded due to market conditions and technological innovations (Jacobsen, 2006).

From 1982 to 1997, the natural resource consumption in this industrial park was reduced by 19,000 tons of oil, 30,000 tons of coal, 600,000 m^3 of water, and 130,000 tons of CO_2 (Nguyen Cao Lanh, 2013). It is estimated that by 2001 EIP companies had saved USD 160 million, as a return on total investments of USD 75 million invested in the symbiotic network (Lowe, 2001).

In general, the industrial symbiosis in Kalundborg provides two essential benefits:

(1) Industrial symbiosis plays an effective role in transforming, substituting and sharing benefits, and is a comprehensive strategy for environmental improvement. However, industrial symbiosis cannot be considered an independent solution. It is one part of a broader process of improving the overall environmental performance of companies (Chertow 2007).

(2) Regarding the economy, industrial symbiosis offers both direct and indirect benefits. However, in many cases, direct benefits to individual companies are very small. Companies should focus on receiving indirect benefits in the future through saving resources, or the aim of having positive spill-over effects "across the factory fence" (Jacobsen, 2006).

The following lessons can be learned from the Kalundborg case (Lowe, 2001):

- All bilateral agreements are voluntarily agreed upon without a master plan. Before signing, each party must carefully consider risks and economic benefits.
- The inclusion of large companies in symbiotic networks is essential, as they create efficiencies of scale and can provide sufficient inputs for smaller companies.
- There must be consistency among industries in the supply of inputs and outputs in the symbiotic network.
- IPs within the symbiotic network must be of comparable or complementary size.
- IPs in the symbiotic network must be located within reasonable and cost-effective distance of each other.
- There is a shared belief and value between the leaders of companies and local governments when they are part of a small community of 20,000 people far from large urban centers, peers who share the same hobbies, share common characteristics of family and children. Community supports business networks.
- Government regulations significantly affect emission rates, particularly, the kind of material that may be emitted, where the material may be emitted and what environmental protection measures are required. Governments may also provide subsidies to offset costs.

2.4. EXPERIENCES OF OTHER COUNTRIES

2.4.1. Italy's experience

Tuscany region[1]

Tuscany encourages the formation of EIPs through a voluntary certification system. This approach reflects the spirit of voluntary public-private partnerships and coordinated management to achieve economic goals with the approval of local communities.

In 1998, Decree 112/98 of the Italian Government authorized the creation of EIPs. In December 2009, Tuscany, a region that has long considered the environmental impact of its policies, launched the Tuscan Regulation 74/2009, an initiative to encourage the development of EIPs on a voluntary basis. Subsequently, Resolution 1245/2009 allowed the IPs to obtain certification as EIPs. These certification standards are fully managed at the regional level. The central government has no role in managing the programme or promoting the spread of EIPs in Tuscany. (Daddi, et al., 2015)

In the Tuscan certification scheme, roles and responsibilities are clearly defined. The regulatory body is a mixed public company, responsible for developing specific measures necessary for an EIP to succeed. The regional government monitors the implementation of certification programmes and performs ad-hoc inspections. Local authorities monitor coordination and effective land use. Municipal authorities have diverse functions, including

1 Content of this part is taken from Daddi et al. (2015).

selecting locations, identifying the regulatory body, and inspecting IPs against EIP certification standard. (Daddi, et al., 2015) The involvement of local businesses is also of great significance. The regulating body is required to sign an agreement with all involved in active participation in the implementation of the relevant standards and authorize the governing boards to represent them. To encourage corporate participation, various administrations have launched different initiatives, such as reducing taxes on contracted companies. (Daddi, et al., 2015)

An IP that *wants to be certified as an EIP needs to meet the standards*. Under Resolution 1245/2009, certification standards are classified into *minimum* requirements and *flexible* requirements. The minimum requirements are divided into three groups: (1) urban and planning criteria; (2) infrastructure standards; and (3) management criteria. Flexible requirements include 78 indicators. All indicators are scored, and enterprises need to reach a minimum threshold. (Daddi, et al., 2015)

The advantages of this programme are:

- For the first time in Europe, *a voluntary certification scheme for IPs has been established*. If local companies want to obtain voluntary certification and related benefits, they are required to cooperate. Benefits include improving the image and attracting investment or government incentives.
- *A broad consensus among various stakeholders* on the issuance of the certification system. This means that EIP certified IPs will have financial incentives. This regulation will also make it easier to apply for certification, especially for existing IPs than for new ones. This is a priority for greening older areas than creating new ones.

However, the programme has the following shortcomings. First, there is the potential for conflicts of interest within the certification auditing process, as the audits are conducted by the municipal government where the IP is located. To overcome this, a separate assessment system, recognized by the regional government, is expected to be developed, based on methods similar to the ISO 14001 environmental certification process. Second, the standards are only partly based on the principles of industrial ecology and industrial symbiosis. For example, there is a lack of regional economic performance indicators as the focus is primarily on environmental issues.

Porto Marghera Industrial Park[2]

The erosion of industrial symbiosis at the Porto Marghera Industrial Park in Venice is a key example of how EIPs can be undermined by both internal and external pressures.

Owing to its favorable location, Porto Marghera Industrial Park developed rapidly from the 1940s. By the 1960s and 1970s, the park was a European center for chemical manufacturing. However, the park became significantly less profitable in the late 1970s due to rising raw material prices, reduced government investment, and increased environmental concerns. In Porto Marghera, factory closures lead to a marked increase in unemployment. The industry adjusted, moving away from a highly concentrated, large-scale model to a network of smaller scale companies spread across a larger geographic area.

From the 1990s, increasing environmental awareness and strict environmental regulation in Italy and the European Union lead to significant changes in the management and operation of IPs. In 1998, private companies

2 Content of this part is taken from Mannino et al. (2015).

and industry associations signed the Chemical Industry Agreement in Porto Marghera, outlining strategies to promote sound environmental management and industry development. The agreement functioned similarly to an early stage EIP, and included monitoring, risk management, and annual environmental accounting.

At the beginning of the 2000s, the symbiosis at Porto Marghera declined. The closure of large chemical companies crucial to the overall supply chain made it difficult to either maintain or restore symbiotic relationships. The closures resulted from both internal and external causes:

- Globalization: To compete with international suppliers, chemical companies needed to specialize and expand to reduce costs. However, this was challenging for Italian chemical companies due to high production costs, especially energy production costs.
- National administrative laws: The chemical companies had to contend with a bureaucratic governmental administrative system. Industrial symbiosis was not recognised as a business strategy because of an insufficient legal framework, licensing restrictions, and limited technology sharing, the lack of cooperation between companies, a lack of information sharing, and the absence of an official lead entity.
- Community response: As the project developed, there was conflict between the plants' production on one hand and protecting the health of the environment and the people on the other. A 2006 lawsuit forced chemical companies to pay compensation to residents, creating concern for companies seeking to invest in the region.

2.4.2. Experience from Lamphun, Thailand[3]

The concept of EIPs was introduced in Thailand in the early 2000s. However, various factors hindered their development. Notably, these factors included difficulties in developing cooperation between stakeholders. Lamphun is the northern province of Thailand.

The Industrial Estate Authority of Thailand (IEAT) was established in 1972. The authority is responsible for the development and construction of IPs in the country. As of 2014, Thailand had 42 IPs in 15 provinces. The development of EIPs in Thailand started in 2000 following the initiative "Development of EIPs and Connected Network". Five pilot IPs were Map Ta Phut, Poo, Northern Region, Eastern Seaboard and Amata Nakorn.

In 2004, a preliminary report showed that the project's success was primarily a result of strengthening the perception of EIPs development, the synergies of industrial automation and control technologies. However, there were some obstacles, such as waste tax issues, a lack of support for clean industry development, and a lack of effective exchange and linkages. Until September 2010, the development of EIPs was re-focused with a public announcement of new initiatives in five categories and 22 areas, towards a bottom-up approach (piecing together enterprises to create more complex systems).

The EIP trial project was conducted at the Northern Region Industrial Estate (NRIE), Lamphun Province, which had operated since 2000 and was highly regarded for its social responsibility. In 2010, IEAT announced its policy on EIPs and a set of initiatives for each IEAT-owned industrial park. This is also reflected in the vision of Lamphun Province, announced in the 2010 Development Plan, which nominated Lamphun as a World Heritage Town and

3 Content of this part is taken from Panyathanakun et al. (2014).

Commune Responsible Industrial City. However, the implementation process had many difficulties. Notably, there was a lack of trust between the IP and the community. To overcome this, NRIE designed a new approach, developing community-based EIPs through a dedicated eco-forum.

Stakeholders were invited to share their thoughts. Members included community and industry representatives, the Lamphun Federation of Industries, city officials, provincial industry representatives, provincial officials, representatives from research institutes, and NRIE representatives. Details of the discussions in the Ecological Forum were recorded and circulated among all members.

The Ecological Forum had initial benefits, such as the establishment of an eco-fund to benefit every party, in order to manage the by-product and "not-in-use" material donation scheme. At the same time, the forum also raised four issues that needed to be resolved:

- The second phase of the NRIE extension project was announced without adequate provision for drainage and waterway management, raising public concerns about the possibility of floods due to congestion of the river system in the region.
- Members wanted to preserve the quality of the Kwang River, as the main freshwater source in Lumphun Province.
- The impacts on the quality of life of people due to the influx of new residents to the NRIE had to be managed, as well as the potential for increased problems such as crime.

In general, trust between NRIE members and local communities was particularly important for the formation of the EIP, and the Eco Forum was one important tool to this end.

The application of specific actions, to put into practice the contents of the minutes of the meetings, facilitated open dialogue and information transparency, thereby gradually building trust between parties.

2.5. SOME LESSONS LEARNED

(1) Establishment of EIP:

An EIP may be developed as a new construction, or through the upgrade of an existing IP. Each of these methods has pros and cons, and different cost-benefit considerations. The formation of an EIP is a complex process involving multiple parties and requiring different technical solutions, so it should be implemented cautiously through pilot programmes. Because of this, the preferred option in most countries is to upgrade existing IPs.

