

Eco-industrial parks in Vietnam towards sustainable industrial zones

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Abstract. Eco-industrial park is the new trend in developing sustainable industrial zones. In Vietnam, the concept of ‘eco-industrial park’ has gained its popularity in the last decade; yet there remain many obstacles in actualizing this model. One of the main reasons is the lack of a criteria set for building eco-industrial parks that fits Vietnamese situation. We analyzed criteria for building eco-industrial parks in other countries in order to compare with current criteria in Vietnam. Suggestions for establishing a criteria set for building eco-industrial parks in Vietnam were discussed.

1 Introduction

Inclusive and sustainable industrial development has become a global trend due to a pressing need to balance between economic, social and environmental goals. Industrial zones are symbols of industrialization and growth, but they are often criticized for causing negative environmental and social impacts, including climate change, pollution, resource depletion, health and labor issues, etc. (Hart, 1994). As Allenby and Cooper (1994) reminded us: “economic systems are inextricably linked to supporting biological, chemical and physical systems; it is our failure to understand and appreciate this integration, and act accordingly, that has generated this unacceptable environmental degradation”. Consequently, sustainable industrial zones are becoming the desired model in response to extended resource depletion and environmental pollution (Fernández and Ruiz, 2009).

Eco-industrial park (EIP) is an appropriate strategy to promote sustainability in industrial zones. EIP provides larger-scope solutions than product- or firm-specific sustainable interventions, as it not only involves changes at firm level or park level but its social and economic impacts can benefit local communities and nations (Hein et al., 2015). The idea was first presented in United Nations Conference on Environment and Development in Rio de Janeiro 1992. The concept of EIP evolves from an ecology of concepts on sustainable and inclusive development, such as resource efficiency and cleaner production, industrial symbiosis, green industry, low-carbon zones, etc. Its attractiveness has spread beyond the academic world. The conversion of industrial zones into EIPs brings considerable benefits. Enterprises in EIPs cooperate to achieve the efficiency in production, trading, economic development and environmental protection through effective

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management of energy, water and materials, reduction in manufacturing costs, reduction of waste discharge, collection, recycling and reuse of waste and waste exchange, solutions for environmentally friendly waste treatment (Heeres, Vermeulen and de Walle, 2004).

EIP is defined as “A community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance.” (Lowe, 1997). Lowe’s conceptualization points out three pillars of EIP: environment, social and economic aspects.

In Asia, the rapid industrialization process has led to unsustainable economic growth. The EIP initiative becomes a designated model to mitigate negative environmental impacts and improve economic and social welfare (UNIDO, 2016). The EIP initiative has been implemented in both developed and developing Asian countries, including China, Singapore, Thailand, South Korea, Malaysia, Philippines, Indonesia, Malaysia, Japan, Taiwan, Vietnam, India. Similar to other countries, in Vietnam, various criteria have been established as requirements for EIP, either through bottom-up or top-down processes (Tran, 2003; Massard, Leuenberger and Tran, 2018). While there have been government regulations on criteria and management of EIPs, more detailed instructions and action plans are required to encourage firms and industrial zones to transform to EIP model. In addition, successful EIP development requires more than the active role of the government. Firm support is the what maintain EIP in the long run (Heeres et al., 2004; Desrochers, 2004).

This paper aimed to review international experiences on requirements of EIPs. China and Korea were selected for discussion and comparison because of their geographical proximity to Vietnam and the similarities in industrialization process. The International framework for EIPs proposed by UNIDO, the World Bank Group and GIZ in 2017 was used as a guideline for comparing between international models and Vietnam models. We also discussed the suitability of existing models in Vietnam towards finding an appropriate, nation-specific set of requirements for EIP in Vietnam.

2 General requirements for eco-industrial park

Despite its popularity, there remains many controversies about the requirements for EIPs. Various individual tools and processes have been developed to assist governments and industrial park stakeholders in developing and evaluating EIPs. However, there lacked a consolidated framework for EIPs at the international level. In an effort to unify existing individual tools and processes in the field, UNIDO, the World Bank Group and GIZ developed a framework for EIP in 2017. The framework provides a standard for developing and transitioning to EIPs.

The three pillars of EIP are well-reflected in three main dimensions of park performance: environmental performance, social performance, and economic performance. Park management performance is added as the fourth dimension to stress the importance of seeing the EIP as a cohesive entity, engaging with different stakeholders.

