The Utility of Health and Safety Performance to examine the 
Eco - Industrial parks development: A case study of Saha 
Group industrial park Sriracha, Thailand

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Abstract

The Industrial Revolution of the 18th and 19th centuries brought the world significant technological and economic development, but also increasing energy consumption and pollution. The new factories around the world have become major users of both energy and virgin materials and producers of large amounts of hazardous waste and pollution. Although many countries have taken steps to address their environmental impacts through pollution prevention, cleaner production, and environmental management measures, industries at large still have not systematically addressed environmental issues either in the long term or in a comprehensive way. The concepts and philosophy of eco-industrial development (EID) have emerged as a useful approach to effectively manage pollution prevention and control towards sustainable development.

To realise EID, the Eco-Industrial Park (EIP), is a promising strategy to promote sustainable industrial development and to improve the industries’ environmental performance in terms of managing materials, energy and waste. The EIP concept has emerged from attempts to apply ecological principles to industrial activities and community design, and there have been many successful examples from the developed economies. However, the concept of an EIP has no universally accepted definition, and the term EIP may refer to many types of development projects. In fact, many EIP projects are already underway in different forms in various countries, including developing countries such as Thailand.

In Thailand, the concepts and approaches of EIP have been introduced and implemented in the industrial sector since 2000 but the projects have lasted only a few years. Driven by rapid industrial development and growing negative environmental consequences, in 2010, the Thai cabinet re-introduced the EIP approach, and set up and regulated development plans at both the national and regional levels. The Ministry of Industry through the Department of Industrial Works developed a set of EIP indicators, covering five dimensions (physical, economic, environmental, social and managerial) and 20 eco-criteria. However, in practice, the eco-criteria for evaluation focus on only a few criteria such as by-product exchange and waste management, leaving out the other eco-criteria in the environmental dimension, partly due to the difficulties of obtaining adequate data. This narrow focus means that the EIPs are not evaluated comprehensively against the
criteria for EID. Thus, although the establishment of EIPs is a good sign that Thailand is moving toward sustainable industrial development, because of a lack of data for meaningful evaluation, thus far no IPs in Thailand can be considered as mature, successful EIP. The key problem is there is no effective means of assessing and guiding EIP development in Thailand.

Apart from the waste and by-product criteria, “health and safety” is proposed as one of the criterion in the environmental dimension that can be used to evaluate the performance of companies wishing to enter an EIP. Thailand has a well-established occupational health and safety (OH&S) system with legislations and reporting requirement. Thus, by law the data should be readily available from every company. Nevertheless, no IP or government agency examines this criterion, nor have they considered using health and safety performance as one means of assessing industry compliance of EIP. But it remains a question whether it is feasible and useful as there has never been any investigation concerning alternate ways of evaluating and guiding EIP development in Thailand using OH&S criteria.

This research aims to examine the feasibility and utility of applying the eco-criterion of health and safety to assess enterprises performance towards developing into an EIP. Feasibilities, barriers and challenges are investigated through examining the OH&S performance of enterprises in the Saha Group Industrial Park in Sriracha as a case example to assess the performance of the Park in compliance to EIP requirements and gain lessons for future strategies to guide industries toward EIP development in Thailand.

Apart from an extensive review of global and Thai literature on EIP and OH&S, the field investigation collected data from 44 out of 65 firms in the industrial park in 2014 through direct observations; document review; in-depth interviews of 12 informants from government officers at national and local level, person in charge of OH&S in the industrial park, and specialists from universities; a questionnaire survey among 44 safety officers or person in charge of OH&S in firms; and 3 focus group discussions with different participants from factories range. The key findings of this research are as follows:

- The reviews of EIPs globally have shown that the concept and approach are useful to guide sustainable industrial development evidenced by many successfully developed EIPs in the developed world.
• The review of current state of development of various EIP pilot projects worldwide reveals that there is still no academic or standardised definition to define an EIP. To facilitate EIP development, it would be useful for relevant international agencies to establish an international standard in industrial development.

• While EIP has been introduced to Thailand since 2000, there has been limited research on its development. Data from the industrial sector is hard to access.

• There has been little awareness and understanding of the concept of EIP among all level of stakeholders involved, from the relevant government officers to the leaders, management personnel and workers in the industries within the IP. It will need a communication strategy to promote awareness and commitment to EIP to stakeholders for future development in Thailand.

• There is a lack of technical services and infrastructure to support the implementation of EIP in Thailand. Moreover, there is a shortage of technical staff competent in offering technical assistance to support the EIP development. But there is no course for students to be trained in these related subjects either in university or in educational training institutes.

• Relationships between an EIP and the surrounding community are important, and successful development needs the active participation of all stakeholders; the industrial park management body, private firms inside the park, local residents and the community do not communicate well with each other about problems that arise.

• The sharing of information and communication among government sector and industry sector is also lacking. The government sector has not been effective in raising the awareness of the community and of the industrial partners nor in explaining the EIP target goals.

• The OH&S sector in Thailand has played an important role to improve health and safety working conditions in the workplaces. However, there remains problems needing to be addressed, for example:
  
  • workers are poorly protected from hazards due to the inadequate provision of personal protective equipment and inadequate knowledge about OH&S;
many enterprises are still not clear regarding OH&S regulations; and,

- government agency inspection is inadequate.

- The employees of firms within the park do not really understand OH&S, nor do they understand the OH&S laws that apply to their workplace.

- OH&S can be a useful indicator of the environmental performance of EIPs in Thailand. However, government agencies and industrial parks have to make clear the specific requirements for OH&S data to be recorded properly both at the national level and at factory level.

Based on these major findings, the research concludes that OH&S can be utilised as one of the criteria to evaluate the performance of an EIP. However, the target values (criteria) and indicators for outcome evaluation should be carefully set up by the policy makers and make them clearer in order to motivate and guide enterprises to actively improve their performance in the EIP.

In conclusion, this thesis has demonstrated the importance of EIPs towards sustainable industrial development, and the usefulness of assessing OH&S performance to evaluate and guide EIP development in Thailand. Specifically, it provides a number of recommendations regarding future management of OH&S management and evidence for Thai government agencies, industrial parks and relevant organisations in developing policies and strategic plans that will actively drive the implementation of a sustainable EIP scheme in Thailand.
Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

............................

