

# Eco-Industrial Park (EIP): Global Trends and Current Situation in Thailand

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**Abstract** This paper focuses on the current situation in the adaptation and adoption of industrial ecology in Eco-Industrial Park (EIP). EIP emerged as a new model of spatial organization for industrial arrangements. An important mention for an EIP is the adoption of the concept of industrial symbiosis (IS), in which firms' reuse/recycle/exchange waste to reach a closed system and to reduce environmental impact. The article describes an overview of the Eco-criteria used in EIPs through a Systematic Literature Review (SLR). In Thailand, the government needs to adopt industrial ecology as a strategic vision and as a strategic approach to plan the economic, social and ecological development of their national economies. In this way, it can be possible for the country to avoid the same problems that occurred when the developed countries experienced industrialization and rapid economic growth, and move toward more sustainable development. As a result, it was shown that they have limitations described and exemplified in the text.

**Keywords:** Industrial ecology, Eco-industrial development, Eco-industrial park, Sustainable development.

## 1. Introduction

In many developed countries, a wide range of environmental management practices are being developed in relation to industry. Environmental audits, environmental assessment, workplace redesign, monitoring measures, inspection standards and new forms of legislation are at the forefront of finding new ways to better systematize the needs of the industry's environment.

The development of industrial symbiosis networks in most parts of the world demonstrates that there are benefits attached to them and there are more opportunities that could be pursued, but the exploitation of those opportunities are

limited due to the lack of a comprehensive model to evaluate the industrial symbiosis projects [1]. The premier Eco-Industrial Park (EIP) is founded in Kalundborg, Denmark where material exchange has occurred for over forty years [2].

In Thailand, for many years, the government has taken a clear direction to transform the country to a newly industrialized country. Many policies were designed to fulfill this purpose, including investment in infrastructure and industrial development, which have caused negative health effects on employees and local people [3]. In 2000, Thailand, led by the DeutscheGesellschaftfürTechnischeZusammenarbeit (GTZ) and its Industrial Estate Authority of Thailand, has embraced

industrial ecology (IE) as a potential approach to economic development[4]. Thai government has applied EIP concept which aims simultaneously to reduce a range of environmental impacts, not only the mass of wastes and gas emissions, but also impacts on human health and ecosystems. The Industrial Estate Authority of Thailand (I-EA-T) and Department of Industrial Works (DIW) have played an important role in Eco-industrial development (EID) since the first launch; but various factors have impeded its development [5].

The purpose of this paper is to examine the implementation of EIPs around the world and current situation in Thailand through a Systematic Literature Review (SLR). As subsequent sections reveal, there has been only limited success in

implementing IE, and we then use this finding as a basis for critiquing the utility of IE both as a policy tool and as a theoretical construct to understand the basis for future environmental sustainability.

## 2. Definition of Eco-Industry

Sustainable development and sustainability have been imposed in many different ways [6]. Some weighted metrics are being considered in the European Union and elsewhere for implementing in environmental legislation. The range of terms utilized in the literature that define these networks of companies is listed in Table.1. The main term that is used in this paper is EIP(s).

**Table.1** Various terms used for industrial developments focusing on environmental management. Adapted from Chiu, 2004 [4] and Massard, 2012 [7].

Acronym	Definition and main specificities
IE	“Industrial ecology” explores the following assumption: the industrial system can be seen as an ecosystem. Industrial systems, just as natural ecosystems, can be described as a particular distribution of materials, energy, and information flows. Furthermore, the entire industrial system relies on resources and services provided by the Biosphere, from which it cannot be dissociated. Industrial ecology suggests to use the design of natural ecosystems to guide the redesign of industrial systems and offers opportunities and solutions to turn industrial parks into Eco-industrial parks [8-9].
IS	“Industrial symbiosis” as a part of the emerging field of industrial ecology, demands resolute attention to the flow of materials and energy through local, regional and global economies. Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The key factors for industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity [10].
EIN	“Eco-industrial networks” is often used as a synonym to industrial symbiosis. The term is used to describe resource exchange network at the regional scale and thus do not strictly require geographical proximity [11].