Environment performance consists of (i) resource-efficient production processes and (ii) management of adverse environmental impacts. Resource efficiency and cleaner production (RECP) are key to EIP. RECP requires integrated strategies to reduce input resources such as water and energy, decrease carbon footprint, and replace fossil fuels with renewable energy (Kjaerhem, 2005). Besides reduction and replacement, exchange is also a commonly encouraged option, which is referred as management of “waste and material use” in the proposed framework. Since the 2000s when the term “industrial symbiosis” was first coined, the exchange of materials, energy, water and by-products between firms of close

geographical proximity has proved its effectiveness in cost saving and pollution mitigation (Chertow, 2007; Lombardi and Laybourn, 2012), and it continues to be the vital requirement of green production and EIP in particular. The second aspect of environmental performance is management and monitoring park performance according to environmental and energy management systems based on existing standards such as ISO 14001 and ISO 50001. Climate resilience is added as a part of park environmental protection to stress the conscious effort of EIP in mitigating emission and managing environmental risks of production.

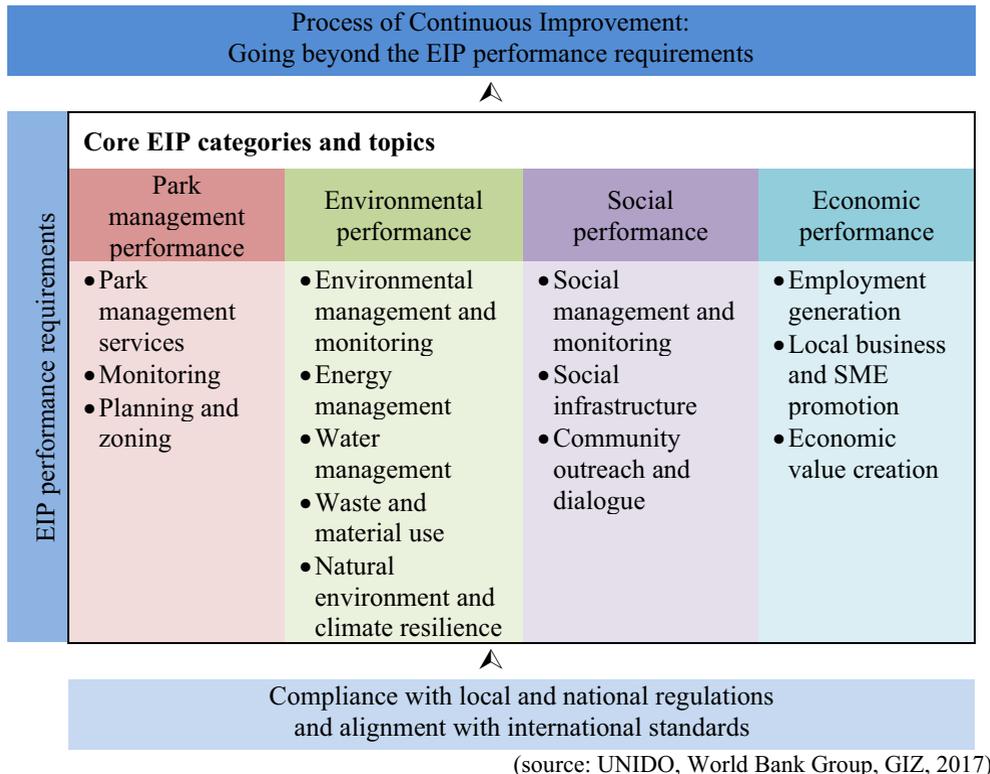


Fig. 1. International framework for EIP.

Social performance refers to ensuring human rights for people at the industrial park (mostly focusing on workers) and creating impacts on the local community. As the framework is built on national regulations and international standards, minimum working conditions and basic human rights need to be guaranteed. These include suitable working hours and rest days, park and firm facilities to address workers' need (local shops, cafeterias, medical facilities, recreation areas, banks, post offices, fire facilities, etc.), and workers' rights such as gender equality, security, and self-development through vocational training. EIP also requires firms and park management entities to reach out to the community in forms of dialogue and outreach activities to create bigger social impacts and fulfill corporate social responsibility.

Economic performance is evaluated not only in term of economic value generated, including investment attraction and tax revenue targets. Sustainability requires EIPs to contribute to resource building of the local community. An EIP should generate local employment opportunities. It should also promote small and medium-sized enterprises (SMEs) through using local suppliers or service providers. These two requirements allow

EIP to create and maximize economic linkages, generating values that strengthen the local community.