Countries such as China and South Korea expanded the scope of their EIP transition, a process that drew on past experience and involved careful policy adjustments. This provides a firm foundation for further development.

Nevertheless, the prerequisite for the formation of an EIP is the consensus and voluntary participation of all stakeholders, the first of which are the businesses involved. This means that the *economic benefits of participation must be properly respected*. Social and environmental benefits are usually obtained after economic benefits are secured.

(2) On the driving force behind EIP development:

Businesses are central to the development of EIPs. The voluntary implementation of cleaner production methods and participation in industrial symbiosis, although partly derived from the legal framework, is mainly due to an enterprise's cost-benefit analysis. The experiences of South Korea and Denmark show that many factors influence this choice, including industry compatibility, scale compatibility and geographical distance. The role of large companies in the industrial symbiosis network is also important when determining the input-output scale. However, as Italy's experience demonstrates, the departure of core companies can also trigger the demise of an EIP.

Infrastructure management companies contribute significantly to the formation and development of EIPs. By designing, building and managing the infrastructure undergirding an EIP, these companies contribute to all related conversion plans and symbiotic network designs. They are also the first to monitor and evaluate the implementation of environmental regulations and environmental quality. This enables them to play a prominent role in developing the EIP application profile, as the Chinese example demonstrates.

EIPs cannot develop sustainably without *the support of the community,* which includes local authorities, the local population and representatives of associations. The Denmark case shows that when businesses and local leaders share similar values and beliefs, IPs can become an integral part of a community. In South Korea, the key to the successful development of EIPs was building a positive local image and garnering community support. In contrast, the closures at the Porto Marghera Industrial Park in Italy were partly due to a failure to address residents' environmental concerns. Meanwhile, Lamphun Industrial Park in Thailand is still trying to form consensus within the community, as it failed to do so properly earlier in the project.

(3) On evaluation and classification of EIPs:

It's important to establish an assessment system that is suitable for classifying IPs and developing conversion options. Based on the principles of industrial ecology and symbiosis, evaluation criteria cover economic, social and environmental aspects. However, *choosing the right criteria, building evaluation thresholds, and synthesizing*

the results is difficult. As well as being scientifically justified, criteria must be tailored to national characteristics, current regulations and global development trends.

China has developed a set of national standards that emphasize environmental and economic aspects, but don't adequately address social issues. Similarly, because Italy's standards lack economic indicators they do not fully reflect the impact of EIP development. Meanwhile, South Korea's more diverse criteria for assessment and classification can be applied quite flexibly.

(4) On the role of the government

EIP projects cannot be successful without government playing a role at all levels. Government *builds the legal framework* for the development of EIPs, designing and coordinating the mechanism between enforcement, control, and evaluation agencies. Without this, the competing interests of different stakeholders can hamper the formation of EIPs. The success of this framework requires a *relevant legal backdrop*, such as laws on cleaner production, social security or economic development.

In the case of Denmark, there was minimal state intervention, but existing environmental regulations contributed to the project's success. The Chinese and South Korean EIP programmes benefited from strict regulatory systems and competent enforcement agencies, from the central to the local level.

The State can also create *effective incentives and supports* for businesses and communities. In South Korea, state financing for cleaner production and industrial symbiosis projects played an important role in the early stages of EIP development.

III. OVERVIEW OF THE INTERNATIONAL FRAMEWORK FOR ECO-INDUSTRIAL PARKS

Several studies have analyzed and identified possible EIP evaluation criteria. In addition to location and country-specific indicators, such as in China and South Korea, there are sets of *general orientations*. These are usually divided into three major categories – environmental, economic, and social – with each group containing quantitative indicators and its own rating system. Different countries can apply, adapt and adjust these criteria flexibly, based on their individual circumstances.

3.1. Environmental requirements

This is the main driver in converting IPs into EIPs. Based on the recommendations of the Global Reporting Initiative, Bastida-Ruiz et al. (2013) developed a *standard of indicators for enterprises in IPs*. By reviewing individual businesses, authors can assess impact on a larger scale, IP or region. The environmental criteria include:

(1) Materials

(2) Energy

(3) Water

(4) Biodiversity

(5) Waste gas, wastewater, and waste

(6) Products and services

(7) Regulatory compliance

(8) Traffic

Tarantini et al. (2007) developed a framework of key strategies for *assessments at the IP level*. Using this, each locality, region or country can form indicators and individual rating thresholds.

Table 4. Environmental aspects of EIP assessment according to Tarantini et al. (2007)

Basic objectives	Key strategies
GENERAL	
Regulatory compliance	• Promote environmental systems • Training and auditing required
Land use optimization	• Evaluate alternative uses relative to existing industrial land sites (for new projects). • optimizing industrial park projects • Sustainable construction • Optimize interaction with surrounding areas (coastal areas, conservation, etc.)
Safety and emergency management	• Risk analysis and management at the IP level • Risk management plan in the IP (e.g. fire prevention)
ENVIRONMENT	
Sustainable use of natural resources	• Efficient use of water and energy • Use the best current technology, clean technology • Maximize use of renewable resources • Give priority to using local renewable resources • Sustainable construction • Green procurement • Use of cascading resources (energy, water, materials) • Green design products and services • Reduced material flow
Reduce emissions (air, water, soil, ground, noise, electromagnetism)	• Use the best current technology, clean technology • Green procurement • Green design products and services • Minimize noise and light pollution
Reduce waste in production	• Take measures to prevent waste • Close material flow (recycled, reused, recycled) • Green procurement • Green design products and services
Sustainability for people and goods	• Promote the efficient use of transportation means (public transport, vehicle sharing) • Optimize transportation inside the IP and the formation of parking lots (mobility management). • Maintenance of roads connecting external traffic networks; promotes conjugate transport
Quality and diversity of environment and landscape	• Sustainable construction • Optimal management of ecosystems and biodiversity in the IPs • Ensure open space quality

Source: Tarantini et al. (2007:14-15).

International organizations have also made great strides in promoting the development of EIPs. UNIDO (UNIDO 2016, 2017a, b) has developed a handbook for the development, construction, and evaluation of EIPs and, together with the World Bank and GIZ (UNIDO, World Bank, GIZ, 2017) have co-developed a comprehensive EIP rating framework. Created for both a park's management and businesses, the framework is based on four aspects: management, economic and social and environmental governance. As well as park regulations, the EIP and related businesses are expected to comply with local and national regulations, including:

- National regulations on air emissions (SO_x, NO_x, greenhouse gas and chemical odor)
- National regulations on water exploitation, watershed management, discharge limits
- National regulations on waste treatment (including pollutants and treatment requirements) and transportation of waste (including labeling, maximum volume, storage, and recycling)
- National regulations on the disposal of hazardous waste (including labeling, blocking and use of qualified contractors)
- National regulations on noise limits in activities (ambient darkness and surrounding, measured in dB)
- National regulations on energy and resource efficiency as well as other regulations related to efficiency (3Rs: reducing waste, reuse, recycling)
- National regulations for the protection of the natural environment and biodiversity (sensitive marine environment, inland waters, natural forests and protected fauna and flora)
- National regulations relating to climate change mitigation and adaptation
- Local laws pertaining to the national regulations listed above.

To satisfy the above-mentioned environmental regulations, the IP must also meet a number of prerequisites:

- The infrastructure management company must have an environmental/energy management system by international standards, which may monitor the performance of the facility and assist the enterprise in maintaining their system management.
- Energy efficiency programmes and materials are available at the enterprise, especially for the 50% of the largest energy consumers.
- There is an industrial heat recovery strategy to consider heat and energy recovery opportunities for the largest energy consuming companies (10-20% of the total).
- The infrastructure management company has a simulation plan and pre-recorded data to increase the short- and medium-term water use (both industrial and rainwater).
- A programme to monitor and mitigate greenhouse gases such as CO_2, CH_4, and NO_x with specific steps to follow.
- The infrastructure management company has a plan to evaluate the actual environmental impacts and to reduce the impact on key local ecosystems.

After satisfying the above minimum conditions, the industrial park is evaluated by the following table.

Table 5. Environmental requirements according to the EIP International Framework

Topic	Sub-topic	Description/ Requirement	Indicator	Unit (target value)
Management and monitoring	Environmental/ Energy Management Systems (EMS and EnMS, respectively)	Firms have functioning and fit-for-purpose EMS/ EnMS systems. Summary information from these management systems is provided to park management, who will aggregate and report on data at the park level.	The proportion of resident firms, with more than 250 employees, which have an environmental/ energy management system in place that is in line with internationally certified standards.	Percentage of firms (40%)
Energy	Energy consumption	The industrial park has adequate metering and monitoring systems in place to measure energy consumption at both the park and firm levels.	The proportion of combined park facilities and firm-level energy consumption, for which metering and monitoring systems are in place.	Percentage of combined park & firm level energy consumption (90%)
	Renewable and clean energy	The industrial park leverages available renewable generation sources, with plans to increase contribution for shared services (for example, solar street lamps, biomass, hydro, natural gas, and so on).	Total renewable energy use in the industrial park is equal to or greater than the annual national average energy mix.	Percentage of renewable energy use in park relative to national average % (>=)
			Park management entity sets and works towards ambitious (beyond industry norms) maximum carbon intensity targets (maximum kilograms of carbon dioxide equivalent (kg $CO_{2\text{-eq}}$)/ kilowatt-hour (kWh)) for the park and its residents. Targets should be established for the short, medium, and long term.	Kg $CO_{2\text{-eq}}$/kwh (in line with local norms and industry sector benchmarks)
	Energy efficiency	Energy efficiency opportunities should be actively identified at the park and firm levels to reduce energy use and associated greenhouse gas emissions. EIPs should identify and promote technological and process-related interventions in their own and resident business operations.	Park management entity sets and works towards ambitious maximum energy intensity targets per production unit (kWh/$ turnover) for the park and its residents. Targets should be established for the short, medium, and long term.	kWh/$ turnover (in line with local norms and industry sector benchmarks)