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<tr>
<td>A.D.*</td>
<td>Anno Domini, the Gregorian calendar</td>
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<td>ADCs</td>
<td>Asian developing countries</td>
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<tr>
<td>BAT</td>
<td>Best Available Technologies</td>
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<tr>
<td>B.E.*</td>
<td>Buddhist Era, Buddhist calendar</td>
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<tr>
<td>BIM</td>
<td>Building Information Modelling</td>
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<tr>
<td>CBEIE</td>
<td>Community-Based Eco-Industrial Estate</td>
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<tr>
<td>CE</td>
<td>circular economy</td>
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<tr>
<td>CSR</td>
<td>corporate social responsibility</td>
</tr>
<tr>
<td>CSS</td>
<td>Corporate Synergy System</td>
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<tr>
<td>DEE + NET Project</td>
<td>Development of Eco-Industrial Estates and Networks Project</td>
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<td>DIW</td>
<td>Department of Industrial Works</td>
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<td>DTV</td>
<td>Daedok Techno Valley</td>
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<td>EIE(s)</td>
<td>Eco-Industrial Estate(s)</td>
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<td>EID</td>
<td>Eco-industrial development</td>
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<td>EIN</td>
<td>Eco-industrial networks</td>
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<td>Eco-Industrial Park(s)</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>IE</td>
<td>Industrial ecology</td>
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<tr>
<td>I-EA-T</td>
<td>Industrial Estate Authority of Thailand</td>
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<tr>
<td>ILO</td>
<td>International Labour Organization</td>
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<tr>
<td>INES</td>
<td>Industrial Eco-System project</td>
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<td>IP</td>
<td>Industrial Park</td>
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<td>IS</td>
<td>Industrial symbiosis</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>GTZ</td>
<td>Gesellschaft für Technische Zusammenarbeit</td>
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<tr>
<td>H&amp;S</td>
<td>Health and Safety</td>
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<tr>
<td>JGSEE</td>
<td>The Joint Graduate School of Energy and Environment</td>
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<tr>
<td>KITECH</td>
<td>Korea Institute of Industrial Technology</td>
</tr>
<tr>
<td>KMUTT</td>
<td>King Mongkut’s University of Technology Thonburi</td>
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<tr>
<td>KNCPC</td>
<td>Korea National Cleaner Production Center</td>
</tr>
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<td>Abbreviation</td>
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<tr>
<td>LEED</td>
<td>Leadership in Energy and Environmental Design</td>
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<td>MTPIE</td>
<td>Map Ta Phut industrial estate</td>
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<tr>
<td>NESDB</td>
<td>National Economic and Social Development Board</td>
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<tr>
<td>NIC</td>
<td>newly industrialised country</td>
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<td>NICE</td>
<td>National Institute for the Improvement of Working Conditions and Environment</td>
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<td>NIOH&amp;S</td>
<td>National Institute for Occupational Health and Safety</td>
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<td>NRIE</td>
<td>Northern Region Industrial Estate</td>
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<td>OCB</td>
<td>Office of Certification Body</td>
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<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
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<td>OH&amp;S</td>
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<td>PRs</td>
<td>proportionate ratios</td>
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<td>pressure-state-response</td>
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<td>Petroleum Authority of Thailand</td>
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<td>PTT ECO-IP</td>
<td>Petroleum Authority of Thailand Eco-Industrial Park</td>
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<tr>
<td>RCEES</td>
<td>Research Center for Eco-Environmental Sciences</td>
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<tr>
<td>REDA</td>
<td>Rizhao Economic and Technology Development Area</td>
</tr>
<tr>
<td>SA</td>
<td>Self-Assessment</td>
</tr>
<tr>
<td>SAA</td>
<td>Situation Analysis and Assessment</td>
</tr>
<tr>
<td>SCBA</td>
<td>self-contained breathing apparatus</td>
</tr>
<tr>
<td>SCG</td>
<td>Siam Cement Group</td>
</tr>
<tr>
<td>SPI</td>
<td>Sahapatana Inter - Holding</td>
</tr>
<tr>
<td>SSE</td>
<td>small-scale enterprises</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities and Threats</td>
</tr>
<tr>
<td>TBL</td>
<td>triple bottom line</td>
</tr>
<tr>
<td>TEDA</td>
<td>Tianjin Economic-Technological Development Area</td>
</tr>
<tr>
<td>TISTR</td>
<td>Thailand Institute of Scientific and Technological Research</td>
</tr>
<tr>
<td>UDIA</td>
<td>Urban Development Institute of Australia</td>
</tr>
</tbody>
</table>
ABBREVIATIONS (Continued)

UNEP       United Nations Environment Programme
WBGT      Wet Bulb Globe Temperature
WEF       World Economic Forum
WELCOA    Wellness Councils of America
WHO       World Health Organization
WHS       Workplace Health and Safety
WISE      Work Improvement in Small Enterprises

Note*: In this thesis, I have used the Gregorian calendar (AD or as some prefer, CE). However some references use the Buddhist Era, Buddhist calendar (B.E.), which is commonly used in Thailand. The Buddhist Era starts 543 years earlier than the Gregorian calendar. Thus, AD 2000 in the Gregorian calendar is equivalent to 2543 B.E. in the Buddhist calendar.
Acknowledgements

As is customary and with good reason, I thank my supervisors first. I am deeply indebted to my principal supervisor Professor Cordia Chu, for her academic guidance, suggestions and encouragement, and enlightenment throughout the research and writing of this thesis. I also appreciate Dr. Sunil Herat who was instrumental initially, particularly in helping me take this work further. I am further obliged to Dr. Dung Phung for assisting me with academic suggestions, editing and proof reading my work. Many thanks must also go to Associate Professor Dr. Jakkris Sivadechathep from Sukhothai Thammathirat Open University, my external supervisor for his support during my field work in Thailand. Thanks of course must go to Mr. Duncan Frewin for his valuable editing and proof reading through my work. This project would not have been possible without funding, so, I am very much grateful to the full funding given by Sukhothai Thammathirat Open University. Next, thanks of course must go to Sahapatana Inter - Holding (SPI) for giving me their valuable time and allowing me to undertake field work at Saha Group Industrial Park, Sriracha.

I would like to express my gratitude to all of my friends at the Centre for Environment and Population Health, YES, CEPH family. You all have provided me with much enjoyment, friendship, and a firm sense of the diversity of life. We will be friends forever from every part of the world. I hope to see you guys again somewhere and sometime.

I would like to give my deep gratitude and thanks to my family. Their love, understanding and endless support and encouragement have enabled me to complete this work. My wonderful husband, Jirat, I have been extremely fortunate to have you as the other half of my life. You have shown me unconditional love and support. The relationships and bonds that I have with you hold an enormous amount of meaning to me.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Finally, and most importantly,

This thesis is dedicated to the memory of my beloved mother

Kanjana Areesawangkit (1942-2012)

Though you passed away just 3 days after I arrived in Australia to Commence my postgraduate study, I profoundly appreciate your Unflinching commitment to my career pursuit!

You will always be in my thoughts and in my heart forever ... I miss you.
Publications

The following publications have so far been produced as a result of the present research.

Journal Papers


Conference presentations and Awards based on this thesis


Manuscript prepared to publish


Chapter One
Introduction
1.1 Introduction

While industrialisation brings wealth and development to a country’s economy, it has also carried along many problems, and one of these is industrial pollution. To protect the environment and the communities from the adverse effects of pollution and to guide industrial development, many nations worldwide have established eco-industrial parks (EIPs), widely seen as a means to promote sustainable development. The many successful EIPs in the developed world promise to advance sustainable development, and present a useful means to resolve the conflict between industry and environmental pollution. But little is known about EIP development in developing countries such as Thailand.