The framework provides a minimum yet comprehensive benchmark for private and public stakeholders to create EIPs or to transform traditional industrial zones into the new model. As such, the authors of the framework clearly stated that nations and international development organizations should develop this framework into specific, flexible EIP programs that take into account local demands and contexts.

It is noteworthy that the framework views requirements of EIP in a constantly evolving status: they are grounded in national regulations and international standards and will continue to develop along with sustainable development goals.

The international framework for EIP proposed by UNIDO, World Bank Group and GIZ would be used as a benchmark for comparison of EIP requirements between Vietnam and other countries.

3 International experiences in establishing requirements for EIPs

3.1 Requirements for EIP in China

China began to implement the EIP initiative since the early 2000s in response to serious pollution situation (Geng et al, 2012). It soon proved its economic values over and beyond environmental benefits (Yuan et al, 2006). While EIP has been applied in many countries before China, China is the first country which designed national EIP standards, reflecting a top-down approach towards EIP (Geng et al, 2008). The State Environmental Protection Administration (SEPA) – the government body responsible for environmental protection – first proposed EIP a win-win solution to reduce pollution since 1997 (Shi, Tian & Chen, 2012a). SEPA appointed two industrial parks as trial EIPs in 2001; and quickly proposed policies to assist the planning and management of national demonstration EIPs in 2003. The first national standard for EIP was established by in 2006, including 3 provisional standards for EIPs. Since then, the national standards have experienced several rounds of revision. From one government body in charge of EIP (SEPA), the leadership of the program has expanded towards a joint leadership by 3 ministries: Ministry of Environmental Protection (successor to SEPA), Ministry of Commerce and Ministry of Science and Technology (Shi, Tian & Chen, 2012a).

It is interesting to note that while Chinese EIP standards are set by the government, industrial parks voluntarily apply to become EIPs. Parks which want to be recognized as National Trial EIP have to submit their own development plan to SEPA for approval (Shi, Tian & Chen, 2012a). The voluntary characteristic of this process has promoted creativity and practicability in EIP planning and implementation.

The most recent version of EIP standards in China was released in 2015 and has been enforced since 2016 for newly applied parks. The requirements in the 2015 standard are presented in Table 1.

Table 1. Indicators to evaluate EIPs in China (released in 2015).

Categories	Indicators
Economic development	The proportion of high tech enterprises output value of gross industrial output value
	Industrial added value per capita
	The average three-year growth rate of industrial added value
	The proportion of remanufacturing industry added value of the gross industrial added value
Industrial symbiosis	The added eco-industrial chain numbers after enforcing EIP demonstration program
	Comprehensive utilization rate of industrial solid waste
	Usage rate of renewable resources
Resource conservation	Industrial added value per unit industrial land area
	The average three-year annual growth rate of industrial added value per unit industrial land area
	Elastic coefficient of comprehensive energy consumption
	Energy consumption per unit of industrial added value
	Application ratio of Renewable energy
	Elastic coefficient of fresh water consumption
	Fresh water consumption per unit industrial added value
	Recycling rate of industrial water
Reuse rate of reclaimed water	
Environment protection	Rate of reaching the discharging standard for key pollution sources
	The conditions of national and local key pollutant emissions
	Frequency of severe environmental accidents
	Completion degree of Environmental management strategies
	Implementation rate of key enterprises' Clean production audit
	Centralized sewage treatment facilities
	The completion rate of environmental risk prevention and control System
	Utilization rate of industrial solid waste (including hazardous wastes)
	Elastic coefficient of main pollutant emissions
	The annual reduction rate of carbon dioxide emissions per unit industrial added value
	Waste water emission per unit industrial added value
	Solid waste discharge per unit industrial added value
Green cover percentage	
Information disclosure	Environmental information disclosure rate of key enterprises
	The completion degree of the ecological industry information platform
	Number of public education campaigns

(source: Huang et al, 2019)

The China's EIP standard system consists of 2 main dimensions: economic performance and environmental performance.

All key elements of environmental performance as indicated in the International framework for EIP are present in China's EIP standard. Of 5 categories of EIP requirements, 3 are about environmental requirements: industrial symbiosis, resource conservation and environment protection. Twenty-five indicators cover all 5 aspects of environmental performance in UNIDO, World Bank Group and GIZ's framework: Environmental management and monitoring, Energy management, Water management, Waste and material use, and Natural environment and climate resilience. The 2015 standard is the first time when industrial symbiosis was added (Huang et al, 2019). It is measured

through the number of new eco-industrial chain project after enforcing EIP. Since industrial symbiosis is the key requirement of EIP, Chinese government has met international standard when taking this indicator in the list. However, more detailed indicators are required to better reflect the practical benefits of industrial symbiosis (Huang et al, 2019).