Topic	Sub-topic	Description/ Requirement	Indicator	Unit (target value)
Water	Water consumption	A mechanism is in place to appropriately monitor water consumption across the park, and ensure demand management practices are in place in case of water stress. Extraction from water sources (such as rivers, and groundwater sources) occurs at sustainable levels.	Total water demand from firms in the industrial park which do not have significant negative impacts on local water sources or local communities.	Percentage of water demand (100%)
	Water treatment	The industrial park has provisions in place to appropriately treat, recycle and reuse treated wastewater. No effluents significantly impact potable water resources and the health of local communities or nearby ecosystems	The proportion of industrial wastewater generated by an industrial park and resident firms, which is treated to appropriate environmental standards.	Percentage of wastewater treated/ total wastewater (95%)
	Water efficiency, reuse, and recycling	The park and businesses have systems in place to increase water savings and reuse.	The proportion of total industrial wastewater from firms in the park is reused responsibly within or outside the industrial park.	Percentage of water reused/total water consumed (50%)
Waste and material use	Waste/by-products reuse and recycling	A program/mechanism is in place to promote and encourage reuse and recycling of materials by firms in the park (for example, raw materials for process and non-process applications)	The proportion of solid waste generated by firms, which is reused by other firms, neighboring communities, or municipalities.	Percentage of solid waste reused/total waste (20%)
	Dangerous and toxic materials	Program/mechanism in place with clear targets to reduce and avoid the use of dangerous and hazardous materials by firms in the park	The proportion of firms in the park, which appropriately handle, store, transport and dispose of toxic and hazardous materials.	Percentage of firms (100%)
	Waste disposal	A functioning waste collection, treatment, and disposal system are in place to ensure that unused waste materials are treated and disposed of in proper landfills.	Maximum proportion of wastes generated by firms in the industrial park which go to landfills.	Percentage of waste to landfill (<50%)

Topic	Sub-topic	Description/ Requirement	Indicator	Unit (target value)
Climate change and the natural environment	Flora and fauna	Native flora and fauna are important to maintain the proportion of natural areas. They are integrated within the industrial park and natural ecosystem where possible.	Minimum proportion of open space in the park used for native flora and fauna.	Percentage of open space (5%)
	Air, GHG emissions and pollution prevention	A mechanism is in place to avoid, minimize, and/or mitigate significant point source pollution and GHG emissions. This should cover gases (CO_2, methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and hydrofluorocarbons (HFCs), local particulate and air pollution emissions (for example, sulfur oxides (SO_x), nitrogen dioxide (NO_x), as well as chemicals and pesticides use and management.	The proportion of firms in the park which have pollution prevention and emission reduction strategies to reduce the intensity and mass flow of pollution/emission release beyond national regulations	Percentage of firms (50%)
			The proportion of largest polluters in the industrial park which have a risk management framework in place that: (a) identifies the aspects which have an impact on the environment and; (b) assign a level of significance to each environmental aspect.	Percentage of largest emitters (30%)

Source: UNIDO, World Bank, and GIZ (2017:44-45).

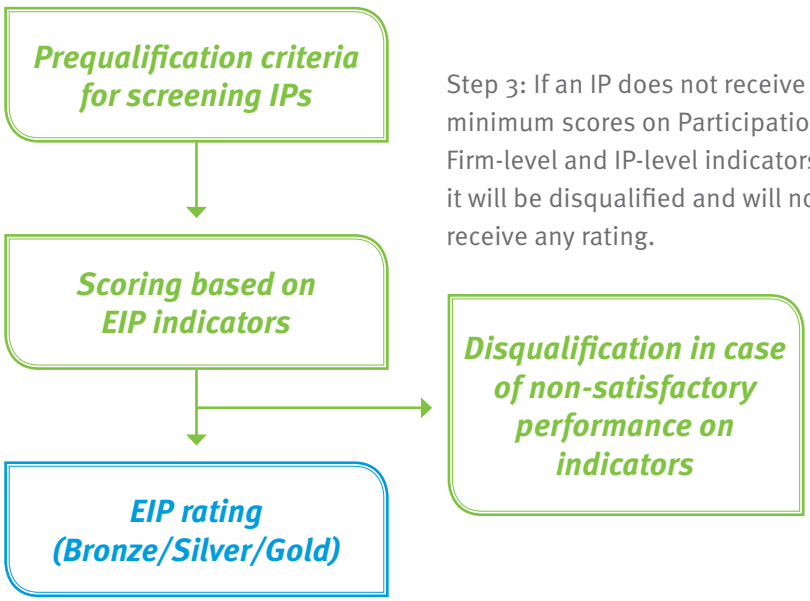
Based on environmental indicators in the international framework for EIPs, Viet Nam's National Technical Guidelines provide indicators on the level of IPs and enterprises. They also describe an approach to ranking EIPs to promote their continuous improvement. The approach to assessing and ranking EIPs is presented in the following figure:

Figure 1. Process for evaluating and ranking EIPs

Step 1: Screen the IPs on the basis of the prequalification criteria. Any IP not meeting the criteria is not eligible to apply to the EIP programme

Step 2: Calculate the total score by adding the score assigned to all indicators

Step 4: Evaluate the rating (Bronze/Silver/Gold) of the EIP based on the total score received under Step 2.



Step 3: If an IP does not receive minimum scores on Participation, Firm-level and IP-level indicators, it will be disqualified and will not receive any rating.

Source: Eco-Industrial Park Technical Guidelines for Vietnam

3.2. Economic requirements

Economic indicators for evaluating EIP have also been proposed for both IPs and enterprises. Bastida-Ruiz et al. (2013) suggest evaluating the economic performance of enterprises on three aspects:

(1) economic efficiency;

(2) gaining market share; and

(3) indirect economic impacts.

Tarantini et al. (2007) suggest considering the economic achievements of the IP in three respects (Table 6).

Table 6. Economic indicators according to Tarantini et al. (2007)

Topic	Indicator
1. Growth in value and profitability of companies	• Marketing of IPs • Organizing events of the IP • Reduce costs by creating efficient sharing services (monitoring, logistics, water and waste management, etc.) • Technological advances
2. Attract economic resources	• Improve infrastructure • Computerized • Create favorable conditions for investment • Marketing of IPs • Participate actively in conferences, events
3. Economic Advancement of Local Communities	• Purchase of goods and services locally • Promote the establishment of local service companies

Source: Tarantini et al. (2007:15).

The economic indicators of UNIDO, World Bank and GIZ (2017) are broader and more detailed, and include meeting regulatory requirements, prerequisites, and metrics.

Using this framework, the EIP and enterprise are expected to comply with all national and local financial and economic regulations, including:

- National regulations on reporting and financial disclosure;
- Regulations on the promotion of small and medium enterprises, local businesses to develop;
- Regulations on technology transfer and intellectual property;
- Regulations on skill development and vocational training;
- Business rules, including financial, trade and fiscal regulations.

The prerequisites include that:

- The infrastructure management company plans to create a number of different types of jobs compatible with government objectives (Yes/No).
- Infrastructure companies allow and encourage the establishment of small and medium enterprises providing value-added services to other enterprises in the IP (Yes/No).
- There is a feasibility study on market demand, along with the business plan, for "green" infrastructure and services to complement the planning and implementation of planning in the IP (Yes/No).
- Under the supervision of an infrastructure provider, the IP implements relevant government goals, including domestic and FDI, and taxes (Yes/No).

The indicators to measure specific results (in addition to the prerequisites) are presented in the table below.

Table 7. Economic indicators according to the EIP International Framework

Topic	Sub-topic	Description/Requirement	Indicator	Unit (target value)
Local jobs	Create jobs in the locality	Each EIP must create job opportunities at the locality in order to ensure the link between revenue and development opportunities.	% of total employees working in IPs, daily travel distance between home and work	% employees (60%)
	Job types	Which EIP sign long-term contracts with employees	% of total workers in IPs who are directly recruited (without job broker) and long-term contracts	% of labors (25%)
Support SMEs and local businesses	Local value added	Each EIP has to consider appropriate local suppliers and cutting cost; give development opportunities to local businesses.	% of enterprises within IPs that use local product and service suppliers for at least 80% of their consumption value	% of enterprises (25%)
			% of total consumption value of IP management board (using local service suppliers)	% total consumption value of IP management board (90%)
Create economic values	IP is ready to invest in enterprises	Each EIP should be ready to invest thus have less economic risks and better investment opportunities for businesses. Essential services and infrastructures should be provided by IPs, including water, energy, roads, etc.	The ratio of rented areas of in use comparing to total industrial area	Occupancy over 5 years (50%)

Source: UNIDO, World Bank, GIZ (2017:53).

3.3. Social requirements

At the enterprise level, Bastida-Ruiz et al. (2013) build on four key dimensions and component indicators, as shown in the table below.

Table 8. Social standards for enterprises in the industrial park according to Bastida-Ruiz et al. (2013)

Aspects	Targets
Working environment and decent jobs	• Jobs • Labor/management relations • Occupational health and safety • Educations
Human rights	• Equal opportunities and diversity • No discrimination • Freedom of association and collective bargaining • Child labor • Forced and forced labor
Society	• Community • Corruption • Public policy
Social responsibility of the product	• The safety and health of the customer • Label products and services • Marketing communications • Compliance

Source: Bastida-Ruiz et al. (2013:1278).

Social indicators are based on reports and regulations from government and international standards, such as ISO (International organization for standardization), OH&S (Occupational Health and Safety Management System), CSR (Corporate Social Responsibility), Accountability, Social Accountability and Global Compact. The social requirements of Tarantini et al. (2007), although designed for industrial parks, cover similar aspects.

Table 9. Social indicators at the industrial park level according to Tarantini et al. (2007)

Aspects	Targets
Improve working conditions	• Prevention of occupational accidents • Improves the cleanliness of the work environment • Establishment of service facilities (canteens, clinics, banks, cultural and sport facilities)
Education and training	• Develop education programs directed towards the local community • Vocational training • Information and cultural activities
Strengthening local identity and industrial park	• Organization of events • Active participation in conferences, events
Equality, solidarity and community cohesion	• Promote the principles of social responsibility • Create a startup environment • Strengthen cooperation between the industrial park and local authorities to create jobs, improve security, well-being and social inclusion.