Acronym	Definition and main specificities
EIP(s)	“Eco-industrial park(s)” is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only [12-13]
EID	“Eco-industrial development” is one way to implement a local sustainable economic development by anchoring companies in their local environment, reducing environmental impact, developing employment, and providing safe work conditions. Therefore, eco-industrial development links economic and regional development with eco-efficiency and environmental protection [14-15].

Sustainable development in industrial parks has been explained by various researchers [16] by applying and emerging appropriate methodologies, while Zhou et al., (2006) offered proper indicators for the determination of the sustainable quality of industrial parks [17]. There is no academic or standardized definition exists to define an EIP. However, some of the definitions available from literature sources consider EIP as a synonym for the concept developed by researchers in the field of industrial ecology [18-19]. EIPs are a promising strategy to promote sustainable industrial development and to improve the industries’ environmental performance in terms of managing materials, energy and waste. EIPs provide substantial benefits for participating companies, for their neighborhoods and for their extended regions. The commonly accepted international definition was based on the one initially created by an Indigo Development team in 1992 and then expanded for the US-Environmental Protection Agency in 1995.

In 1995, Côté and Hall (1995) [20] proposed this definition:

*“An eco-industrial park is an industrial system which conserves natural and*

*economic resources; reduces production, material, energy, insurance and treatments costs and liabilities; improves operating efficiency, quality, worker health and public image; and provides opportunities for income generation from use and sale of wasted materials.”*

Yet another definition was put forward by Garner and Keoleian (1995) [21] as a scientific subject:

*“The study of the physical, chemical and biological interactions and interrelationships both within industrial systems and between industrial and natural ecological systems.”*

According to the EPA Fieldbook[22], a definition is described as:

*“An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual*

*benefits each company would realize if it optimized its individual performance only.”*

At an October 1996 workshop hosted by the United States President’s Council on Sustainable Development [23], two definitions received serious consideration. The first was:

*“A community of businesses that cooperate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat), leading to economic and environmental quality gains, and equitable enhancement of human resources for the business and local community.”*

The second definition considered by the participants was:

*“An industrial system of planned materials and energy exchanges that seeks to minimize energy and raw materials use, minimizes waste, and builds sustainable economic, ecological and social relationships.”*

Then, it was refined in 2001 by Ernest Lowe in an Eco Industrial Handbook published by the Asian Development Bank [24]:

*“An eco-industrial park or estate is a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues.”*

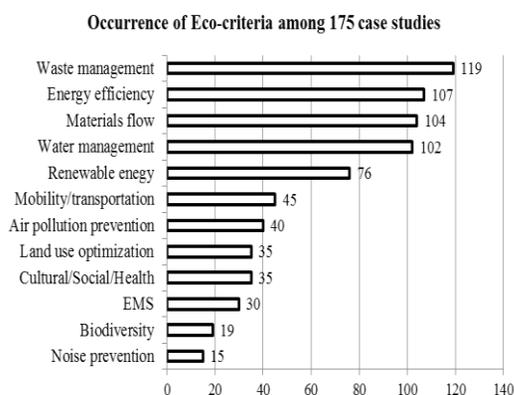
The definition and the subsequent development of EIPs have been profoundly

based on the practice of industrial ecology theory, which pays attention to the exchanges within industrial systems to specify a deep reduction of restricted resource consumption and a minimization of waste production in the framework of a sustainable development paradigm. Despite the EIPs configurations being importantly based on the concept of sustainability, the problem of defining their appropriate layout inside the boundary and the consequent of land used for the design to minimize land consumption have not frequently been major in the wide range of studies and practices regarding the EIPs. However, the particular problem of a harsh dwindling of land consumption at the EIP planning phase acquires a precious mission and also requires to be cautiously evaluated inside the sustainable urban development point of view [25].