The indicators of economic performance in China's EIP standard system refer to economic value creation, i.e. output values and growth rates. Two other important requirements of economic performance of EIP as suggested by the International framework are left out. No indicator was built to target employment creation and local SME support.

Social performance and park management are completely missed out from the requirements. This reflects the direction of EIP in China. All the missing requirements reflect continuous improvements and long-term commitment of EIPs to people and the community. EIP in China, on the other hand, was first proposed as an environmental strategy in response to the alarming pollution rate in this fastest growing economy. Its vitality derives from the economic benefits of EIP, in particular how EIP can attract more environmentally responsible investors, especially multinational corporations than traditional parks (Shi, Tan and Chen, 2012b). As such, sustainability has never been the target of EIP in China (even though it can be achieved along the way), leading to the exclusion of one of the three main pillars of sustainability.

Nevertheless, the case of EIPs in China presents an excellent example of how top-down influences when combined with voluntary participation can become a drive for the economy towards greener production. The Chinese requirements of EIP, while missing two important requirements of EIP as suggested by the International framework, still show their suitability to China current stage of economic development.

3.2 Requirements for EIP in South Korea

Korea's EIP projects were started in 2005 under the Act on the Promotion of the Conversion into Environment-Friendly Industrial Structure (MSF, KDI and GGGI, 2013). A 15-year master plan was proposed with 3 phases for EIP projects in Korea. Phase 1 (2005-2010) was to establish 5 pilot EIPs; phase 2 (2010-2014) was to design a standard EIP model for application in 46 industrial parks, and phase 3 (2015-2019) was to mature Korean model of EIP.

Korea's EIP program includes 4 core strategies (KICOX, 2014). The first strategy, Network infrastructure for resource circulation, refers to networking among manufactures, universities, research institute and government agencies to stimulate the circulation between enterprises. This network provides support for the planning of EIP (i.e. how to carry out industrial symbiosis in any particular firm or park) and its implementation. The second strategy, Research and development energy and resource circulation technology, promotes technical development and diffusion of outstanding techniques for energy and resource between enterprises. This is, in other words, the execution of industrial symbiosis and resource efficiency. The third strategy is Achievements diffusion of EIP project. Achievements of the EIP project are towards commercialization of the tasks completed and dissemination to other industrial parks. The last strategy is In-external exchange – cooperative project. Measures are taken to exchange information and techniques among collaborating networks of the subsidiary organizations for revitalizing the exchange and enhancing cooperative. Different from the third strategy, the fourth strategy promote collaboration at the international level so that Korean EIPs can benefit from international lessons and its successful stories can be shared with developing nations.

The Korean government has not established an official standard system for EIPs. We drew out the focus of Korean EIPs through a national report of its achievements over the 15 years of development (see Table 2).

Table 2. Indicators to evaluate EIPs in Korea.

Categories	Indicators
Economic benefit	Cost reduction for waste treatment and raw material purchase
	Sale increase through selling recycled goods and surplus steam
Environmental benefit	Reduction of energy use through reuse of incineration waste heat
	Reduction of greenhouse gas emissions
	Reduction of waste by-products through recycling of slag and waste metal
	Reduction of industrial water use through reuse of wastewater
	Reduction of materials emitted into the air, such as SO _x and NO _x
Social benefit	Attraction of new investment to the local area
	Creation of new jobs
Park management	A government body (KICOX) responsible for general planning, coordination and evaluation of all projects
	Local operation committee at EIP project group responsible for park planning and management

(source: KICOX, 2014)

According to KICOX's evaluation of the phase 2 of EIP project in 2014, EIPs in Korea have significant achievements in 4 dimensions: park management, economic, environmental and social performance. However, when compared with the International framework for EIP, the 9 indicators of EIPs in Korea fit into 2 core categories of requirements: economic performance and environmental performance. The social benefits of EIPs as mentioned by KICOX actually overlap with economic performance in the International framework.

With regard to indicators of economic performance, the Korean standard system covers all 3 topics suggested in the International framework. Economic value creation is reflected through cost reduction and sale increase. According to KICOX's report in 2014, the economic gain of EIP program was 5.2 times government funding and 3.7 times the project expense (KICOX, 2014). EIP also contributed to the local community through creating new jobs and attracting new investments, improving the image of the surrounding area.