Source: Tarantini et al. (2007:16)

Similarly, the social requirements of the EIP International Framework also include compliance with national regulations, minimum requirements and performance indicators.

The EIP and enterprises are expected to comply with all local and national regulations, including:

- National regulations on human rights (e.g. gender equality and rights of women and children);
- National regulations for the protection of indigenous peoples (including ethnic, tribal and other national traditions);
- National regulations for the settlement of discrimination (e.g. discrimination based on race, ethnicity, religion, sex, age, and disability);
- National labor laws (including working hours, occupational health and safety, child labor and maternity leave);

The table 10 presents the prerequisites, the performance indicators and the rating thresholds.

Table 10. Minimum requirements and social indicators

Topic	Sub-topic	Description/Requirement	Indicator	Unit (target value)
Prerequisites for EIP				
Social management system	Management Group	Functional systems are implemented to ensure the provision of social, operational and performance infrastructure, as well as important collection, monitoring, and management of information and social impacts related to the industrial park.	Have dedicated staff (of the area management agency) to plan and manage the social quality standards	Yes/No
Social infrastructure	Main social infrastructure	Providing basic social infrastructure in the industrial park or around, facilitating and encouraging the employment of women; for example, public toilets, drinking water, canteens, recreation areas, and kindergartens. This infrastructure needs to be fully operational to encourage the employment of women	The essential social infrastructure is already in the master plan, and fully operational in the industrial park	Yes/No
Performance indicators				
Social management system	Occupational health and safety (OH&S) management system	Businesses in the industrial park need to have an on-site OH&S management system (based on ISO 18001), keeping records of injury levels, occupational diseases, absences, as well as the total number of deaths. related to work	The percentage of all companies with more than 250 employees has a good OH&S management system	% of companies (75%)
	Claim Management	Complaints should be available, and access to and settlement of complaints from within the IP, as well as external parties, such as: help desks, complaints boxes and hotline (telephone booth) located inside and outside the industrial park	Complaints received by the park management organization are resolved within 90 days The percentage of complaints received by the district manager and made conclusively The percentage of all firms with more than 250 employees has a code of conduct for resolving complaints	% of claim (100%)
	Respond to harassment	An anti-harassment system with clear complaint and response procedures is required	The percentage of all enterprises with more than 250 employees take precautionary measures and respond to harassment	% of companies (75%)

Topic	Sub-topic	Description/Requirement	Indicator	Unit (target value)
Social infrastructure	Main social infrastructure	Social infrastructure must meet the standards and requirements of the workforce and the expectations of the client	The percentage of employees surveyed said that satisfaction with social infrastructure	% of employees surveyed (75%)
	Industrial park security	The industrial park has security systems and services that work well and fit the purpose. Examples: Suitable lighting systems in and around the industrial park, closed-circuit television, central security office, and night transport	The percentage of security and safety issues is reported and fully resolved within 30 days	% of reported security and safety issues (100%)
	Capacity building	There are training and skills development programs by groups of workers, with emphasis on equal opportunity, e.g. skills development and training programs, and business development programs for women.	The percentage of all enterprises with more than 250 employees has vocational training/ development and skills The percentage of the female workforce benefited from the infrastructure/support program available to develop skills	% of companies (75%) The proportion of female labor force (75%)
Access to local communities	Community dialogue	Provide communication facilities or other facilities to maintain regular dialogue with relevant communities and civil society organizations, such as newspapers, newsletters, and the mass media.	More than 80% of community members surveyed were satisfied with community dialogue	% of community members surveyed (80%)
	Participate in the public	Industrial park management organizations and companies involved in outreach activities and document retention. These activities may include: an anniversary within the industrial park; road clearing or community activities organized by the management of industrial park; building community infrastructure (e.g., providing clean water, sanitation)	The number of annual access activities conducted by the IPA is more than 80% of the community members surveyed.	Number of activities approaching each year (2)

Source: UNIDO, World Bank, GIZ (2017: 47-49).

The thresholds used in this set of expenditures are detailed, and may be used by countries as a reference. Each topic can be screened, adjusted and supplemented to suit the specific development context.

The EIP International Framework of UNIDO, World Bank, and GIZ (2017) is a flexible tool. In Viet Nam, UNIDO (2015) and IFC (2017, 2018a, b) made suggestions for evaluating existing IPs in their transition to EIPs. However, when applying this framework, the minimum thresholds need to be discussed further and adjusted to local conditions. Other indicators can also be added, and a more detailed weight system developed for each. This ensures a more accurate assessment of each issue. The first step in this process is reviewing the development strategies and legal framework applicable to the development of the EIP in Viet Nam.

IV. DEVELOPMENT STRATEGY AND REGULATION OF ECO-INDUSTRIAL PARKS IN VIET NAM

4.1. Development strategies for industrial parks and EIPs in Viet Nam

After Viet Nam began to open up its economy in 1986, it implemented a series of socio-economic development programs that supported the development of IPs and export processing zones. These included the establishment of Tan Thuan export processing zone in Ho Chi Minh City (1991), the Export Processing Zones Regulations (Decree 322/HDBT of the Council of Ministers dated 18 October 1991) and the Industrial Park Regulations (Decree 192/CP of the Government dated 28 December 1994).

IPs and export processing zones (EPZs) have contributed significantly to the industrialization and modernization of the country in the past 30 years, showing the effectiveness of new policies and strategies that have supported their development.

The Export Processing Zone Regulations (1991) and the Industrial Park Regulations (1994) were the first stages in this journey, aiming to develop local industry in areas that produce raw materials by providing favorable infrastructure for domestic enterprises and to attracting foreign-invested enterprises.

In 1996, a resolution from the 8th Party Congress defined a development strategy. It aimed to distribute IPs in a way that encouraged industrial development while solving environmental problems in the process of industrial production: "Forming IPs (including EPZs and hi-tech parks) contribute to create favorable conditions for the construction of new industrial establishments; strongly develop the rural and peri-urban industry; contribute to upgrading and renovating existing industrial establishments, dislocating the establishments incapable of avoiding pollution outside of the cities, and limiting the construction of new IPs with residential areas".

Then, in the years 2001-2006, the 9th and 10th congresses linked the pursuit of a strong economy with that of sustainable development. Developing IPs and EPZs efficiently and sustainably, and building high-tech parks and large industrial clusters, was a priority in the efforts to rationalize the country's industrial sector. But proliferation of IPs in the 2000s took a socio-economic toll, and led to issues including loss of agricultural land, threats to national food security, environmental pollution, and discontent about land acquisition for projects, etc.

Since 2010, the country has radically changed its IP development strategy, aiming to ensure the long-term sustainability of IPs at both regional and national levels. Most recently, the 12th Congress (2016) reaffirmed its goals as: "*More reasonable industrial allocation throughout the national territory; improving the efficiency of economic zones, industrial parks and export processing zones; putting some high-tech industrial parks into operation*".

The development of IPs in Viet Nam over nearly 30 years has been consistent and in line with the national strategy. On May 22nd 2018, Decree 82/2018/ND-CP announced further development of the eco-industrial park model, representing a leap forward in the process.

4.2. Regulations relating to the development of eco-industrial parks

About a decade after eco-industrial parks were established in Viet Nam, Decree 82/2018/ND-CP (replacing Decree 29/2008/ND-CP, Decree 164/2013/ND-CP and Decree 114/2015/ND-CP) is an important milestone in the management of IPs and economic zones. It creates a legal framework for the development of the EIP model and is in fact the only legal document about EIPs in Viet Nam that reaches up to the present. This represents a positive change in government attitudes to the responsible use of natural resources and environmental impact in the industrial sector.

The operation of the industrial park and its resident companies is governed by a number of other legal provisions covering all aspects, including investment policies, financing, environment, social security, as well as institutional arrangements. These provisions also include regulations that encourage the development of enterprises and industrial parks into EIPs. Nevertheless, the context and coordination mechanisms can be unclear and overlap between documents.

4.2.1. Mechanisms and policies on economic aspects

Decree 82/2018/ND-CP is Vietnam's first legal document regulating issues related to EIPs. It includes the definitions of an EIP and industrial symbiosis, and regulations for the development of EIPs. It also encourages use of the following EIP model:

- The EIP is an industrial park, in which enterprises are engaged in cleaner production and the efficient use of natural resources, as well as cooperation in production and on industrial symbiosis to improve the economic, environmental and social efficiency of enterprises.
- The state encourages and applies measures to support organizations and individuals to invest in the establishment or conversion of all or part of the IPs, under the planning approved by the competent agencies, towards the model of EIP.
- Investors in the development of infrastructure and investors renting land or subleasing land with infrastructure in EIPs will enjoy the incentives applicable to investment in IPs, or those specific to local jurisdictions, industries or sectors, and shall be entitled to support from competent state agencies in administrative procedures, technical consultancy, investment promotion and provision of information on investment cooperation under the provisions of this decree.

To develop an EIP, the state encourages infrastructure investors through investment incentives, applied by area and by industry:

a. Incentives according to investment areas

The construction of infrastructure for an industrial park in difficult areas is regulated in Article 18, Article 20 and Article 27 of the Decree 118/2015/ND-CP, guiding the implementation of investment law as follows:

Article 18- Support for investment in the construction of infrastructures in IPs and export processing zones

1. The scope, subjects, principles, criteria, limits of investment assistance from central government budget for construction of infrastructure of industrial parks and export-processing zones in disadvantaged areas or extremely disadvantaged areas shall comply with the applicable Industrial Park Infrastructure Investment Target Program.

Article 20- Investment in technical infrastructures of IPs and export processing zones

2. With regard to a disadvantaged area, depending on its conditions, the People's Committee of the province shall request the Prime Minister to establish or appoint a revenue-earning public service agency as an investor in the project for construction and operation of technical infrastructure or the industrial park or export-processing zone.