Thailand, over the past few decades, has undergone significant social changes and industrial development which has brought about environmental problems such as air and water pollution, and hazardous waste issues. Thus, Thailand, too, has established a number of EIPs but without success in the 16 years since it first introduced them in the year 2000. One of the difficulties has been the lack of clear criteria to guide participating firms in developing sustainable industrial practices. An exception is health and safety data because there is an established requirement for firms to make the data on health and safety available by law. Thus, an assessment of health and safety data from an EIP may present an opportunity to examine the performance of an industry park and guide its development into an EIP.

This study aims to examine the utility of health and safety data as a possible means to assess and guide EIP development. This chapter provides an overview of the thesis. It discusses the background and rationale of the research, explains its aims and purpose, outlines its nature and scope, and describes the methodology used. Finally it presents the structure of the thesis.

1.2 Research Background and Rationale

1.2.1 Research background

Large Industrial Parks (IPs) have had a significant impact on communities and on people’s health. While industrialisation brings wealth and development to a country’s economy, it has also brought many problems, and one of these is industrial pollution. The current environmental problems in Thailand have been also created by the development of industry. Eco-Industrial Parks are one of the strategies to implement the concept of
industrial ecology that manipulates the industrial pollution [1]. EIPs are distinguished from IPs in their focus on ecological sustainability. Thai society has undergone significant changes and developments with important implications for issues of workplace health and it has focused on significant health care needs of workers and the surrounding communities. The problem emerging from these considerations is the continuous restructuring and reorientation of occupational health services, to meet challenges created by the changing nature of working life and the environment [2].

Eco-industrial development (EID) in Thailand has been implemented by the Industrial Estate Authority of Thailand (I-EA-T) and Department of Industrial Works (DIW) since the first launched in 2000. Nevertheless, they have very limited experience about the actual evaluation of EIP initiatives. One major issue in EIP planning and development in Thailand is that the definition is in very narrow terms as ‘companies utilising each other’s' 'wastes' or ‘by-products exchange’. This approach is not practical and fails to achieve the full benefits of an EIP developed according to a more systemic definition [3]. In Thailand, there is a need to build capacity for using industrial waste. Often illegal dumping is common, and illegal dumpsites are often not discovered until nearby soil and groundwater is discovered to be contaminated. The monitoring of industrial waste disposal is needed, as well as encouragement of policy compliance by improving accessibility to waste collection and treatment equipment. The private sector and local communities are potential partners in improving waste management across many waste streams, but cooperation with both is not emphasised by governmental policies. The country’s responses to the need for cooperation therefore show that overarching and wide-ranging issues affecting many waste streams must be addressed [4]. Thus, instead of focusing on wastes and by-products exchange, other eco-criteria need to be used to realise the eco-industrial paradigm in Thailand such as health and safety aspect.

During the past few decades, research activities have continued to play an important role in the development of occupational health and safety (OH&S) in Thailand. Such research activities have been conducted by several government agencies as well as by academic institutions offering OH&S programs. Unfortunately, OH&S research activities conducted by the Department of Labour Protection and Welfare have played a less important role in the past 3-4 years. The Bureau has been facing some limitations on budget and internal facilities which have significantly affected its capacity to conduct OH&S research during this period. However, under the Occupational Safety, Health and
Environment Act 2554 B.E. (A.D. 2011), the Institute for Promotion of Occupational Safety, Health and Environment was established to promote the OH&S activities [5].

This study aims to examine the utility of applying health and safety (H&S) criteria to assess EIP performance. The findings should lead to policy recommendations to guide the future development of EIP in Thailand.

1.2.2 Research rationale

With the growing recognition of the importance of the industrial revolution, the trend of clustering industries into estates or parks was adopted in the mid-20th century [6]. This trend is continuing to be popular in both developed and developing countries especially when there is rapid industrialisation. Although individual industries in many countries have taken key steps to address environmental pollution through pollution prevention, cleaner production, and environmental management systems. The idea of “green” is principally an emerging paradigm, especially amongst developing countries, since its initiative by United Nations Environment Programme (UNEP) [7]. Many international organizations and developed countries have proposed many major challenges to be addressed to deal with pollution such as green growth, green economy, green transformation, green structural transformation, sustainable transformation, and green industrial policy, as revealed by the United Nations Environment Programme (UNEP) studies [8]. Some of these challenges include: climate change, energy consumption, waste production, threats to public health, management of natural resources, and land use. However, it is slowly becoming a significant part of the developmental plans and processes amongst countries [9]. In recent years, the sustainable development concept has been widely recognised as a way to promote industrial growth without negative impacts on the environment. The implementation of integrated management of industrial production through “Eco-Industrial Park Development” can help to avoid these negative environmental impacts [10-13]. The literature provides recommendations for management concerning sustainable development through the eco-industrial park concept but there is, however, limited research on the effective implementation of EIP projects especially in Thailand. So there are few published articles to guide the effective implementation of EIP projects in Thailand.

The evolution of EIP projects in Thailand have changed. In particular, since 2000, Thailand has promoted the EIP projects to enhance the industrial development in the
country. However there is insufficient current research on EIPs in Thailand and thus a lack of systematic analysis of the current situation. Research regarding the current and future direction of EIPs is now desirable. While experience and analysis of EIPs project have generated significant learning and consensus building over the past years, there is still some considerable uncertainty, misunderstanding and divergence of opinion among stakeholders about this concept. More research is needed to provide the conceptual clarity, basic ground rules and institutional innovations necessary to make key players more effective and strategic. EIPs need to consider a combination of various strategies and criteria. Thailand has launched many pilot projects of EIPs in critically polluted areas as well as set up specific criteria for assessing their effectiveness. Unfortunately, all pilot projects only focused on 'wastes' and ‘by-products’ management in the environmental dimension, and no EIP has yet met even those criteria. Other criteria have not been addressed in the research to date. This research addresses these gaps and examines an alternative criterion, health and safety, to achieve the status of EIPs. It analyses and discusses them through a case study of an industrial park intending to transform into an EIP. The findings of this research may also have useful implications for other developing countries wanting to develop EIPs.

1.3 The Thai Context

Industrial development in Thailand is still mainly based on processing of agricultural products, but now heavy industry is developing, contributing to the economic advancement of the country. At the same time, however, negative impacts are being generated. The question is therefore the direction of development that would enhance sustainability, health and better living of the citizens while industries remain the driving force of national development. External forces e.g. trade barriers, environmental measures etc.; have to be taken into serious account as well. Even though Thailand is not directly bound by all of these external forces, non-compliance with international norms might pose negative impacts on the country’s involvement in the international market.

According to the World Bank data [14], Thailand became an upper-middle income economy in 2011. Over the last four decades, Thailand has made great progress in social and economic development, turning from a low-income country into an upper-income country in less than a generation. Consequently, Thailand has been one of the popularly
cited development success stories, with sustained strong growth and impressive poverty reduction, particularly in the 1980s.