Environmental performance also had detailed indicators of energy management, water management, waste and material use, and natural environment and climate resilience. Cleaner production and industrial symbiosis are evident in the indicators. Resource efficiency and cleaner production are reflected through the reduction of input materials: energy and water. Industrial symbiosis is reflected through reuse of waste heat and recycling of slag and waste metal. EIPs in Korea are also conscious of pollution reduction through reduction of greenhouse gas emissions and materials emitted into the air.

Park management in Korean EIP program covers all three indicators of park management performance as suggested in the International Framework: park management services, monitoring and planning and zoning. The two tiers of management (central level and park level) reflect the network infrastructure strategy promoted by the Korean government.

It is noteworthy to mention that continuous improvements are a requirement for EIPs in Korea. One of the core strategy for promoting EIPs in Korea is exchange of information and techniques between Korean EIPs and international networks, thus allowing the Korean EIP program to constantly update to match international standards.

The Korean standard system is more comprehensive than the Chinese system in term of the number of core dimensions required in EIP development. However, there is still room

for improvement as the social dimension is still missed out in the Korean example.

3 Requirements for EIPs in Vietnam

EIP is relatively new in Vietnam. Until 2019, Vietnam has 3 industrial zones selected for transition into EIP. Different sets of requirements for EIPs in Vietnam have been proposed by several authors before the government release of official requirements for EIPs in 2018. We discussed the individually proposed sets before looking at the national standard system.

3.1 Requirements for EIPs proposed by Tran, Phan and Hoang (2012)

Tran, Phan and Hoang (2012) proposed a two-step process to evaluate EIPs in Vietnam, in particular in Ho Chi Minh city. Pre-evaluating criteria were designed to assess all industrial zones. They include 3 categories with 7 indicators: (i) willingness to follow the EIP model, (ii) compliance with national regulations on environment protection, mostly waste management and pollution regulations, and (iii) public image of the industrial park: the park receives no complaints from workers and the neighborhood. Industrial parks that meet the pre-evaluating requirements are eligible for the second round of assessment, i.e. evaluation of EIP criteria.

Table 3: Indicators to evaluate EIPs in Vietnam proposed by Tran et al, 2012.

Categories	Indicators
Criteria 1	
IZ complies with current environmental management regulations	Industrial zone (IZ) has staff who are responsible for environmental protection activities
	IZ conducts annual environmental monitoring program
	IZ has accident and emergency precautionary and response program
IZ complies with Vietnamese technical regulations on environmental protection	Collect and treat properly wastewater generated from all enterprises located in IZ. Effluent from central wastewater treatment system meets the national technical regulation for industrial wastewater.
	Manage domestic solid waste collection and treatment activities of all enterprises located in IZ. IZ infrastructure investment and development company has to ensure 100% of domestic SW from enterprises to be collected and treated properly. The company has all information of service companies who provide this service to enterprises
	Manage industrial solid waste and hazardous waste collection and treatment activities of all enterprises located in IZ. IZ infrastructure investment and development company has to ensure 100% of these wastes from enterprises to be collected and treated properly. The company has all information of service companies who provide this service to enterprises
Criteria 2	
Saving water use in IZ	Water supplied demand for staff of IZ infrastructure investment and development company (in L/person. day) is less than or equaled domestic water supply standard for worker.
	IZ recycle effluent from the central wastewater treatment system for street cleaning, watering of green areas or other purposes (amount of recycled water compared to water demand).
Saving electricity use in IZ	IZ applied technical measured to save electricity for lighting within public areas of IZ (electricity used for lighting/area needed to be lighted compared to the standard).
Criteria 3	

IZ has characteristics of industrial symbiosis	Recyclable byproducts generated from some enterprises are exchanged to other enterprises in the same IZ
	Recyclable byproducts generated from some enterprises are exchanged to other enterprises in the residential areas (as no enterprises in the IZ can use such byproducts).
	Effluent from the central wastewater treatment system of IZ is reused in surrounding residential area (for instance for watering or other purpose).
	IZ has information sharing and exchanging system among enterprises and between enterprises and IZ infrastructure investment and development company (by any possible methods).
Awareness raising on environmental protection for both IZ and enterprises	Environmental protection, natural resources and energy saving activities in IZ are published in website or other mass media.
	IZ and enterprises in IZ participate in or support (including financial support) for environmental protection activities and public information for public awareness raising.
Criteria 4	
Arrange apartment for workers in IZ	IZ arranges apartment block for workers nearby IZ and have necessity services (within 500 m from the apartment block).
Green area in public space of IZ	Total green area in public space of IZ must be in the range of 10 - 15% of total area of the IZ.