Article 27- Assurance of implementation of investment projects

6. The investor shall receive a deposit reduction in the following cases:

> a) 25% reduction of deposit for investment projects in business lines eligible for investment incentives; investment projects in disadvantaged areas, investment projects in industrial parks and export-processing zones, including projects for construction and operation of infrastructure in industrial parks and export-processing zones;

b. Investment incentives

Incentives can be found in Decree 32/2017/ND-CP on investment credits of the state and in Decree 45/2012/ND-CP on industrial extension:

- *According to Decree 32/2017/ND-CP*: for projects on the list of investment credit loans, including:

- Investment projects on the construction of wastewater and garbage disposal facilities in urban centers, industrial parks, export processing zones, economic zones, hi-tech parks, hospitals and industrial clusters and craft villages; and
- Infrastructure investment projects in industrial parks, exporting processing zones and hi-tech parks;
- The investor will be entitled to a preferential loan, with the maximum lending amount for each project equal to 70% of the total investment capital (excluding working capital), and the maximum loan term, usually, no longer than 12 years.

In addition, *according to Decree 45/2012/ND-CP* on industrial promotion, establishments operating in the industrial park applying cleaner production will be entitled to financial support.

c. Private investment incentives for enterprises in the EIP

In order to encourage enterprises to participate in the development of the EIP model, Decree 82/2018/ND-CP also stipulates specific incentives for enterprises, including preferential loans:

Article 43- Preferences for enterprises in EIPs

3. Enterprises developing infrastructure of eco-industrial parks and eco-enterprises shall be given priority in borrowing preferential loans from the Viet Nam Environment Protection Fund, the Viet Nam Development Bank and funds, financial institutions, domestic and international donators to construct technical infrastructure of industrial parks, implement cleaner production methods, efficiently use resources and industrial symbiosis solutions.

d. Preferential policies on taxes and charges

In addition to the above investment incentives on industrial park infrastructure, enterprises, including infrastructure enterprises, also enjoy tax breaks and fees:

(1) Corporate income tax:

Enterprises are exempted from corporate income tax for two years and a 50% reduction of payable tax for four subsequent years on incomes from new investment projects in IPs located in geographical areas subject to poor socio-economic conditions (Item 3, Article 16, Decree 218/2013/ND-CP)[4].

(2) Personal income tax:

Individuals (residents and non-residents) working in industrial parks receive a 50% reduction in personal income tax. (Circular 128/2014/TT-BTC)

(3) Value added tax:

Business establishments which pay value-added tax according to the tax credit method are entitled to input value-added tax credit as follows: Input value-added tax on goods or services used for the production or trading of goods or services subject to value-added tax may be wholly credited, including input value-added tax that is not be compensated of the damaged goods subject to value-added tax and input value-added tax of goods and services for forming fixed assets such as canteens, rest houses, dressing rooms, garage, restrooms, water basins serving employees in zones of production and business and dwelling houses, health station in industrial parks (Decree 209/2013/ND-CP).

(4) Land rental fee and land use fee:

The regulations relating directly to land leasing, land rental and land use fees in industrial parks are also mentioned in other documents:

- Infrastructure investors are exempt from land rent for land used for the construction of infrastructure used in the industrial park, industrial clusters, and export processing zones (Land Law 2013).

4 The areas with favorable socio-economic conditions specified in this Clause are urban districts of special grade, grade-I urban centers, and grade-I urban centers.

- Investment projects on construction and trading of industrial park infrastructure are exempted from land rent at district level (Decree 46/2014/ND-CP). In administrative divisions of rural districts facing extremely difficult socio-economic conditions, these investors shall be exempt from land rent for the whole lease term (Decree 135/2016/ND-CP).

e. General assessment

Decree 82/2018/ND-CP has created certain advantages in calling for investment in the construction of IPs as well as EIPs, such as:

- For regulations on EIP, it provides a framework for general investment incentives for infrastructure investment enterprises as well as resident enterprises. Detailed regulations are provided in the specialized documents, creating unity, synchronization, reducing the overlap between the relevant legal documents.
- It also contains the details of regulations and incentives for new IPs (which are, according to the document's definition, EIPs).

These regulations are important: as incentives for investment in EIP infrastructure are an essential cost item in the development of new parks. But the current regulations are general and need clarification. For example, businesses can obtain preferential loans from a range of institutions - including the Vietnam Environment Protection Fund, the Vietnam Development Bank, domestic and international funds[5], and financial institutions and donors - if they are building a park's technical infrastructure, applying cleaner production methods, using natural resources more efficiently or working towards industrial symbiosis. However, there are no specific provisions on loan rates, interest rates, or terms and procedures. In fact, businesses in Viet Nam can apply for loans from the same funds and credit institutions anyway, and it's not clear if there are different loan/liability interests for an EIP loan compared to another loan.

Other preferential regulations related to the development of IPs and EIPs are clearer, but their implementation in the past has often been inadequate. For example, Decree 45/2012/ND-CP provides policies to encourage and support organizations developing rural industrial production and using cleaner production methods, but in many localities, there is no budget for implementing industrial promotion. Circular 26/2014/TTLT-BTC-BCT offers guidelines for the use of both national and local industrial promotion funds, but provides no budget norms for local cleaner production activities, meaning provincial Departments of Finance have no basis to allocate funds for cleaner production.

4.2.2. Mechanisms and policies on social aspects

National policies on labor, employment and workers' welfare - including specific provisions for workers in industrial parks - are broad. They include:

a. Salary of employees

Decree 49/2013/ND-CP provides detailed wage guidelines for employees and employers, and lays out the principles for building wage scales and labor standards. Decree 122/2015/ND-CP determines minimum wage levels for workers. The current regional minimum wage is:

- VND 4,180,000/month, applicable to enterprises operating in geographical areas I;
- VND 3,710,000/month, applicable to enterprises operating in geographical areas II;
- VND 3,250,000/month, applicable to enterprises operating in geographical areas III;
- VND 2,920,000/month, applicable to enterprises operating in geographical areas zone IV.

This is the minimum salary that, in normal working conditions, allows workers and business to agree on sufficient monthly working hours, while meeting the requirements of labor standards. The salaries for untrained workers cannot be lower than the regional minimum, and they must be at least 7% higher for vocationally trained workers. For IP-based enterprises that operate in multiple locations with different minimum salaries, the highest minimum salary by region will be applied.

In reality, although the average salary for workers in IPs has increased, it is still lower than the national average for workers in other enterprises - equal only to 60-70% of what is needed to reach the minimal living standard.

5 A collation of green financing sources for EIP development in Viet Nam can be found in: 2019, UNIDO, Handbook on how to access green financing in Viet Nam, available online at https://www.unido.org/sites/default/files/files/2019-01/2018_Green_Financing_in_Viet_Nam.pdf

Salaries for workers in non-state owned enterprises are the lowest, followed by those in FDI enterprises. Increases are small, with increments of about VND 10,000 – 20,000 separating the many different salary levels, which can reach up to 30 or 35 in some enterprises. Increases are rarely based on seniority, meaning some senior workers see little change in their salaries. FDI enterprises sometimes pay workers according to how many low-priced products they can produce in a standard working period. During eight working hours, workers with higher outputs are paid at a level equal to or slightly higher than the minimum wage.

Low pay is one of the main causes of labor disputes and strikes over time. The EIP model needs to develop an effective mechanism to deal with this issue.

b. Housing and social-cultural facilities

Localities with several IPs have struggled to provide sufficient housing for workers. Several policies have been designed to deal with this issue.

(1) Article 32, Decree 82/2018/ND-CP on housing, social, cultural and sport works for workers clearly states:

- Organizations and individuals are encouraged to invest in building houses for rent to workers in IPs and EZs; as well as employers and infrastructure development enterprises participate in the construction of houses, social, cultural and sports facilities for workers.
- People's Committees at all levels are responsible for enabling workers to have easy access to health, education, social, cultural and sports services in their localities.
- Planning houses and social, cultural, and sports facilities for workers in IPs shall be closely connected with the planning IPs in the area. Provincial People's Committees shall set up the land use planning and reserve unoccupied land in appropriate locations for agencies, organizations, and enterprises to build houses, social, cultural and sports facilities for workers in IPs. In the investment process, investors must report to the authorized agency on plans for the settlement of houses, and social, cultural and sports facilities for workers.
- For IPs with difficulties in providing houses, and social, cultural and sports facilities for workers, based on specific conditions, it is possible to adjust the acreage of industrial park land which has been cleared for building houses, and social, cultural and sport facilities for workers. In the case where the planned area for housing, social, cultural and sports facilities is located adjacent to the IP, the province will approve the IP construction plan in association with the construction plan of houses, and social, cultural and sports facilities for workers.

(2) In the 2014 Law on Investment, Article 21 has provisions on houses, service and public facilities for workers in IPs and EZs: (i) Based on the general master plan for development of industrial parks, provincial People's Committees shall make a plan for the development of residential housing, service facilities and public facilities for individuals working in the IP; and (ii) For localities facing difficulties in arranging land area, competent state agencies shall decide to adjust the IP planning to reserve an area for the development of houses, service, and public facilities.

(3) Decree 100/2015/ND-CP was established to replace the Decree 188/2013/ND-CP on the development and management of social housing in IPs. It has articles on the responsibility to provide housing for workers in IPs:

- Provincial People's Committees have the responsibility to allocate enough land for social housing development for IP development plan projects;
- During the development of an industrial park, the local management board of the park or the enterprise running the park's infrastructure will be responsible for organizing land clearance and investing in technical infrastructure construction of social housing for workers in the industrial parks. Costs of compensation, ground clearance, investment in technical infrastructure construction of social housing shall be partially or fully included in the price of infrastructural services of the industrial park;
- If an industrial park has been completed but there are not enough houses for workers, the provincial People's Committee will be responsible for making or adjusting the plan to provide sufficient land area for social housing, and organizing land withdrawal, land clearance and compensation. The costs of land clearance and compensation will be covered by land levies and land rents retained by the local government. For Industrial parks whose industrial land has not been utilized entirely, the provincial People's Committee will be responsible for adjusting the planning to construct social housing;
- Enterprises with production bases in IPs have the responsibility to develop a housing settlement plan, to provide financial support to support the development of social housing for households and individuals with housing difficulties; newly established or production-expanded enterprises are responsible for ensuring housing for all households and individuals working in their units.