Based on the range of classification of EID initiatives in literature [19, 26-28], it is clear that the explanation of EID has not developed well to scope the boundaries in order to identify what kind of initiatives can constitute an EID initiative. According to the study on “Eco-innovation parks survey” [7] which a large majority of case studies are strictly industrial parks (139/175). The rest are a combination of industrial activities and housing (28/175) or strictly urban (8/175). The result showed that Eco-criteria as detailed in Fig.1 proposes a statistical analysis based on 175 case studies detailed in the survey.

The eco-criterion with the highest occurrence (119/175) is waste management, meaning that a majority of eco-innovation parks have onsite collection, recycling or disposal of waste. Another frequent criterion is energy efficiency (107/175), identifying energy issue as a main component of industrial park innovation strategies. These two criteria are usually considered as common strategies for

industrial park management in many countries. Their innovative component in case studies is sometimes unclear. Thus, the high occurrence does not mean that the resource management can be in any case characterized as innovative.



**Fig. 1** Occurrence of Eco-criteria among 175 case studies [7]

In contrast, eco-criteria as biodiversity, cultural/social/health, mobility/transportation, land use optimization, air pollution prevention and noise prevention are probably under represented due to the tendency to apply solutions at the microscale (company) rather than at the mesoscale (park) and to their under representation in the industrial ecology literature.

Literature on EID is clumsy and fragmented despite a growing interest in the field [29]. Various strategies have been suggested as a means of increasing the efficiency of businesses in order to realize environmental, economic, social and institutional benefits. At the organizational level some strategies have concerned health and safety, such as health and well-being [30], and planning on health and safety in the concentration of waste agglomeration [19]. Moreover, Côté and Cohen-Rosenthal (1998) stated that in America, most of the communities exploring EIPs have high

percentages of low income and/or minority residents.

### 3. Significant Elements of the Eco-Industrial Developments

The “Eco” in Eco-Industrial Park refers to a basic EIP theory: design the park in relation to the qualifications of its local and regional ecosystem. “Eco” also mentions to other traditional pillar that the development concept must gather the resources and needs of local and regional economy [24]. Both meanings support the demand for working in an enquiry mode when planning an EIP. Lesson from the experience of other countries and communities are applied to develop other Eco-Industrial Park. However, it needs to encounter the reasonable solutions for specific site and community within the broad principles of industrial ecology, sustainable planning, architecture and construction. The literatures [18-19], [31-34] list a variety of forcers for the development of EIPs, including financial considerations, the desire/need to increase competitive advantage, ‘locational’ factors and government policies and legislation. Desrochers (2004) summarized that industrial recycling networks have awoken to decrease total costs of waste treatment and disposal, obtain to lower charges of materials and energy, and to generate income from residues [34]. Desrochers (2004) also commented that competitive afflictions would motivate firms to search for plans to reduce waste or to extract worthiness from it. Moreover, Seuring (2001) also mentioned that enlarged competition on the international market has been one of the key drivers for the installation of EIPs [32]. Identically, exploration by Van Hemel and Cramer (2002) of 77 Dutch SMEs (small and medium sized enterprises) concluded that innovation opportunities, the potentiality to increase

the quality of product and find new market were the most influential internal drivers for eco planning [33]. Alternatively, customer demands, government regulation and industrial sector organizations were the major external stimulator.

Apart from the above, a range of measures has also been found to enlarge the achievement of the EIP. These are listed below in no specific order:

1. Cooperation (between firms together and/or between firms and local government) on the basis of enhancing environmental and business performance [35, 36].

2. The preliminary action should be initiated from the firms rather than government [35].

3. Active cooperation from a range of stakeholders including public sector, representatives from companies, workman, community and environmental organizations and industry, as well as specialists in various disciplines such as architecture, engineering, ecology and environmental management [36].