(source: Tran et al, 2012)

The EIP criteria are divided into 4 categories (see Table 3). The first criterion assesses compliance with national regulations on environmental protection, including park management and monitoring and compliance with national regulations on waste management, particularly wastewater and solid waste treatment. The second criterion assesses resource efficiency and cleaner production. It includes indicators for water and energy management. It is important to note that these indicators promote reduction and utilization only without mentioning transformation to renewable energy.

The third criterion refers to industrial symbiosis. Tran, Phan and Hoang (2012) proposed industrial symbiosis can extend beyond the spatial boundary of the EIPs, so that the by-products of firms inside EIPs can be exchanged to firms in the residential areas when none of the firms inside EIPs can use the by-product. This is different from the common perception that industrial symbiosis requires physical proximity to reduce chances of pollution during by-product and waste exchange, as well as to save cost of transfer (Lombardi and Laybourn, 2012). However, as Tran, Phan and Hoang (2012) pointed out, 20/24 firms in the industrial zone surveyed did not have recyclable industrial byproducts. The remaining 4 firms recycled their by-products such as paper, plastic packages, cardboard boxes, etc. by selling them to recycling firms. While industrial symbiosis is the core of EIPs, its impracticability in the current Vietnam context poses a significant challenge to the implementation of EIP model in Vietnam.

The fourth criterion refers to environmental friendly design, including housing option, necessary services and green areas in park zoning.

Depending on the scoring of an industrial park, it can be ranked as level 1 (pollution control park), level 2 (environmental friendly park) or level 3 (eco-industrial park).

The four categories of requirements for EIPs in Vietnam proposed by Tran, Phan and Hoang (2012) fit 2 out 4 categories in the International framework for EIPs, i.e. environmental and social performance. Almost all indicators of environmental performance and social performance in the International framework are addressed. However, economic performance is completely missed out from the model. Park management performance is also omitted from the standard system, although elements of it can be recognized in the first criterion.

3.2 Requirements for EIPs proposed by Massard, Leuenberger and Tran (2018)

In an effort to build Vietnam's indicators of EIPs, Massard, Leuenberger and Tran (2018) had proposed a three-tier framework to assess EIPs in Vietnam (Massard et al., 2018). The criteria set is the result of participative bottom-up discussion between national ministries and experts, representatives from local government and industrial zone management boards, and international experts in 2016. During the discussion, the expert panel was able to come up with a Vietnamese version of EIP before proposing its indicators. The definition of EIP adapted to the Vietnamese context is as follows: "An eco-industrial park is a model of industrial zone that combines in harmony the three pillars of sustainable development: economy, society, and environment. In an EIP, economic development activities - including site planning, investments, and marketing - foster resource efficiency, dissemination of clean technologies, and environmental protection" (Massard et al, 2018, p. 85). Table 4 presented the list of indicators of EIPs in Vietnam.

Table 4. Indicators to evaluate EIPs in Vietnam proposed by Massard et al, 2018.

Categories	Indicator		
	Bronze level	Silver level	Gold level
Technical/ Environmental performance	<ul style="list-style-type: none"> • Reliable energy • Potable water • Effluent treatment • Industrial landfill • Compliance with water, waste and energy legislation 	<ul style="list-style-type: none"> • Sorting and recycling of nonhazardous wastes • Secure handling of hazardous wastes • Renewable energy and energy networks (CHP) • RECP and IS activities • Environmental management system (EMS) 	<ul style="list-style-type: none"> • Technology transfer and development activities • Specific recycling technologies • Green supply chain • Advanced CP & IS requiring high-level technical skills • On- or off-site R&D • Eco-design of products
Social performance	<ul style="list-style-type: none"> • Basic transport and housing infrastructure • Compliance with working conditions for women and children • Basic sanitary conditions • Safe and healthy working environment 	<ul style="list-style-type: none"> • Support for social insurance, medical care • Access to public transport, housing, child care, entertainment parks, shopping areas • Security and emergency services • Safe and healthy overall environment 	<ul style="list-style-type: none"> • RECP and environmental issues introduced to education system • Participative activities to plan economic and industrial development
Park management performance	Light park management structure overseen at the provincial scale	Trained park management structure active at the park scale	Trained park management structure with dedicated RECP and innovation services, including capacity to develop new business models

(source: Massard, Leuenberger and Tran, 2018)

Requirements for EIPs are classified into 3 levels. The bronze level indicates obtainment of basic facilities and minimum legal compliance. The silver level indicates resource efficiency and cleaner production. The gold level indicates EIPs are able to come

up with eco-innovate strategies that have long lasting-effect on sustainable industrial development.