Thailand’s economy grew at an average annual rate of 7.5 percent in the late 1980s and early 1990s, creating millions of jobs that helped pull millions of people out of poverty [14]. Gains along the multiple dimensions of welfare have been impressive: more children are now getting more years of education, and virtually everyone is now covered by health insurance while other forms of social security have expanded.

The number of people in poverty has declined substantially over the last 30 years from 67 percent of the population in 1986 to 11 percent in 2014 as incomes have risen [14]. However, poverty and inequality continue to pose significant challenges, with vulnerabilities as a result of faltering economic growth, falling agricultural prices, and ongoing droughts. Poverty in Thailand is primarily a rural phenomenon. As of 2013, over 80 percent of the country’s 7.3 million poor live in rural areas. While another 6.7 million were living within 20 percent above the national poverty line and remained vulnerable to falling back into poverty.

The manufacturing and service industries of Thailand play in an important role in driving the country’s economy as can be learnt from the fact that manufacturing and service industries accounted for 86 percent of the country’s annual GDP on average from 2005-2009 [15]. In 2014, the World Economic Forum (WEF) ranked Thailand in the 6th place in terms of competiveness, which was higher than the previous year. It also moved up to 12th place in the macroeconomic environment ladder. Despite Thailand’s constantly changing political dynamic, it has a firm economic foundation that proves its resiliency time and time again [16]. However, manufacturing industries still face various problems on all sides such as low production capacity, competition for market leadership, movement of manufacturing bases from Thailand to countries with lower wages, lack of essential up-stream industries, lack of ability to accommodate and upgrade to advanced production technology and new products [15].

In the period of Thailand’s transition over the past five decades, many of its health indicators have shown advancement: a clear increase in life expectancy, while mortality and the incidence of communicable diseases and malnutrition have decreased [17]. From 1960 to 2013, life expectancy increased from 53.4 to 71.5 years for males and 57 to 78.8 for females [18]. From 1990 to 2015, the maternal mortality ratio fell from 40 to 20 per
100,000 live births [19]. And from 1981 to 2015, the infant mortality ratio fell from 45 to 11 per 1,000 live births [20]. By 2005 eight of the top ten causes of death in Thailand had strong links to modern aspects of work and life. Ischemic heart disease, stroke, HIV and road accidents are the leading causes of death in modern Thailand [21].

In short, at its current stage of development, Thailand needs to develop EIPs for sustainable development.

1.4 Scope, Aims, and Objectives of the Research

This research focuses on the use of OH&S as an alternative eco-criterion to assess whether an IP can be classed as an EIP in the country. This study will examine the implementation of OH&S in a potential Industrial Park which is planning to become an EIP in Thailand. It identifies barriers and challenges for implementation of EIP in the industrial park, and explores the future development of EIP projects in Thailand.

This research asks the question: *What are the feasibilities and challenges of utilising OH&S performance to assess and guide eco-industrial parks development in Thailand?*

This research aims to examine the utility of using health and safety performance which is a criterion from the environmental dimension to evaluate the EIP performance in Thailand. The research selected Saha Group Industrial Park, Sriracha which plans to develop into an eco-industrial park as the case study.

The objectives of this research are:

1. To understand the nature, purpose, and historical development and achievement of EIPs globally;
2. To examine the history and progress of EIPs in Thailand;
3. To assess the current system and historical development of OH&S in Thailand particularly within IPs;
4. To investigate the feasibilities, barriers and challenges for using OH&S as an indicator of EID achievement through examining OH&S performance of a Saha Group Industrial Park as a case example to assess its progress in meeting the requirements and guiding EIP development in Thailand; and
5. To provide recommendations to assist the Thai government agencies, the industrial park and relevant organisations in developing policies and strategic plans for promoting more effective EIPs in Thailand.

1.5 Methodology

This research used a mixed-methods approach which combined qualitative and quantitative approaches. The research process included three stages: develop a research protocol, fieldwork and data collection, and data analysis.

In the first stage, a large number of data sources including books, journal articles, government documents, policy reports and conference papers covering the research’s contextual fields were reviewed. The literature review established the background of the study and the context for the analysis, helping the researcher to understand the knowledge, share the results of other studies, and provided a framework for establishing the importance of the research.

The second stage of this research, fieldwork, the study carried out an in-depth exploration through various methods, including reviews of documents and program reports, and a series of key informant interviews. The analysis of the data led to the conceptualisation of the research and contributed to the construction of the research question. The researcher used multiple sources of evidence to address the research question. These sources included documentary review, participant observation, in-depth interviews, focus group discussions and existing and secondary data analysis. All the data was analysed and interpreted to provide the evidence for the findings.

The third stage was the data analysis stage. Both qualitative and quantitative data were analysed to inform the findings and recommendations for the research.

1.6 Structure of the Thesis

This thesis includes two parts, in a total of nine chapters. Part I, the literature review, sets the background for this research; it provides a review of the literature of three contextual fields. The first contextual field pertains to the global project of eco-industrial parks (EIP), the strategies to implement them and also the development of the concept in various countries. The second contextual field concerns occupational health and safety (OH&S) as a response to the health and safety of workers, and the integration of OH&S objects
into EIP. The third contextual field is Thailand, focusing on EIP implementation and OH&S policies in the nation. Part II, the research methodology and results and key findings, starts with the research design and methodology of this study, followed by the results, and highlights the major findings of the research. The findings are followed by a discussion of their significance. Then, the final chapter draws the conclusions about the EIP projects, makes some recommendations and ends with a summary of the thesis.

Chapter One, the introductory chapter sets the scene of research in the context of the thesis, presents the background including rationale, the Thai context, scope, aims and objectives, a brief of methodology, and then describes the structure of the thesis.

Part I, the Literature Review, includes Chapters Two to Four.

Chapter Two focuses on EIP implementation worldwide that provide an overall picture of global EIP development, strategies used for designing an EIP as well as past and present EID projects in the world. At the end of this chapter, the gaps in the knowledge about eco-industrial projects are highlighted.

Chapter Three examines EIP implementation in Thailand. The chapter first introduces a brief demography including a brief summary of Thailand’s economic growth. Then, it describes the experiences and the strategies used to develop the EIP projects in Thailand. Finally it analyses the primary problems of current EIPs in the nation. This chapter lists the relevant government agencies and outlines their activities in the country, as well as discussing the factors necessary for success of an EIP in Thailand.

Chapter Four presents an overview of occupational health and safety (OH&S) in the setting of Thailand. The chapter begins by introducing the concept of OH&S, including several definitions, policies, brief historic and changes in labour policy of OH&S. The potential role of OH&S in EIP is also discussed in this chapter. Finally it describes some problems of OH&S practices in Thailand.

Part II, Chapters Five to Eight, includes the methodology, key results and findings of this research. Chapter Five is concerned with the research design, methodology and the details of the research processes. This chapter first describes the research location and site, background and its rationale. Next, the research question and focus questions were developed. Based on the conceptual framework, the chapter then design and explains how the methodological approach for this research was chosen. Three stages of research design are detailed: developing a research protocol, fieldwork and data collection, and data
analysis techniques. The issues of rigour and ethics are also discussed at the end of this chapter.