4. The organizations should not involve in direct competition with each other [37].

5. A level of trust would rather keep between participants [38].

6. Strategies should endorse full integration of environmental, ecological and spatial concepts [38].

7. An association of the firms and an extensive support process should be created [38].

8. Good public connections between firms located near to each other are essential [35].

9. A diversity of companies with supplementary materials needed should be engaged [35].

10. The existing management processes should be utilized as much as possible [35].

11. Data gathering on a number of issues, for example, background company information, resource flows, employees, future plans, and markets are required [36].

12. In the beginning stage, the project should be focused on utility sharing, energy, water and material waste exchanges and once created more company specific and economically challenging projects [36].

Therefore, there are a range of considerations needed to be taken to improve the possibility of achievement. These should include material flows, site structure and composition, the gathering of widespread support and participation from both the individual companies and key stakeholders such as government and the public, and financial/logistical planning [18].

#### 4. Past and Present Eco-Industrial Development Projects around the World

All over the world, different aspects of eco-industrial development can be found. In the following, lists of EIP projects are stated as a detailed description is not possible in this context, references for further information are added.

**Table.2** List of Global Eco-Industrial Development initiatives.

Country	Location of some EID initiatives
Australia	Shenton Sustainability Park, Synergy Park Brisbane [4] , Coolum Eco Industrial Park [39]
Canada	Burnside Industrial Park, Sarnia Ontario, Bruce Energy Centre Ontario, Portland Industrial District Toronto [40]

Country	Location of some EID initiatives
China	13 projects (e.g. Dalian, Yantai, Soo Chow, Tianjin, Guiging, Yixing, Taihu, Shanghai, Chong Yuan, Guiyang and Jiangsu) [41]
Germany	The Bayer Chemical Park at Leverkusen, The Chemical Park Krefeld-Uerdingen [42], Value park, Schkopau [43]
Indonesia	Lingkungan (LIK), Tangerang; Semarang; Industri Sona Maris [4]
India	Naroda; Tirupur Textile sector; Tamil Nadu tanneries; Calcutta foundries; Tamil Nadu paper/sugar; Bangalore water project; Ankleshwar, Nandesari, Thane–Belapur [44, 45]
Japan	26 projects (e.g. Kitakyushu, Itabashi, Fujisawa, Toyota city) [46]
Korea	Daedok Technovalley (DTV) Development Project [4, 47], 6 Industrial Parks in Ulsan city [48]
Malaysia	BioXcell Ecosystem Industrial Park in Nusa Jaya [49]
Philippines	Laguna International Industrial Park, Light Industry and Science Park, Carmelray Industrial Park, LIMA, Laguna Technopark, Philippine National Oil Company Petrochem Industrial Park, Clean City Center project (USAID) [4]
Singapore	Jurong Island Industrial Park [50]
Sri Lanka	ADB supported major policy studies in 2002 [4]
Taiwan	Tainan Technology and Industrial Park, Changhua Coastal Industrial Park; CSS II (corporate synergy system II) projects, Hua Lian and Kaohsiung [4]
Thailand	I-EA-T and DIW plans ( <i>See Section 5.2</i> )
United Kingdom	9 projects (e.g. Crewe green business park, Dyfi eco-park: Wales, Ecotech: Swaffham, London remade eco-industrial sites) [42]
United States	35 projects have been identified, about 6 are operational with completed projects [51]
Vietnam	Amata (environment management), Hanoi Sai Dong (feasibility study) [4]

Although some research and design projects have attempted to identify the essential characteristics of EIPs, as yet, there is no agreement. Côté and Cohen Rosenthal (1998) addressed that the evolution of industrial parks into ecosystems is still at a very early stage. While the most well-known EIP [12], Kalundborg Park in Finland, has its critics, it has clearly inspired a wide range of projects in a number of countries. Inconceivably, Gibbs and Deutz (2005) insisted this idea in their research in 34 EIPs of the USA [51]. They showed the evident from the paper that the idea making IE operational through EID is at an early stage of development. Yet in