These regulations only go as far as allowing the locality to plan the construction of housing for IP workers. The greatest challenge for localities is the cost of building on unused land, particularly the costs of ground clearance and infrastructure construction.

c. Social and health insurance

Social insurance and health insurance for employers and workers are regulated in the Labor Law, the Law on Social Insurance and the Law on Health Insurance.

- *For social insurance*: The subjects of compulsory social insurance participation for workers working in IPs are Vietnamese citizens who satisfy the conditions specified in Clause 1, Article 2 of the Law on Social Insurance, including:

- Persons working under labor contracts with indefinite terms, labor contracts with definite terms and seasonal labor contracts or a specific job with the working term of between three months and under 12 months, including the labor contract, signed between the employer and the legal representative of the person aged under 15 in line with the labor law;
- Persons working under labor contracts with a term ranging from one month to less than three months;
- Officials and state employees;

- *For health insurance:* The subjects of compulsory social insurance participation for workers working in IPs are those defined in Article 12 of the Law on Health Insurance 2008, including:

- Workers working under labor contracts with indefinite terms, labor contracts with definite terms and

with a term of full 3 months or more under the labor law; Employees who are managers of enterprises shall receive salaries or wages according to the provisions of law on salaries and wages of officials, state employees according to the provisions of law.

In reality, access to health services and social insurance is very low in IPs and EZs. According to MPI's statistics, just 22-25% of workers in IPs receive regular medical examinations and only around 10% of workers who are exposed to high-risk contaminants are examined for occupational diseases. Most enterprises don't comply with state regulations on health, and prefer to pay the penalty fine for noncompliance, which is lower than the cost of providing healthcare (the maximum annual penalty is two million VND or above, while the cost of medical exams are about 25,000 VND per person per year). Employers also engage in fraud, evasion and failure to pay social insurance debts.

Healthcare and social insurance conditions for workers must be improved, and EIPs need to ensure all parties are in compliance with national social security regulations.

d. Labor safety

The principles of guaranteeing occupational safety are included in the Law on Occupational Safety and Health in 2015:

- Guaranteeing the workers' right to work in occupational safety and health conditions.
- Guaranteeing that all occupational safety and health measures are implemented during the working process; prioritizing measures to prevent, preclude and control dangerous and hazardous factors in the working process.
- Consulting trade unions, employers' representative organizations, and occupational safety and health councils at all levels in the formulation and implementation of policies, laws, programs and plans on labor safety and hygiene.

Responsibility for maintaining the right conditions and working environment for workers lies first with the employer. For workers in IPs, the Law on Occupational Safety and Health and the guiding decree (Decree 39/2016/ND-CP) clearly state the responsibility of the management board of the IPs for occupational safety and hygiene as follows:

> 1. Propagate, disseminate and urge production and business establishments within the scope of management to comply with the provisions of the law on occupational safety and hygiene;
>
> 2. Inspect the implementation of occupational safety and hygiene for production and business establishments within the scope of management, unless otherwise provided by specialized laws;
>
> 3. Coordinate with the inspection and examination teams on labor safety and hygiene as well as the occupational accident investigation team when requested;
>
> 4. Summarize and report on occupational safety and hygiene and reality of labor accidents and occupational diseases of production and business establishments within the scope of management to the Department of Labor, War Invalids and Social Affairs when authorized under the provisions of law.

To manage and assess the quality of the working environment and protect the health and safety of workers in industrial working places, the Ministry of Health has also introduced a series of standards related to the working environment. National Technical Standard QCVN 22: 2016/BYT on lighting, QCVN 21: 2016/BYT on high-frequency electromagnetic fields, QCVN 23: 2016/BYT on ultraviolet radiation. However, with the exception of some large FDI enterprises, most of small domestic enterprises fail to adequately guarantee the rights of employees, in particular the right to work in a safe environment. These provisions and the improvement of working conditions is a requirement in eco-industrial parks.

4.2.3. Resource and environment management

a. Environment management

In 2004, the government issued Resolution 41-NQ/TW on environmental protection in a period of accelerating national industrialization and modernization. A series of related programs and policies have followed, including specific policies for the protection of the environment and environmental diversity in industrial production and

IPs. These include the National Environmental Protection Strategy until 2010 with a vision towards 2020, the Plan to thoroughly handle establishments causing serious environmental pollution, the National Environmental Protection Strategy until 2020 with a vision towards 2030, and the Strategy for cleaner industrial production to 2020.

Pollutants in industrial parks are varied and complex: to protect environmental diversity, the abovementioned regulations need to be implemented.

IP-based enterprises comply with these regulations through environmental technical standards, which include environmental quality parameters, guidelines on the permissible amount of contaminants in waste, and technical and management requirements issued as mandatory documents by the competent state body.

Article 113 of the Environmental Protection Law 2014 establishes environmental technical regulations under two main categories:

1. Environmental quality of soil, surface water and groundwater, seawater, air, sound, light, radiation and noise and vibration; and
2. Waste management standards for wastewater from industries, services, breeding, aquatic production, domestic, traffic and other activities; for exhaust gas from mobile and fixed sources; and for hazardous waste.

Because the quality of the environment in the areas around IPs depends mainly on the emissions of the plants within, waste sources must be strictly managed according to regulations.

a. Wastewater management

According to Decree 80/2014/ND-CP on drainage and wastewater treatment, wastewater is water whose characteristics have been changed due to human use or human activities, discharged into drainage systems or the environment. Wastewater discharge in industrial parks can be divided into three groups: (1) discharge from the IP into receiving sources; (2) discharge from factories in the IP into the park's centralized wastewater treatment plant; (3) decentralized waste from factories in the IP.

- Discharge from IPs into receiving sources: The discharge of wastewater from the industrial sewage system into the receiving source must comply with the environmental technical regulations provided by the Ministry of Natural Resources and Environment.
- Discharge from factories in the IP into the park's centralized sewage treatment plant: Wastewater discharged into the park's sewage treatment system of the must comply with current regulations on environmental management of IPs and regulations of wastewater management agencies in IPs.
- Decentralized waste from factories in the IP: Wastewater treated by IP-based factories and discharged into receiving sources must comply with technical regulations provided by the Ministry of Natural Resources and Environment.

The Ministry of Natural Resources and Environment issued Circular 47/2011/TT-BTNMT and QCVN 40: 2011/BTNMT to regulate national technical standards for industrial wastewater. These include separate parameters for industrial wastewater discharged into (a) potable water sources and (b) non-potable water sources. There are also

specific wastewater regulations for different industries, including: Decision 16/2008/QD-BTNMT on the aquatic product processing industry; QCVN 52:2013/BTNMT on the steel industry; QCVN 13-MT: 2015/BTNMT on the textile industry; and Circular 12/2015/TT-BTNMT on waste paper and pulp industry.

To monitor the quality of wastewater, the Law on Environmental Protection lays out the responsibilities of those investing in the construction of IP infrastructure. Decree 38/2015/ND-CP and Circular 35/2015 require companies building industrial park infrastructure to install a continuous automatic wastewater monitoring system, with direct data transmission to the local office of the Department of Natural Resources and Environment. It also states that water treatment plant operation teams must have at least three people with college degrees (or higher) on them. If IP-based enterprises build separate wastewater treatment systems and discharge directly, they must report on their implementation of strategic environmental assessment, environmental impact assessment and the environmental protection plan, as prescribed in Circular 27/2015/ND-CP (Appendix 3).

Before it can be discharged, Decree 38/2015/ND-CP requires all industrial wastewater to be collected, treated and reused or transferred to functional units where they can be made suitable for reuse or treatment, according to national environmental technical standards.

Decree 54/2015/ND-CP contains incentives for economic and effective water use, but the scope of the decree is relatively small. Article 7 details credit and tax incentives for organizations that are: (i) building or upgrading work items to collect and treat wastewater to national technical standards on reuse, and using at least 80% of treated wastewater for their activities; (ii) building or renovating, upgrading and investing in water recirculation works with a capacity of 500 m3/day or more, but not including recirculating cooling systems and other water recirculation systems belonging to production processes and technologies. However, these incentives are not linked to specific provisions, and other regulations and incentives (including those on circulation and water use in IPs) have not been mentioned.

In practice, IPs discharge large amounts of wastewater, but only treat about 60% what's generated. The remaining wastewater - partly because of IP units that have exemptions and treat their own wastewater - is sometimes released directly into the environment untreated. This is why much of the wastewater discharged by IPs into the environment has pollution parameters higher than the national standard.

Consequently, the application of technical regulations on wastewater as a minimum requirement for EIPs is absolutely necessary. This is in line with the 2025 national objective to have 100% of the wastewater discharged by IPs treated according to national technical standards before being released into urban water drainage systems or discharged into the environment.

b. Solid waste management

Decree 38/2015/ND-CP on management of waste and discarded materials provides regulations on solid waste management, and distinguishes ordinary solid waste from hazardous solid waste and industrial solid waste.

Regulations for the management of industrial park solid waste are provided in Circular 35/2015/TT-BTNMT on environment protection in EZs, IPs, and EPZs:

- Production, business and service units in IPs must classify their solid waste according to regulations; dispose of such waste themselves or sign collection and disposal contracts with qualified units in accordance with the law;

- Sludge from the centralized wastewater treatment plant and water drainage system of an industrial park and operating units therein must be collected, transported and treated or reused according to regulations on sludge management.

Solid waste management is generally undertaken by the waste generators, i.e. the enterprises in an industrial park. Their responsibilities include classifying and storing solid waste according to regulations: it can be reused, preliminarily processed, recycled, treated, co-processed, licensed for transportation and handling, or energy recovered or contracted to be transferred to functional units. They must periodically report on their solid waste management. If enterprises fail to handle solid waste management by themselves, they must sign contracts with functional units for handling.

Those generating hazardous solid waste must register with the local office of the Department of Natural Resources and Environment to be issued a waste generator book, and report on their management of this waste every six months. The storage of hazardous wastes pending treatment shall comply with Clause 2, Article 7 of Circular 36/2015/TT-BTNMT, and enterprises must arrange hazardous waste and hazardous waste storage areas as regulated in Appendix 2 (A) attached to the Circular.