At each level, indicators of park management performance, environmental performance and social performance are specified. While in this framework, the Vietnamese-version definition of EIP consists of 3 pillars of sustainable development: environment, economic and social pillars, the criteria for assessing EIPs include only 2 pillars: environment and social criteria. Technical criteria are added to the environmental pillar as a specification of actual environmental protection practices. The reason for this inconsistency lays in the fact the discussion on challenges to developing EIPs in Vietnam merely addressed social, technical/environmental and governance challenges. ECINNOVERA's survey on success factors of 168 EIPs in 27 countries identified 3 main success factors: social, technical and governance-related factors (Massard et al., 2014). As a result, the expert discussion in Vietnam was restricted to these 3 domains. Economic challenges were not mentioned as a challenge; so when criteria for assessing EIPs were proposed, the economic dimension was missing from the big picture.

Nevertheless, the framework has been able to meet most of the minimum requirements for park management performance, social performance and environmental performance proposed by UNDP, WB and GIZ (2017). The three tiers also reflect the process of continuous improvement, which is a key requirement for EIPs.

3.3 National requirements for EIPs in Vietnam

In 2018, the first national standard requirements for EIPs was released under Decision 82/2018/ND-CP by the Vietnamese government. It was clearly stated in the Decision that EIPs in Vietnam are both an economic and environmental initiative. EIPs are promoted to (i) increase economic values of firms inside the parks through cleaner production, resource efficiency and industrial symbiosis; (ii) support environment protection in the local area through pollution mitigation, waste management and eco-friendly production; and (iii) form a competitive enterprise community towards achieving sustainable development goals.

The Vietnamese government identified 3 categories of requirements for EIPs in Vietnam (Table 5). In order to be classified as an eco-industrial park, industrial parks must submit an application to the government for consideration.

Table 5. Indicators to evaluate EIPs in Vietnam issued by the Vietnamese government.

Categories	Indicators
Park management	Park infrastructure and firm activities in compliance with national laws on manufacture, environment protection and labor rights. Encourage park infrastructure according to ISO standards
	Provide essential infrastructure and services inside the park in accordance to legal regulations
Environmental performance	90% of firms are aware of cleaner production; at least 20% of firms apply resource efficiency and cleaner production, and innovative technology in reducing emissions and recycling wastes
	At least 1 industrial symbiosis link per park and 10% of firms have plans for industrial symbiosis
	Monitoring of water, energy and waste management
	Publicize reports of environment protection.
Social performance	Provide housing, sport and entertainment facilities for employees inside the park
	Publicize reports of social responsibility and community contributions

Although the official standard system provides a very brief guideline to forming and transitioning to a EIP, the indicators address most requirements proposed in the International framework. It should be noted that some criteria are set at the “awareness” level rather than “action” level. For example, for industrial symbiosis, only 1 link per park is required; but 10% of the firms must have plans for industrial symbiosis, meaning they must be aware of the idea and try to put it into practice. Similarly, only 20% of the firms are required to apply resource efficiency and cleaner production, as well as climate resilience; yet 90% of firms must be aware of the concepts. Given that EIP in Vietnam is at the beginning stage of development, these indicators are practical and achievable. However, to turn awareness into action, it requires more than firms’ awareness and plans of application. The government should design phases of development for EIPs in order to monitor and support their establishment.

Similar to the other two sets of requirements for EIPs in Vietnam, the official standard system of EIPs in Vietnam also lacks indicators of economic performance, despite the fact that economic benefits are stated as one of the purposes of EIP development. This reflects a gap in understanding strategies for developing EIPs in Vietnam.

4 Towards building eco-industrial parks in Vietnam

Over the last three decades, eco-industrial park has proved itself an effective tool for both developed and developing economies to achieve inclusive and sustainable industrial development. The International framework for EIPs proposed by UNIDO, World Bank Group and GIZ in 2017 presents a comprehensive approach to the conceptualization of EIPs. In order to become the force of sustainable development, EIPs should cover all three pillars of sustainability with a vision of continuous improvements.