2007, in one of them assured their idea by identify EIPs in the USA and Europe and indepth interview surveys of 16 EIPs, the research discovered few examples of networking between firms or processes using wastes and materials recycling. The result was found that most EIPs are at a very early stage of development, where linkages are potential rather than real. Agarwal and Strachan (2006) also raised that it is clear from their literature review that there is very limited literature available that can guide the evaluation of industrial symbiosis initiatives [29]. This is due to the fact that the IS networks are in the early stages of development and therefore the methods

/models to evaluate performance are not well developed. Most of literature in this area focuses on particular industrial symbiosis initiative as EIP. There is a need for the development of a generic methodology in order to evaluate industrial symbiosis projects.

Although IE and EID are new fields of enquiry, it is important to concisely discuss these fields to provide appropriate background to the development of industrial symbiosis initiatives and the progress made in the attempts to develop methods to evaluate industrial symbiosis projects [52]. Literature and commentators in the field have identified several criteria that are complimentary and contradictory to each other in order to evaluate the success of industrial symbiosis projects. Every IS project is quite different from others, it is reasonable to develop a generic criteria for evaluating their success. Based on a definition of eco-industrial park by Côté and Hall (1995), they revealed an industrial system which conserves worker health and public image as a guideline for evaluating EID projects [20].

Moreover, Chiu and Yong (2004) argued that there is some encouraging evidence to support which is beginning to yield positive benefits in the Asian developing countries (ADCs) [4]. However, very few Asian studies have been reported in the international scientific refereed journals. Hence, IE is usually presented in instructional materials and projected in Asian settings, instead of being presented in in-depth research studies.

## **5. Eco-Industrial Park (EIP) Implementation in Thailand**

The cultural backgrounds and developmental experiences of the implementation of IE may explain both as a policy tool and as a theoretical construct to understand the basis for future environmental

sustainability especially in regard to the EID. In Thailand, The Ministry of Industry of the Kingdom of Thailand is the major ministry which responsible for the promotion and regulation of industries. The development of Eco-Industrial Estates has also received support from several authorities which are directly related to the industry, such as Department of Primary Industries and Mines, and the Federation of Thai Industries. The two main departments are the I-EA-T, a state enterprise under the Ministry of Industry, and the DIW under the Ministry of Industry. In the environmental awareness societies, EID has received wide interest.

### **5.1 Specification criteria and indicators to promote the Eco-Industry in Thailand**

In 2010, the cabinet of Thailand approved the concepts of Eco Industry Town Development proposed by National Economic and Social Development Board (NESDB) and assigned the National Industry Development Committee and Eastern Seaboard Development Committee to set up and regulate development plan both in the national and regional levels [53]. In the following year, the 11th National Economic and Social Development Plan (2012-2016) determined the Eco Industry Town Development and restoration of the environment in the area of main industrial zone. Ministry of Industry developed the indicators of EID consisting of 5 dimensions--Physical, Economic, Social, Environment and Management aspects. To achieve sustainable EID, I-EA-T explains the specifications standard of Eco-industry city for factories and Industrial Estates that plan to develop into Eco-industry city and they have to follow these Eco-criteria in 5 dimensions and 22 aspects as shown in Table. 3[54].

An overview of each category is given below:

1. The physical category aims to achieve a proper landscaping plan and surrounding area including infrastructure development under the Industrial Estates.

2. The economic category aims to achieve growth and sustained positive economic results, as well as to strengthen the local economy, the surrounding communities, and industry. Other target areas of this category include marketing development, transportation, and logistics.

3. The social category is intended to facilitate a better quality of life for people who work in the estate and who live in surrounding communities.

4. The environment category is focused on supporting the efficient use of resources, and effective emission and remedying pollution. I-EA-T proposes the appropriate management of waste water, solid waste, noise pollution, air pollution, efficient use of energy, eco-friendly processes, safety & health management, and environmental monitoring.