Chapter Six describes the quantitative findings from the case study. This chapter first describes the general data about Saha Group Industrial Park, Sriracha including OH&S practices of the Park. This chapter also provides the evolution of EIP implementation in the Park and how health and safety criteria are applied in the Park. It then presents the key findings from the case study.

Chapter Seven focuses on the qualitative findings from the case study. It presents the main results from various data collection methods. The levels of awareness, the levels of participation of the firms in OH&S in accordance to the requirements of EIP regulations, and the levels of agreement about OH&S management through industrial ecology schemes are analysed. Barriers and challenges for implementation of health and safety programs in EIP are also discussed.

Chapter Eight carries on a discussion of the research and provides a summary of the thesis. The factors that are critical to the success of EIP projects in Thailand are identified. Then, the utility of OH&S performance to guide the development of EIP is examined. Finally recommendations for the future development of OH&S management in EIPs are offered.

The concluding chapter, Chapter Nine, gives a brief summary and critique of the research findings. It includes a discussion of the advantages and limitations of this research and implications of the findings for future research into this area.

1.7 Conclusion

This chapter has set the scene of this research, and then provided background and rationale, nature, scope and purpose, and methods of this research. The structure of the thesis has been outlined in this chapter. The following chapters of Part I contain the literature review of the contextual fields of this research.
Part I: Literature Review

Chapter Two

Eco-Industrial Parks: Concept and Current Situation in the World
2.1 Introduction

Different countries in the world are confronting different kinds of industrial pollution problems. 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 systematise the needs of the industrial environment. In order to respond to these global challenges, many efforts have been made, such as improved energy efficiency management, industrial ecology, green procurement, sustainable consumption, etc. All of them encourage an eco-industrial development (EID) approach, a method that has been promoted since the 1990s [22]. The strategies to achieve greater materials and energy efficiency, improved environmental safety and enhanced social integrity, can best function in the context of integrated systems approaches, which are built upon partnerships designed to optimise the use of energy, materials, and community resources [23]. Currently, many countries are actively promoting EID by enacting new regulations, initiating pilot projects, providing financial help, supporting research and development and by organising capacity-building activities. This chapter shows the results relevant to the 1st focus question of this thesis. To explain the background and nature of the central subject matter of this study, this chapter aims to review the concept and current situation of eco-industrial parks (EIP) and to highlight the complexity of EID and the difficulties in its governance. The review starts with a brief overview of EID from the perspective of industrial ecology. It will then describe strategies and global trends for designing an EIP, drawing on current studies on EID experience from around the world. This is followed by a discussion of its benefits to stakeholders – industry / businesses, environment, and society / communities. Finally, this chapter will present related research work from various disciplines regarding EIP and identify gaps in this field.

2.2 Overview of Eco-Industrial Development

The eco-industrial park idea emerges from the concept of industrial ecology. In this concept, industry is compared with natural ecology: a linkage between partnerships enables each partner to use the others’ by-products and waste products [24]. More specifically, an EIP is a partnership where co-located firms engage in industrial symbiosis. Industrial symbiosis presumes that a group of businesses or individual firms
enhance their collective economic and environmental sustainability by combining their resource handling [25]. Although the industrial symbiosis idea has been selected by policy makers and contemporary technical and economic planners, actual implementation of the concept is quite difficult and a high number of failed projects has been recorded [26, 27]. 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 is limited due to the lack of a comprehensive model to evaluate the industrial symbiosis projects [28]. The premier EIP was founded in Kalundborg, Denmark where material exchange has occurred for over forty years [29]. Recently, with a high concern from various institutions such as World Bank, International Finance Corporation, United Nations Industrial Development Organisation, and Deutsche Gesellschaft für Internationale Zusammenarbeit, there has been a significant scaling up in the introduction of EIPs in developing countries [30].

The primary weakness of existing EIPs is the significant environmental impacts including the discharge of wastewater, the generation of solid hazardous wastes and the utilisation of natural resources including not only the mass of wastes and gas emissions, but also impacts on human health and ecosystems [31, 32]. Generally, sustainable development and sustainability have been encouraged in many different ways [33]. Some weighted metrics are being considered in the European Union and elsewhere for use in environmental legislation. The range of terms utilised in the literature that define these networks of companies is listed in Table 2.1. The main term that will be used in this research is EIP.

Table 2.1 Various terms used for industrial developments focused around environmental management [34]. Adapted from Chiu, 2004 [35] and Massard, 2012 [36].

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition and main specificities</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>“Industrial ecology” explores the assumption that industrial system can be seen as an ecosystem. Industrial systems, like natural ecosystems, can be described as a particular distribution of materials, energy, and information flows. Industrial ecology uses the design of natural ecosystems to guide the redesign of industrial systems and offers</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition and main specificities</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>opportunities and solutions to turn industrial parks into eco-industrial parks [37, 38].</td>
</tr>
<tr>
<td>IS</td>
<td>“Industrial symbiosis” as a part of the emerging field of industrial ecology, focuses on 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. [39].</td>
</tr>
<tr>
<td>EIN</td>
<td>“Eco-industrial networks” is often used as a synonym for industrial symbiosis. The term is used to describe resource exchange networks at the regional scale and thus does not strictly require geographical proximity [40].</td>
</tr>
<tr>
<td>EIP(s) or EIE(s)</td>
<td>“Eco-industrial park(s)” or “Eco-industrial estate(s)” is based on sciences profoundly linked to sustainability of development by managing the environment and manipulating resources including energy, water, and materials in manufacturing and service businesses. By working together, the community and businesses hope for a corporate benefit and environmental quality gains, and equitable enhancement of human resources [41]. This concept includes interactions and interrelationships both within industrial systems and between industrial and natural ecological systems in the physical, chemical and biological subjects [42].</td>
</tr>
<tr>
<td>EID</td>
<td>“Eco-industrial development” is one way to implement local sustainable economic development by anchoring companies in their local environment, reducing environmental impacts, developing employment, and providing safe work conditions. Therefore, EID links economic and regional development with eco-efficiency and environmental protection [43, 44].</td>
</tr>
</tbody>
</table>

### 2.2.1 Industrial ecology and industrial symbiosis

Industrial ecology is a concept emerging in the evolution of environmental management paradigms [26], and emerges from the compilation of concepts of sustainability into
environmental and economic systems [11, 45, 46]. The part of industrial ecology learnt as industrial symbiosis engages traditionally differentiated entities in a collective approach to competitive profit involving physical exchange of materials, energy, water, and/or by-products, and aims at reducing overall production costs [47]. Industrial symbiosis emerges at the inter-firm level because it includes exchange amongst various firms (See Figure 2.1). Eco-industrial parks can be seen as substantial realisations of industrial symbiosis.

**Figure 2.1 Industrial ecology operates at three levels [39]**

At the same time that interest began to develop in industrial symbiosis and EIPs, a number of other parallel lines progressed that might be interpreted, broadly, as “green development.” These include sustainable architecture design, green building, sustainable communities, materials and energy flow, and many other terms.