There is sufficient basis to implement solid waste management in IPs, but statistics show that several issues get in the way. Small and medium enterprises – especially domestic ones - often violate regulations on waste classification and the storage and treatment of hazardous wastes. They also frequently bypass controls at the final disposal, delegating control entirely to the waste collection unit, and keeping inaccurate records of waste statistics. IPs, meanwhile, fail to acknowledge the waste content of enterprises, and often lack internal waste treatment companies. These issues are a major barrier to promoting recycling and reuse in enterprises, and industrial symbiosis in IPs. Tightening and strictly implementing regulations on solid waste management are therefore a mandatory requirement for EIPs.

c. Managing emissions and noise in the industrial park

The national emission standards are stipulated in the Circular 25/2009/TT-BTNMT and Circular 39/2010/TT-BTNMT on noise and vibration.

Decree 19/2015/ND-CP guides the implementation of the Law on Environmental Protection. Regulations on the management of exhaust gas and noise in industrial parks are detailed in Article 10 of Circular 35/2015/TT-BTNMT. Enterprises in IPs that generate exhaust gas and noise must invest in and install the exhaust gas treatment and noise reduction according to environmental technical regulations.

An industrial park's management board is responsible for the implementation of these technical regulations, and the Department of Natural Resources and environment is responsible for the supervision, guidance and inspection of their implementation. However, IP management boards are often decentralized when it comes to implementing environmental standards in enterprises, and emission standards in particular.

Additionally, investors in industrial park infrastructure are responsible for monitoring the industrial park environment, including emissions and noise. They report to both the management boards of IPs and the Department of Natural Resources and Environment, as stipulated in Clauses 3 and 4, Article 15 of the Circular 35/2015/TT-BTNMT.

In reality, the management of emissions, dust and noise is not particularly effective. Domestic enterprises, SMEs,

construction materials manufacturers, feed manufacturers, food-processing enterprises and agricultural product enterprises are usually difficult cases for the management of emissions, odors, dust and noise. Dealing with this issue thoroughly is a critical task for EIPs.

b. Strategies for saving resources, energy and cleaner production

In general, policies on environmental resources management such as the Environmental Protection Law 2014 and Chapter 7 of Decree 19/2015/ND-CP, the Water Law 2012 and the Land Law 2013 are based on the principle of encouraging behaviors that protect the environment and save resources. Recommendations include the provision of a wide range of incentives and endowment schemes for environmental protection and shared use of resources.

a. Cleaner production strategy in industry:

The views, objectives, tasks, solutions and implementation of the effective use of natural resources and cleaner production are stipulated in Decision 1419/QD-TTg, which lays out the Cleaner Production Strategy in Industry until 2020. The strategy should be applied in every industrial manufacturing facility in the country in order to improve

efficiency in the use of natural resources, raw materials, fuels and materials; reduce emissions and limit pollution levels; protect and improve the quality of the environment, human health and ensure sustainable development.

The objectives for the period from 2016 to 2020 include:

- 90% of industrial manufacturing enterprises are aware of the benefits of applying cleaner production in industry;
- 50% of industrial manufacturing enterprises apply cleaner production; save from 8 to 13% of consumption of energy, raw materials, fuel and materials per product unit; 90% of medium and large enterprises have a specialized department of cleaner production;
- 90% of the Departments of Industry and Trade have qualified staffs to guide the application of cleaner production to industrial manufacturing enterprises.

The strategy also provides practical solutions on communication and awareness raising; organization, management, and mechanisms and policies; technical assistance, human resource training and international cooperation; and investment and finance.

The Ministry of Industry and Trade issued Decision 4135/QD-BCT dated June 21, 2013 to approve the strategy and implement its proposals using a bottom-up approach (piecing together enterprises to create more complex systems).

The Ministry of Finance and the Ministry of Industry and Trade issued Joint Circular 221/2012/TTLT-BTC-BCT to guide the management and use of state budget funds to implement the Cleaner Production Strategy. It allocates funds for:

- Raising awareness and capacity to apply cleaner production in industry;
- Supporting the application of cleaner production in industrial production enterprises;
- Completing the network of organizations supporting cleaner production in industry;
- Building and operating a database and website on cleaner production in industry at the Ministry of Industry and Trade;
- Improving financial mechanisms and policies to promote the application of cleaner production in the industry (survey, assessment, policy mechanism).

Expenditures to support cleaner production assessment for industrial manufacturing enterprises shall not exceed 50% of consultancy expenses and must not exceed VND 50 million per facility.

Though there is no specific regulation on cleaner production for industrial parks, it's clear that the legal framework for cleaner production in Vietnam is quite comprehensive, including technical specifications and financial support. Businesses can create their own cleaner production standards to save costs and increase their competitiveness, thus contributing to cleaner production methods of the park. That means that the Cleaner Production Strategy's targets for industrial enterprises are generally applicable to IP-based enterprises, for the application of cleaner production methods, and saving raw materials and fuel.

b. Use strategy in renewable energy sources

The most important legal regulation currently applied to the use of renewable energy is Decision 2068/QD-TTg dated November 25, 2015 approving Vietnam's Renewable Energy Development Strategy up to 2030, with a vision to 2050. It aims to increase the total number of renewable energy sources and generate electricity from renewable sources. For industrial production, the strategy establishes a goal of converting traditional biomass energy use in industry and small industry from low-efficiency equipment into advanced and high efficiency equipment. It also outlines development directions in the following areas: (i) hydropower; (ii) biomass energy; (iii) wind power; and (iv) solar power. However, regulations for IP operations are not mentioned in the strategy, despite IPs having the potential to use biomass resources through the provision and reception of biogas among businesses in IPs. There are no legal regulations guiding this issue.

c. Policies to encourage EIPs development

Section 4, Chapter IV of Decree 82/2018/ND-CP outlines the standpoint, objectives and supporting mechanisms to encourage the development of EIPs:

- Article 41 states the policies to encourage EIP development including (1). Encouraging investors to develop infrastructure of industrial parks, improve technical and social infrastructure, provide high-quality public utilities, connect and support enterprises in the area to implement industrial symbiosis to convert it into an EIP; (2). Encouraging enterprises in an industrial park to improve management and operation procedures, renovate and apply technologies towards cleaner production, reduce polluting sources, reuse waste and scraps, consume resources effectively; (3). Enterprises are encouraged to cooperate with each other or with a third party to use or acquire shared infrastructure or services, raw materials and other inputs; allowed to reuse waste, scraps and surplus energy of their own and other enterprises in the industrial park to reduce costs, improve operational efficiency and competitiveness; (4). The construction of new EIP shall be carried out by planning and arrangement of functional sub-zones to attract enterprises operating in similar sectors or industries, facilitate enterprises to implement industrial symbiosis; and (5) and (6) Encouraging the building of a database system on efficient use of materials in industrial park to support and connect enterprises in the symbiosis activities.
- Point 43 lays out incentives granted to enterprises operating within eco-industrial parks: (2). Enterprises participating in cleaner production, efficient use of resources effectively and industrial symbiosis activities shall be certified as eco-enterprises; (3). Enterprises developing EIP infrastructure and eco-enterprises shall be given priority in borrowing preferential loans from the Vietnam Environment Protection Fund, the Vietnam Development Bank and Funds, financial organizations, domestic and international sponsors to construct the infrastructure of industrial parks, implement cleaner production methods, efficiently use resources and industrial symbiosis solutions; (4). Enterprises developing EIP infrastructure and eco-enterprises shall be given priority in participating in technical assistance and investment promotion programs organized and managed by state agencies; and (5). Enterprises operating within EIPs shall be given priority for information related to the technology market and the possibility of cooperating in effecting industrial symbioses in the scope of production and business activities of these enterprises.

4.3. Comparison of the framework of assessment criteria for EIP of Vietnam and foreign countries

Being a developing country, the study and application of knowledge about the eco-industrial system in Vietnam is strongly influenced by the experience of other countries, including China, Korea, Japan, the US, Denmark, etc., and international organizations including UNIDO, WB and GIP. These organizations also contributed to and assisted in researching the initial results of the application of EIPs in Vietnam. Consequently, basic factors including definitions, the objectives and functions of an EIP, the approach to EIP construction and the set of criteria and indicators used to assess EIP of Vietnam is consistent with those of other countries.

Regarding the framework of assessment criteria for EIP, Vietnam uses the criteria of UNIDO, WB and GIP as its basis. The framework is divided into two basic steps: (1) ensuring minimum requirements and (2) extra encouraged objectives, which are further divided into four groups of indicators: management, environment, economy and society.

Until now, however, the indicators set for Vietnam target two indicator groups: management and environment. When compared with international indicators, these two groups show both differences and similarities, which are detailed in the table below. The differences can be obvious, due to the differences and particularities in strategy, condition, etc. of different countries.

Using nine indicators of management and 20 indicators of environment, the comparative analysis between the international framework and Vietnam's indicator sets shows that:

- Vietnam matches most of the international criteria. This is due to the fact that Vietnam used the same set of indicators, which had already been developed, experimented with and consulted upon in many countries. It acts as a guide for countries, to be implemented based on their individual conditions and realities.
- There are six indicators with high similarity to the international framework (two under management, four under environment). The two management indicators agree on the need for a management entity for an EIP, and on the responsibility of infrastructure management companies to maintain the common infrastructure. The four environment indicators agree about (1) raising awareness on energy saving and cleaner production among enterprises, (2) improving the effectiveness of energy consumption, (3) having strategies to reduce CO_2 emissions and (4) having a minimum area to maintain green space and natural ecosystems.
- There are five indicators with no similarity to the international framework (one under management and four under environment). These are related to planning and risk management, which Vietnam is not yet able to apply properly. They include plans to respond to climate change risks, risk management frameworks, heat recovery, management of toxic and hazardous materials, and mitigating negative effects of water consumption on the public water source.