5. The management category aims to organize a systematic management process for the estate and to facilitate continuous improvement. This will focus on collaboration among stakeholders, maintenance and improvement of the estate's management system, effective information and report management, and continuous improvement in the capability of personnel.

## 5.2 Eco-Industrial Developments Practice

### 5.2.1 The development of Eco-Industrial projects by the Industrial Estate Authority of Thailand

In B.E. 2543 (A.D. 2000), I-EA-T was the first development agency which applied the concept of sustainable industrial development based on the principles of ecology to implement the Eco-Industrial estate. The project was named Development

of Eco-Industrial estate and Networks Project: DEE+NET project under the collaboration between I-EA-T and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Germany [55].

In B.E. 2553 (A.D. 2010), the Ministry of Industry organized a workshop, Going Green to Eco Industry, to determine the direction of the industrial development in Thailand. The workshop received good feedback from the operators, the industrial estate developers, government and private agencies. The event included a lecture on the subject of eco-industries and small-group sessions to offset criteria to measure the 5 dimensions and 24 indicators of development of the Eco Industry.

In the same year, I-EA-T launched the Eco-Industrial project in the three pilot industrial estates-Bang Pu Industrial Estate, Northern Industrial Estate and Eastern Seaboard Industrial Estate into the Eco Industrial Estates.

In B.E. 2554 (A.D. 2011), I-EA-T made (Draft) of Specification Standard of the Eco-Industrial town from the development guideline of 5 dimensions with 22 sides (*See details in Table. 3*) as the indicators (developed from the former 24 indicators) [56]. Moreover, three more pilot industrial estates were launched in Laem Chabang Industrial Estate, Amata Nakorn Industrial Estate and NongKhae Industrial Estate-into Eco Industrial Estates & Network. This includes a 5-year operation plan (2011-2015) which provided a framework for future development. In addition, the I-EA-T started upgrading industrial estates in Map Ta Phut area to Eco-Industrial estates.

In B.E. 2555 (A.D. 2012), I-EA-T jointly developed the PTT Eco-Industrial Park (PTT ECO-IP) for sustainable cohabitation [57]. Petroleum Authority of Thailand (PTT) plans to develop a pilot Eco-Town industrial project in the Asia Industrial Estate located in Rayong

province's Map Ta Phut area. There were three more pilot industrial estates at Banchan Industrial Estate, Samut Sakhon Industrial Estate and Amata City Industrial Estate launched in this year.

**Table. 3** Eco-Industrial city feature in 20 (and 22) aspects related to 5 dimensions of development proposed by DIW and I-EA-T, B.E. 2554 (A.D. 2011)

Dimension	DIW (20 aspects)	I-EA-T (22 aspects)	
<b>Physical</b>	1.Location and space layout 2.Building and surrounding area design	1.Industrial Estate Area 2.Public Utility and Infrastructure Systems 3. Buildings of Factories in the industrial estate	
	3.The economics of the industry 4.The economy of local community 5.Marketing 6.Transportation and logistics	4.Economy of the Industrial Sector 5.Local economy 6.Community economy	
<b>Economic</b>	7.Water management 8.Air pollution management 9.Waste and waste materials management 10.Energy management 11.Sound management 12.Production process 13.Eco-efficiency 14.Health and safety 15.Environmental monitoring	<b>Eco Efficiency</b> 7.Resource Management 8.Energy management <b>Production process &amp; Product</b> 9.Production System and Product <b>Pollution Control</b> 10.Water Pollution 11.Air pollution 12.Waste 13.Noise, Odour, Dust and Smoke Pollution and Nuisance <b>Safety &amp; Health</b> 14.Safety & Health <b>Industrial Symbiosis</b> 15.Business Linkage/Inter Utilization/ Industrial Symbiosis Management	
	<b>Social</b>	16.Quality of life and society of the surrounding community 17.Quality of life and social life of workers	16.Quality of life and Society of Employee 17.Quality of life and Society of Community around Industrial Estate
		<b>Management</b>	18.The management of the involved area 19.Improvement and maintenance of international management system 20.Information and reporting