In this article, we have presented two sets of requirements for EIPs from two great economies from Asia, one from a developed country (South Korea) and one from a developing country (China). The two cases present different approaches to establishing EIPs. While China relies on a top-down approach in which the government sets a general standard for EIPs, Korea uses a more bottom-up approach in which various stakeholders participate in planning and implementing park-specific strategies. Nevertheless, in both countries, industrial parks play an active role in transitioning into the EIP model through voluntary participation and creative planning. The achievements of EIPs in China and Korea are the result of effective collaboration between governments and key stakeholders in managing industrial parks, creating a win-win situation for all. The two countries also share similar conceptualization of EIP requirements: park management, environmental performance and economic performance.

To represent the effort of the Vietnamese government and academia in popularizing the EIP idea, we discussed 3 sets of requirements for EIPs designed for Vietnam, including 2 standard systems proposed by researchers and 1 national set of requirements released by the government. The three models share a common framework for operationalizing EIPs: park management, environmental performance and social performance.

Eco-industry park will be the trend of the future not only because of its contribution to sustainable industry but also because of its economic attractiveness. The lessons of China and Korea in successfully transforming existing industrial zones into EIPs show that the economic and environmental aspects should be closely linked together, complimenting each other. Moreover, developing an EIP should be a conscious, voluntary choice of park developers and different stakeholders, not a forced government choice. Only then will the EIP model proves its values to the private sector. Our analysis shows that while the Vietnamese government also requires voluntary participation in EIP program, the economic-environment link is not present in existing sets of requirements for EIPs in

Vietnam. All three sets of requirements for EIPs in Vietnam. When this important link is missing, the potential of long-lasting development of EIPs in Vietnam becomes very limited.

As a result, our first proposal to improving requirements of EIPs in Vietnam is government's increasing effort in highlighting the economic-environment link in EIPs. EIP remains a relatively new idea in Vietnam, and even the government's view is skewed towards its environmental benefits as reflected through its requirements for EIP. Any effort to promote the EIP idea is most likely to come from the government, especially in Asian settings (China and Korea cases are good example of EIPs initiated by the government then spread to the wider public). Consequently, the government has to play the key role in promoting the economic benefits of EIPs, making the idea attractive to the industrial sector. Only then can the government encourage creative contributions of private stakeholders in developing their own solutions to EIPs.

In both China and South Korea, the social performance aspect of EIPs has been left out of the requirements. The social-economic-environmental conception of sustainability has emerged from the quest to reconcile economic growth as a solution to social and ecological problems (Purvis, Mao and Robinson, 2019); thus without social equity, sustainable development cannot be achieved. As EIPs in China and South Korea finalize its models, more attention should be put on the social aspect of EIPs in order to achieve sustainable development goals. An opposite situation happens in the case of Vietnam, as Vietnamese models of EIP stress social performance even before EIP is carried out in practice. This might be the result of the growing human right movement in Vietnam, the effect of which spreads from the Constitution to all other aspects of socioeconomic development. This presents a good start for Vietnam in assuring the sustainable characteristic of EIPs.

In comparison with China, Vietnam is more cautious in establishing criteria for EIPs. Some of the official requirements for EIPs in Vietnam require awareness of the requirements, not quantitative achievements. This situation reflects the concern of the Vietnamese government in the plausibility of EIPs in Vietnam. We believe that this concern is grounded in the current state of development of industrial sector in Vietnam, as Vietnam still remains limited in high-tech industry and waste management capacity. However, the China example shows that the government should make EIP an attractive option for the private sector, who will then spread on the appeal of EIP to investors. If EIP is not an attractive and plausible model to government, it cannot be an attractive and plausible model in the eye of other stakeholders. The success of entrepreneurship movement in Vietnam also conveys the same idea.

Therefore, we propose that a fundamental change in the plausibility of EIPs in Vietnam is required. EIPs should be viewed as a model that can be put into practice with appropriate state support and continuous creativity and effort from the private sector. While limited technological or waste management capacities cannot be improved in a day or two, intensive and focused investments in transforming one or two suitable industrial zones can be an appropriate strategy for the Vietnam case.

5 Conclusion

Inspired by the experiences in other countries, EIP projects have been launched in Vietnam as a strategy to foster sustainable development. Our paper compared requirements for EIP in China, Korea and Vietnam in line with the International framework for EIP proposed by UNIDO, World Bank Group and GIZ. Notable differences in the conceptualization and criteria of EIPs between China and South Korea and Vietnam were discussed and two recommendations to the existing national requirements for EIPs in Vietnam were proposed. EIPs in Vietnam are still in the beginning stage of development, and more conscious efforts

from both the public and private sector are required to facilitate this model.

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