Table 11. Comparison between international and national requirements

INTERNATIONAL FRAMEWORK			
Topic	**Sub-topic**	**EIP prerequisites and performance indicators**	**Domestic match International?**
PARK MANAGEMENT: prerequisites			
Park management services	Park management entity	A distinct park management entity (or alternative agency, where applicable) exists to handle park planning, operations and management, and monitoring.	**Yes**
	Park property and common infrastructure	Park management entity to manage and maintain the industrial park property, common infrastructure, and services as prescribed in the tenant contract and the park's Master Plan.	**Yes**
Monitoring and risk management	Monitoring performance and risks	Park management entity maintains a monitoring system in place.	**Partly**
		Has a plan in place to react to possible negative impacts due to climate change risks (heat waves and droughts, storms and floodwater events). All adaption needs for infrastructure and services are identified and in place for the industrial estate to protect against climate change risks and potential damages.	**No**
	Information on applicable regulations and standards	Has a functioning system in place to comply with local/national regulations and international standards applicable to the industrial park. Park management informs compliance by resident firms including compliance information that firms share with the park management entity.	**Partly**
Planning and zoning	Master plan	A Master Plan for any new and existing industrial park has been developed and is reviewed periodically (and updated if required).	**Partly**
PARK MANAGEMENT: Performance indicators			
Park management services	Park management empowerment	100% of firms in the industrial park have signed a residency contract/ park charter/code of conduct (depending on what is legally binding on park firms according to the existing legislation in the country); and additional legally binding arrangements that empower the park management entity to perform its responsibilities and tasks and charge fees (sometimes absorbed in rental fees) for common services.	**Partly**
	Park management entity property and common infrastructure	At least 75% of resident firms indicate satisfaction with regard to the provision of services and common infrastructure by the park management's entity (or alternative agency, where applicable).	**Partly**
Monitoring and risk management	EIP performance and critical risk management	At least every 6 months, park management entity monitors and prepares consolidated reports regarding the achievement of target values.	**Partly**
ENVIRONMENT: prerequisites			
Management and monitoring	Environmental/ Energy Management Systems	Park management entity operates an environmental / energy management system in line with internationally certified standards, monitoring park performance and supporting resident firms in the maintenance of their own firm-level management systems.	**Partly**

INTERNATIONAL FRAMEWORK			
Topic	**Sub-topic**	**EIP prerequisites and performance indicators**	**Domestic match International?**
ENVIRONMENT: prerequisites			
Energy	Energy efficiency	Supporting programs and documents are in place to improve the energy efficiency of resident firms, especially for the top 50 percent of major energy-consuming businesses in the park.	**Yes**
	Exchange of waste heat energy	An industrial heat recovery strategy is in place to investigate opportunities for heat and energy recovery for the major energy-consuming firms in the park. (Typically, these are firms that individually consume at least 10-20 percent of total firm level energy consumption).	**No**
Water	Water efficiency, reuse and recycling	Park management entity has demonstrable plans and (preferably) prior documented evidence to increase water reuse in the short and medium term. This would be achieved by either reuse of industrial effluents, or by rainwater/storm water collection.	**Partly**
Climate change and the natural environment	Air, GHG emissions and pollution prevention	A program is established to monitor, mitigate and/or minimize GHG emissions, such as carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (NO_x), and so on. There is clear evidence of steps taken to introduce mitigation activities.	**Partly**
	Environmental assessment and ecosystem services	The park management entity has a plan in place to assess operational environmental impacts, and aims to limit the impact on prioritized local ecosystem services.	**Partly**
ENVIRONMENT: Performance indicators			
Management and monitoring	Environmental/ Energy Management Systems	At least 40% of resident firms with more than 250 employees have an environmental / energy management system in place that is in line with internationally certified standards.	**Partly**
Energy	Energy consumption	At least 90% of combined park facilities and firm-level energy consumption have metering and monitoring systems in place.	**Partly**
	Renewable and clean energy	Total renewable energy use in the industrial park is equal to or greater than the annual national average energy mix.	**Partly**
		Park management entity sets and works towards ambitious (beyond industry norms) maximum carbon intensity targets (maximum kilograms of carbon dioxide equivalent (kg CO_2-eq) / kilowatt hour (kWh) for the park and its residents. Targets should be established for the short, medium, and long term, in line with local norms and industry sector benchmarks.	**Yes**
	Energy efficiency	Park management entity sets and works towards ambitious maximum energy intensity targets per production unit (kWh/$ turnover) for the park and its residents. Targets should be established for the short, medium, and long term, in line with local norms and industry sector benchmarks.	**Yes**

INTERNATIONAL FRAMEWORK			
Topic	**Sub-topic**	**EIP prerequisites and performance indicators**	**Domestic match International?**
ENVIRONMENT: Performance indicators			
Water	Water consumption	100% of total water demand from firms in industrial park does not have significant negative impacts on local water sources or local communities.	**No**
	Water treatment	At least 95% of industrial wastewater generated by industrial park and resident firms, which is treated to appropriate environmental standards.	**Partly**
	Water efficiency, reuse and recycling	At least 50% of total industrial wastewater from firms in the park are reused responsibly within or outside the industrial park.	**Partly**
Waste and material use	Waste / by-products re-use and recycling	At least 20% of solid waste generated by firms, which is reused by other firms, neighboring communities, or municipalities.	**Partly**
	Dangerous and toxic materials	100% of firms in park appropriately handle, store, transport and dispose of toxic and hazardous materials.	**No**
	Waste disposal	Less than 50% of wastes generated by firms in the industrial park goes to landfills.	**Partly**
Climate change and the natural environment	Flora and fauna	At least 5% of open space in the park is used for native flora and fauna.	**Yes**
	Air, GHG emissions and pollution prevention	At least 50% of firms in park have pollution prevention and emission reduction strategies to reduce the intensity and mass flow of pollution/emission release beyond national regulations.	**Partly**
		At least 30% of largest polluters in industrial park have a risk management framework in place that: (a) identifies the aspects which have an impact on the environment and; (b) assign a level of significance to each environmental aspect.	**No**

V. CONCLUSIONS

In recent years, the transformation of traditional IPs to more environmentally friendly models has attracted the attention of governments and international organizations around the world. The theoretical foundation for this transformation stems from the introduction of a new approach of IE and IS, which brings other social and economic co-benefits. These approaches focus on the co-evolution between production systems, ecosystems and communities, with the main principles being to make industrial production more 'circular' in order to save materials, reduce emissions, and improve resource use efficiency, while increasing the quality of life of workers and communities.

In this context, the concept of EIP was developed, aimed at building a community of partners to work together in better managing IPs, exchanging resources, preventing pollution and supporting communities. These interwoven relationships are expected to improve the competitiveness of businesses and the image of IPs; promote cleaner production and consumption; attract investments; and bring benefits in terms of regional and local development. However, the choice between new EIP construction and retrofitting existing IPs is not straightforward and needs consideration in terms of real costs and benefits.

The development of EIPs in other countries has seen both successes and failures. Successful experiences often have the convergence of many factors, typically: (1) taking cautious steps in forming the EIP and having the active participation of a variety of stakeholders, including government, businesses, associations, infrastructure investors, local authorities and residential communities on a voluntary basis, with shared values and benefits; (2) there is relevance in terms of scale, industry, distance between enterprises participating in the network, symbiosis and resource coordination; (3) there are clear and scientific indicators, suitable to the development context to enable the evaluation and classification of IPs; thereby developing a mechanism, roadmap and measures to support the development of EIPs; and (4) suitable state laws, regulations, policies and visions facilitate the inception and development of EIPs.

Recently, sets of indicators for EIP evaluation have been developed, both at the national and international level. The general tendency is to integrate social and economic indicators, , reflecting interest in these topics in the development of an EIP. One of the frameworks, which is relatively complete and can be easily applied to specific contexts is the EIP International Framework developed by UNIDO, World Bank and GIZ (2017). However, to be able to tailor those indicators to the specific circumstances of Vietnam, it is necessary to review and refine them. One of the first recommendations would be to review the current legal framework as well as the long-term development orientation of IPs.

Eco-Industrial Park Technical Guidelines for Vietnam are based on the EIP International Framework, and it provides a system of indicators and a related EIP ranking approach for Vietnam. The guidelines focus mainly on environmental indicators, but the international experience presented in this study shows that the economic and social aspects are just as important in assessing EIPs. The review of legal regulations on IPs in Vietnam also shows that many economic and social regulations exist specifically for IPs. These sometimes need to be specified further and systematized in order to improve their effectiveness and avoid overlaps in regulation.

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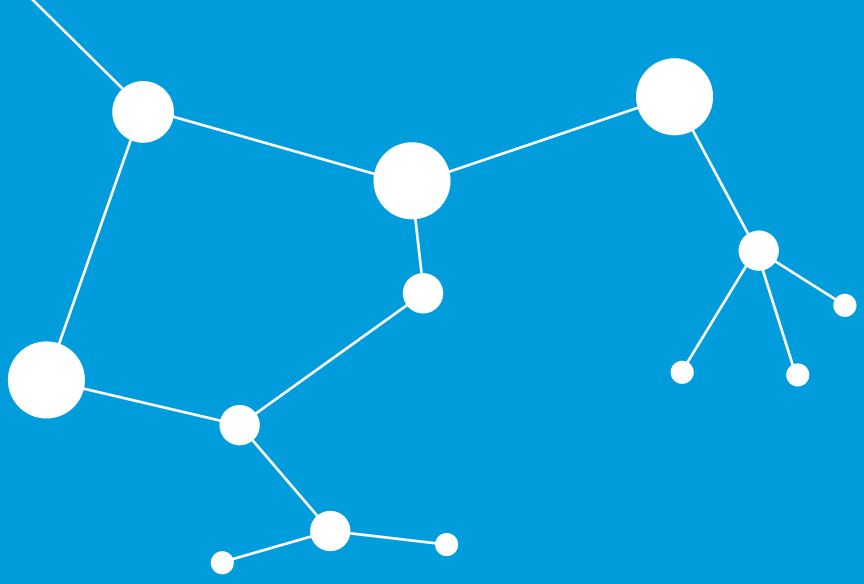

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