Dimension	DIW (20 aspects)	I-EA-T (22 aspects)
		20. Encourage Factories to apply the International and National Management System 21. Promotion of Innovation/ Novel Management Tool/ System for Application by Factories 22. Information Disclosure and Reporting

At 2013, there were 12 industrial estates from 36 industrial estates in the process to be Eco-Industrial city, including Bang Pu, North, Eastern Seaboard, Laem Chabang, Amata Nakhon, Nong Khae, Samut Sakhon, Bang Chan, Amata City, LatKrabang, Bang Plee, and Bang Pa-in. Six of the twelve industrial estates have passed the I-EA-T’s assessment to be in the level of “Eco-Champion,” including North, Nong Khae, Laem Chabang, Bang Chan, SamutSakhon and Amata City.

For 2014, I-EA-T has set plans to turn four industrial estates into Eco-Industrial city, including South (Songkhla province), Gateway City, Sin Sakhon, and those in the Map Ta Phut Complex.

**5.2.2 The development of Eco-Industrial projects by the Department of Industrial Works [58]**

In B.E. 2553-2554 (A.D. 2010-2011), DIW launched two pilot industrial park zones for Eco-industry -- Rojana Industrial Park zones and Bang Kra Dee Industrial Park.

In B.E. 2554 (A.D. 2011), the DIW developed 5 dimensions of comprehensive management for industry: physical, economic, environmental, social and management dimension. The policy of the Ministry of industry also focused on the development of the entire operation. Therefore, 5 dimensions and 20 aspects

(developed from the former 24 aspects) of EID was offered from a seminar for creating aspects in EID for Thailand (*See details in Table. 3*).

Furthermore, in the fiscal year of 2012 (B.E. 2555) DIW continued to develop this project in five more Industrial Parks–Saha Group Industrial Park–Sriracha, Saha Group Industrial Park - Kabinburi, IRPC Industrial Park, 304 Industrial Park, and I.P.P. Industrial community. The implementation of the development of area based eco industry project has indicated that each industrial zone has different problems, capacities and needs. The development of eco industry thus requires an exploration and consideration of information in order to identify the real problems and capacities of each area. It will significantly contribute to the project planning and implementation towards eco industry. In addition, industrial developers will have to be the key drivers through all the whole process. They also need to get full cooperation from all involved in the area, including firms within the premise, communities, public organizations and academic institutions, to monitor and support the move towards eco industry in a sustainable manner [59]. In August 2014, nine Industrial Parks in six provinces (Ayutthaya, Pathumthani, Chonburi, Saraburi, Rayong and Prachinburi province) participated in the grand opening of the Eco-Industrial town.

By this purpose, the industry has expanded the target areas covering the province that have high-density industrial areas. With the progress of the operation in the above six provinces industrial areas, the nine areas have set up as a mutual exchange

of knowledge and strengthening the development of Eco-Industrial city. The timeline of EIEs and EIPs projects launched by I-EA-T and DIW since B.E. 2553 (A.D. 2010) can be seen in Fig.2.