Many authors have attempted to recommend structured classifications for the industrial symbiosis literature. These classification tools focus on the networks, types of exchanges and geographical contexts for the exchanges, and offer a means for structured research presentation in their own successive areas [48]. Some researchers such as Ehrenfeld and Gertler (1997) [26], Chertow (1999, 2000) [39, 49], Lowe (2001) [50], Van Berkel (2006) [51] and Martin et al. (2009) [48] have provided a structured method to classify industrial symbiosis activities and exchanges between industries. These categorisations are
presented in Table 2.2 to show the structure that they provide for industrial symbiosis and classification of synergies.

**Table 2.2 Initiatives to Classify Industrial Symbiosis Exchanges and Interactions**  
Adapted from Martin et al, 2009 [26, 39, 48-51]

<table>
<thead>
<tr>
<th>Researcher (s)</th>
<th>Industrial Symbiosis Classification Description</th>
<th>Limitations/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehrenfeld and Gertler [26]</td>
<td>Industrial ecological principles</td>
<td>Potential forms of industrial linkages are critically reviewed</td>
</tr>
<tr>
<td>Lowe [50]</td>
<td>Types of eco industrial parks and their motivation</td>
<td>Reasons and Origins for Industrial Symbiosis</td>
</tr>
<tr>
<td>Chertow [39, 49]</td>
<td>Geographical distribution of exchanges</td>
<td>Explanations of types of exchanges between firms geographically and practically</td>
</tr>
<tr>
<td>Van Berkel [51]</td>
<td>Nature of synergy exchanges</td>
<td>Differentiations produced for interactions and sharing of by-products, utilities and management</td>
</tr>
<tr>
<td>Martin et al. [48]</td>
<td>Conditions necessary for synergy implementation</td>
<td>Classification method maps the interactions between different industries</td>
</tr>
</tbody>
</table>

Industrial ecology (IE) has been described in several ways, but it is not easy to fully understand the holistic concept of industrial ecology. Erkman (1997) noted that most authors endorse at least three key elements of industrial ecology. The first element is its systems approach where industrial ecology studies the whole system including the material and energy flows, rather than just studying a component of the system [38]. The second element of industrial ecology is that it takes into consideration the material and energy flows inside and outside a company’s border. The third element is the use of key technologies as a critical component to achieve the conversion from an unsustainable industrial system to a sustainable industrial ecosystem (See Figure 2.2).
With the industrial ecology concept, industry performs with nature and utilises the wastes and byproducts of other industries as input into their own processes [53]. The principles of industrial ecology as defined by Tibbs (1992) [54] are:

- Create industrial ecosystems – close the loop; see waste as a resource; build up partnerships with other firms to exchange by-products which are used as raw materials for other processes.

- Balance industrial inputs and outputs to natural levels – manage the environmental-industrial interface; develop knowledge of ecosystem behavior; increase knowledge of industries’ interactions with natural ecosystems and the limitations.

- Dematerialisation of industrial output – use less virgin materials and energy by upgrading resource efficiency; reuse materials or use more environmentally friendly materials.

- Enhance the efficiency of industrial processes – redesign products, processes, equipment; reuse materials to preserve resources.
- Energy uses – incorporate energy supply into the industrial ecology; use alternative sources of energy that have no or less impact on the environment.
- Align policies with the industrial ecology concept – incorporate environment and economics into organisational, national and international policies; internalise the externalities; use economic instruments to encourage a move towards industrial ecology.

The benefits and limitations of industrial ecology include many areas of the environmental scene and relations with other industries as shown in Figure 2.3.

**Figure 2.3 Benefits and limitations of industrial ecology [53]**

### 2.2.2 Definition of Eco-industrial Park

Sustainable development in industrial parks has been explained by various researchers [55] as applying appropriate emerging methodologies, while Zhou et al. (2006) offer proper indicators for the determination of the sustainable quality of industrial parks [56]. There is no academic or standardised definition to define an EIP. However, some of the definitions available from the literature consider EIP as a synonym for the concept developed by researchers in the field of industrial ecology [57, 58]. EIPs are a strategy to promote sustainable industrial development and to improve the environmental performance of industries in terms of managing materials, energy and waste. EIPs provide
substantial benefits for participating companies, for their neighbourhoods and for their extended regions. The commonly accepted international definition is based on the one initially created by an Indigo Development team in 1992 and then expanded for the US-Environmental Protection Agency in 1995 [59].

In 1995, Côté and Hall (1995) proposed this definition [59]:

\[
\text{An eco-industrial park is an industrial system which conserves natural and economic resources; reduces production, material, energy, insurance and treatments costs and liabilities; improves operating efficiency, quality, worker health and public image; and provides opportunities for income generation from use and sale of wasted materials.}
\]

Yet another definition was put forward by Garner and Keoleian (1995) as a scientific subject [42]:

\[
The\ study\ of\ the\ physical,\ chemical\ and\ biological\ interactions\ and\ interrelationships\ both\ within\ industrial\ systems\ and\ between\ industrial\ and\ natural\ ecological\ systems.
\]

According to the EPA Fieldbook [41],

\[
\text{An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only.}
\]

At an October 1996 workshop hosted by the United States President’s Council on Sustainable Development [60], 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 [50]:

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 resource consumption and a minimisation of waste production in the framework of a sustainable development paradigm (See Figure 2.4). Despite the EIP configurations being importantly based on the concept of sustainability, the problems of defining their appropriate layout inside the boundary and the consequent area of land use design, to minimise land consumption, have not frequently been major concerns in the wide range of studies and practices regarding the EIPs. [61].
2.3 Strategies used for Designing an Eco-Industrial Park

Although there are many examples of symbiosis involving the exchange of materials and energy cascading, multi-faceted industrial ecosystems are few and far between. Nevertheless, planning and design of these ecosystems is underway in many countries [62]. An EIP may also be planned, designed, and built in the direction that makes it easier for businesses to work together, and that result in a more financially sound, environmentally friendly project for the developer.

Table 2.3 presents other strategies that are components of the broader field of industrial ecology and that might be adopted by EIP participating firms, but do not necessarily contribute to the inter-firm cooperation characteristic of industrial symbiosis. Strategies such as resource recovery or deconstruction and remanufacturing could be adopted either by individual firms or serve as a theme for an EIP as a whole.
Table 2.3 Eco-Industrial Development Strategies.