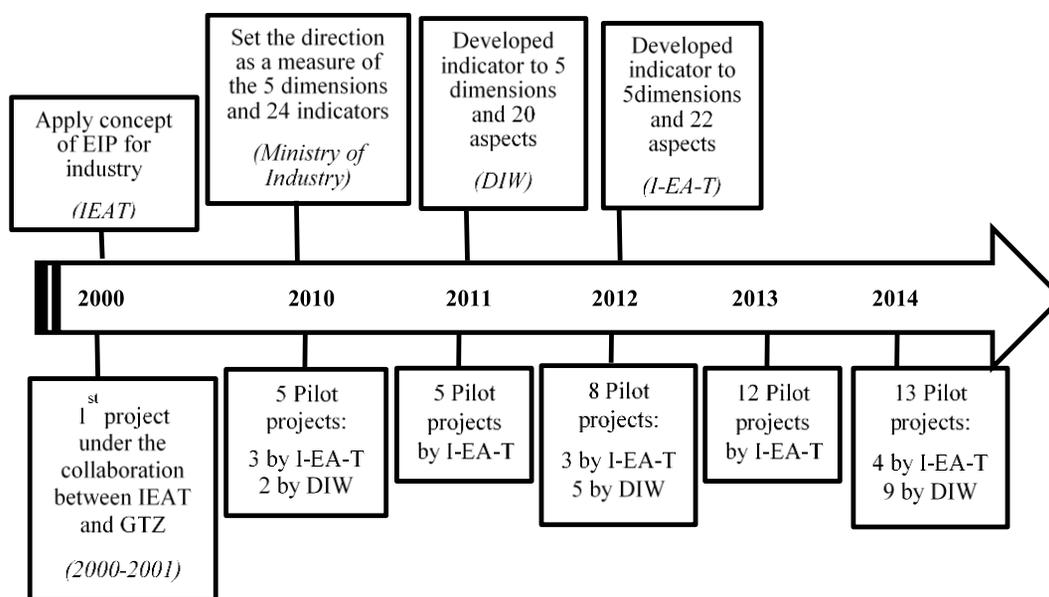


Fig. 2 Timeline of EIP Practices in Thailand

## 6. Conclusions

Industrial ecology and EID are still developing steps towards a more sustainable prospect. EIPs are significant steps of infrastructure and provide the inspirers to the development of industrial ecology. Presently, “successful” development of the various EIP pilot projects initiated all over the world could come together with the defining of an international standard in industry development. The succeed projects function as examples and help motivate other enterprises to follow their example. An ongoing international comparison of EIP projects could further help stimulate governments and industrial parks to initiate EID projects. In the recognition on EIPs, it is guided to pay more attention to mixed

industrial parks, and to find and implement solutions that ensure both the continuity and the sustainability of preference parks. Although the desires of the enterprises and the authorities with respect to sustainability are obvious, the implementation of substantial proceeds slowly and has only a marginal result. The diversity of interests of the different stakeholders, and the brightness in claiming new industrial zone because of modest ground prices opposes the essential reengineering of existing parks as well as a stricter regulation in both existing and new parks.

In order to stimulate development, it is important to focus on the establishment of low cost, high benefit utility sharing projects and “simple” exchanges. However, it has

taken more than 15 years to develop the concept of EIPs in Thailand. A number of useful lessons have been learned from the planning of projects. Without the latter, the concept would not have worked. It is necessary for developers to engage the community early in the planning process in order to avoid misunderstandings and to develop trust and community support for the concept. Moreover, the importance of government support and direct involvement in projects of this kind is essential. There were many obstacles that had to be overcome in securing interagency support and approval for EID. The platform for cooperation for such a partnership must be established from the outset. The EIP project is still in an early phase of project development and a definite project organization structure has yet to be designed. From these points, one can identify those which one should keep in mind when developing an EIP.

First and foremost, one should ensure active industry participation in the planning stages of the project. Participants in the project should be assured through the involvement of the local entrepreneurs' association or through an active recruitment procedure by the project initiator.

Second, the initial focus of the EIP project should not be on the establishment of physical energy, water and/or waste exchanges but on the utility sharing projects. The project should initially be focused on such projects because the physical waste exchange projects require relatively small economic investments while at the same time they offer a possibility for a reasonable economic and environmental benefit.

Finally, when the project is well assigned—that is when companies are fully aware of the benefits that are to be gained—the development can move along to more extraordinary and economically challenging projects, even though the

projects should perform an economic as well as environmental benefits.

## 7. Acknowledgements

I would like to thank Griffith University and Sukhothai Thammathirat Open University for the generosity in funding which supports throughout this study.

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