<table>
<thead>
<tr>
<th>Country/ References</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| **USA**              | • Resource recovery, pollution prevention and cleaner production / Environmental management systems  
| Review of Economic Development Interaction and Practice, 8. [63] | • Materials and energy interchanges  
| Schlarb, M. (2003). Eco-industrial development feasibility study: City of Fairborn, Bath and Mad River townships. Wright State University, B-W Greenway Community Land Trust. [64] | • Integration into natural ecosystems  
| Trillium Planning and Development INC. (2003). Eco-industrial development feasibility study: City of Fairborn, Bath and Mad River townships. Wright State University, B-W Greenway Community Land Trust. [64] | • Sustainable/green design / Life cycle assessment  
| Japan                | • Deconstruction and remanufacturing / Job training  
| Japan                | • Public participation and collaboration  
| Japan                | • Bio Based Industry Cluster: produce alternative fuels, lubricants and co-products increasing the value of agricultural resources such as biodiesel from corn and soybean.  
| Japan                | • High Performance Warehouse and Distribution Centres: used for logistics division of retailers and wholesalers by co-locating combination of firms with complementary distribution channels  
| Japan                | • Research and Technology Park: focus on commercialisation of research  
| Japan                | The impact diagrams cover different aspects of the environmental and sustainability agendas for government, business and society. These have been characterised by means of four circles:  
| Japan                | • Eco-Efficiency: producing less waste and using less material in productive activities.  
| Japan                | • Corporate Social Responsibility: improving the well-being of employees, their families and communities.  
| Japan                | • Environmental Restoration: reversing environmental damage from past activities to levels that are no longer harmful to humans and ecosystems.  

<table>
<thead>
<tr>
<th>Country/ References</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td>• Integration into natural systems / Energy Systems</td>
</tr>
<tr>
<td></td>
<td>• Water -- Design water flows to conserve resources and reduce pollution.</td>
</tr>
<tr>
<td></td>
<td>• Effective EIP management, construction /rehabilitation</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td>• A holistic systems’ approach to resource management, balancing environmental issues with economic and industrial viability.</td>
</tr>
<tr>
<td>Roberts, B. H. (2004). The application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: an Australian case study. Journal of Cleaner Production, 12(8), 997-1010. [58]</td>
<td>• Use of an interdisciplinary approach for research, planning and implementation, linking fields such as ecology, economics, engineering, business, public administration and law.</td>
</tr>
<tr>
<td></td>
<td>• Examination of material and energy flows through complex industrial systems.</td>
</tr>
<tr>
<td></td>
<td>• Reduction of energy and material flows used for production and consumption to moderate impacts on the environment to levels that the natural systems can sustain.</td>
</tr>
<tr>
<td></td>
<td>• The re-design of manufacturing development to include activities which have reduced human ecological impacts.</td>
</tr>
<tr>
<td><strong>Worldwide</strong></td>
<td>• Site Selection: Prepare a site development plan, and have available the relevant regulations and guidelines.</td>
</tr>
</tbody>
</table>
Country/ References  | Strategies
---|---
 experiences. Journal of Cleaner Production, 6(3), 181-188. [62]  | • Substitution/Use of Environmental Products: There should be an ongoing review of materials and wastes to replace chemicals whose quantity, toxicity, persistence and degradability are a cause for concern.

• Waste Reduction: Establish a plan for industrial wastes, solid waste management. Advise enterprises on noise, air quality reduction measures and materials for buildings and machinery.

• Material Cycling/Exchanges: A system to allow the cycling, exchange or transfer of materials within the park.

• Co-locating of Businesses: As much as is possible, companies should be co-located so as to maximise use of waste heat and waste water.

• Cascading: The overall quantity of materials required to manufacture products and offer services in the park can be reduced by cascading higher quality wasted materials to businesses that can use lower quality materials.

The range of classification of EID initiatives in the literature [3, 58, 63, 64] makes it 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 “Eco-innovation parks survey” [36], 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). Figure 2.5 categorises the eco-criteria most frequently used in the 175 cases of eco-innovation parks.
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 issues as a main component of industrial park innovation strategies. These two criteria are common strategies for industrial park management in many countries. Their innovative component in the case studies is sometimes unclear. Thus, the high occurrence does not mean that the resource management can be in any case characterised as innovative.

In contrast, eco-criteria such as biodiversity, cultural/social/health, transportation, land use optimisation, air pollution/noise prevention are probably under represented due to the tendency to apply solutions at the micro scale (company) rather than at the meso scale (park) leading to their under representation in the industrial ecology literature.

The literature on EID is inexact and fragmented despite a growing interest in the field [66]. Various strategies have been suggested as a means of increasing the efficiency of businesses in order to realise environmental, economic, social and institutional benefits. At the organisational level some strategies have focused on health and safety (H&S), or health and well-being [67], and on planning for H&S in their focus on waste integration [58]. Table 2.4 provides a list of additional fields where eco-industrial connections can be facilitated for eco-industrial development [68].
Table 2.4 Potential Fields of Eco-Industrial Networking [69]

<table>
<thead>
<tr>
<th>Information/Communication Systems</th>
<th>Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Communications</td>
<td>Green Labelling</td>
</tr>
<tr>
<td>External Information Exchange</td>
<td>Accessing Green Markets</td>
</tr>
<tr>
<td>Monitoring Systems</td>
<td>Joint Promotions (e.g. advertising, trade shows)</td>
</tr>
<tr>
<td>Computer Compatibility</td>
<td>Joint Ventures</td>
</tr>
<tr>
<td>Joint Management Information System for Park</td>
<td>Recruiting New Value-Added Companies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of Life/Community Connections</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrating Work and Recreation</td>
<td>Common Buying</td>
</tr>
<tr>
<td>Cooperative Education Opportunities</td>
<td>Customer/Supplier Relations</td>
</tr>
<tr>
<td>Volunteer and Community Programs</td>
<td>By-product Connections</td>
</tr>
<tr>
<td>Involvement in Regional Planning</td>
<td>Creating New Material Markets</td>
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</table>

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Production Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Commuting</td>
<td>Pollution Prevention</td>
</tr>
<tr>
<td>Shared Shipping</td>
<td>Scrap Reduction and Reuse</td>
</tr>
<tr>
<td>Common Vehicle Maintenance</td>
<td>Production Design</td>
</tr>
<tr>
<td>Alternative Packaging</td>
<td>Common Subcontractors</td>
</tr>
<tr>
<td>Intra-park Transportation</td>
<td>Common Equipment</td>
</tr>
<tr>
<td>Integrated Logistics</td>
<td>Technology Sharing and Integration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environment, Health &amp; Safety</th>
<th>Human Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Prevention</td>
<td>Human Resources Recruiting</td>
</tr>
<tr>
<td>Emergency Response</td>
<td>Joint Benefits Packages</td>
</tr>
<tr>
<td>Waste Minimisation</td>
<td>Wellness Programs</td>
</tr>
<tr>
<td>Multi-media Planning</td>
<td>Common Needs (maintenance, security)</td>
</tr>
<tr>
<td>Design for Environment</td>
<td>Training</td>
</tr>
<tr>
<td>Shared Environmental Information Systems</td>
<td>Flexible Employee Assignments</td>
</tr>
<tr>
<td>Joint Regulatory Permitting</td>
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<table>
<thead>
<tr>
<th>Energy</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Green Buildings</td>
<td></td>
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<tr>
<td>Energy Auditing</td>
<td></td>
</tr>
<tr>
<td>Cogeneration</td>
<td></td>
</tr>
<tr>
<td>Spin-off Energy Firms</td>
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<tr>
<td>Alternative Fuels</td>
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</tbody>
</table>
2.4 Benefits of Development in Eco-Industrial Parks

Eco-industrial parks might affect the companies that participate in them, the managers of EIPs, the members of the communities that host them, and the wider community. Each company would realise more benefits than if it optimised its individual performance only. Moreover, EID could bring a lot of benefits to the environment and the communities involved as well [50].

Each EIP member could exchange inputs such as labour, capital, and materials with other members, communities, suppliers and purchasers. The EIP management unit could add value to the production and service functions of members by performing roles that in some way support improvements in the EIP’s efficiency. The local community which includes community government, households, and community businesses that are not members would be the area in which the EIP has the greatest economic, environmental, and sociological impact [70]. Antonopoulos et al. (2013) proposed the determination of the Best Available Technologies (BAT) to be applied by the preparation of a SWOT (strengths, weaknesses, opportunities and threats) analysis report which is used for the investigation of common problems and weaknesses of the industrial areas and for the identification of the required steps towards sustainability [32]. The entire methodological approach is indicated in Figure 2.6.

<table>
<thead>
<tr>
<th>Data mining procedure</th>
<th>Findings</th>
<th>Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislation</td>
<td>Existing BAT</td>
<td>Required steps towards sustainability</td>
</tr>
<tr>
<td>Environmental management of industrial areas</td>
<td>SWOT analysis</td>
<td>Appropriate networks in line with IS</td>
</tr>
<tr>
<td>Infrastructure and centralized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental and architectural quality of the buildings:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Composition of economic, social and environmental activities

**Figure 2.6 Methodological approach for industrial areas towards sustainability[32]**
2.4.1 Benefits to industry / business

For the enterprises involved, an EIP offers the opportunity to cut down production losses through enhanced materials and energy efficiency, waste reuse and recycling, and elimination of practices that attract regulatory or legal penalties [50]. Increased efficiency may also enable industrial park members to produce more competitive products. Additionally, some common business services may be supported by firms in the same park. These may include shared waste management, training, marketing, emergency handling groups, environmental information systems, and other support services. Such industrial cost sharing could help industrial park members gain greater economic efficiency through their cooperation.

For small and medium size firms, the integrative approach of EID can support them in overcoming barriers and gaining access to investments. To obtain investment, they may be required to improve performance, but to improve performance they often have a problem in gaining access to information, consultation and know-how [71]. These benefits for participating companies may possibly increase the value of the property for the private or public real estate developers. The services generate new remunerations for IP management companies.

2.4.2 Benefits to the environment

Eco-industrial parks will reduce many sources of pollution and waste, as well as lower demand for natural resources [3]. The site’s tenants will reduce their environmental responsibility through more innovative approaches to cleaner production. These include pollution prevention, energy efficiency, water management, resource recovery, and other environmental management systems and technologies. Decisions about an EIP’s siting, infrastructure, and recruitment objectives will be reached in the context of the limitations of local handling capacity and ecological characteristics of potential sites. Each EIP will serve as a working exemplar for park developers and managers to learn how to improve their weakness while facing high environmental and social standards.

2.4.3 Benefits to society / communities

The enhanced economic performance of participating businesses will make EIPs a powerful economic development tool for communities. The parks would be able to attract leading-edge corporations and open new channels or expanded local ventures. Both will create new jobs in much cleaner industrial facilities [50]. Companies in the region will gain new clients for services and buyers for products in the new firms in a park. EID will
create programs for extending their economic and environmental benefits across a community’s whole industrial sector.

As environmental regulations and community pressures increase, industries will be devoted to proactive strategies that address those concerns, including EID. The benefits to communities and businesses from adopting EID strategies are diversified, depending on the local conditions. Moreover, a high quality of life would be significant in attracting and keeping a skilled workforce. Likewise, reductions in environmental emissions such as air and water can lead to improvements in the quality of life for residents. In these ways, EIPs abroad have helped to improve community-industry relations [72].

2.5 Global Trends in Eco-Industrial Development

Eco-industrial parks have been found to be most efficient when there is incorporation or clustering of companies to make use of waste as a resource. This relationship generates externality reserves by cutting operation costs and encourages innovation in the evolution of new industries [57, 58]. Eventually, flexible designing is required in order to propose an overall strategy to produce the most effective combination of industries, technologies, skills, experiences, resources and legal rules, as well as incentives to encourage cooperation [57, 58].

2.5.1 Brief history of Eco-Industrial Developments

The “Eco-” in eco-industrial parks refers to a basic EIP theory: design the park in relation to the quality of its local and regional ecosystem. “Eco-” also refers to the other traditional pillar: that the development concept must include the resources and needs of the local and regional economy [50]. Both meanings support the demand for working in an enquiry mode when planning an EIP. Lessons from the experience of other countries and communities are applied to develop other EIPs. However, the eco-strategy needs to seek the most reasonable solutions for a specific site and community within the broad principles of industrial ecology, sustainable planning, architecture and construction. The literature [57, 58, 73-77] lists a variety of drivers for the development of EIPs, including financial considerations, the desire to increase competitive advantage, ‘locational’ factors and government policies and legislation. Desrochers (2004) concludes that industrial recycling networks have arisen to decrease total costs of waste treatment and disposal, to obtain lower charges for materials and energy, and to generate income from residues [76]. The researcher also commented that competitive pressures would motivate firms to search
for plans to reduce waste or to extract benefits from it. Seuring (2001) suggested that enlarged competition on the international market has been one of the key drivers for the establishment of EIPs [74]. Similarly, investigation by Van Hemel and Cramer (2002) of 77 Dutch small and medium sized enterprises (SMEs) concluded that innovation opportunities, the potentiality to increase the quality of product and find new markets were the most influential internal drivers for eco-planning [75]. Alternatively, customer demands, government regulation and industrial sector originations were the major external stimulators [75].

2.5.2 Past and present Eco-Industrial Development projects in the world

Different aspects of EID can be found all over the world. In the following, some examples for EIP projects are presented and briefly described in order to show practical implementation of the different approaches. As a detailed description is not possible in this context, references for further information are added.

a) Eco-industrial parks in the United States of America (USA)

Many planned EIPs in the USA were initiated following the U.S. President’s Council on Sustainable Development in the 1990s [77]. According to research published in 2015, of the 15 planned EIPs, four are open, four have failed, and 7 remain as planned [77]. Success is debatable even among the projects identified as open. All of these projects have experienced setbacks such as a change in scope of project, failure to meet defined objectives, and financial difficulties. Table 2.5 shows the characteristics of some eco-industrial parks in the USA.

Table 2.5 Eco-industrial parks in the USA.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Port of Cape Charles Sustainable Technologies Industrial Park -- Cape Charles, Virginia [78]</td>
<td>The park was designed as part of a comprehensive Sustainable Development Action Strategy. The EIP incorporated industrial ecology linkages such as recycled water and by-product exchanges.</td>
</tr>
<tr>
<td>2. Fairfield Ecological Industrial Park, Baltimore, Maryland [1, 62]</td>
<td>Transformation of an existing industrial area with over 1300 acres zoned for heavy industry and approximately 60 operating companies. The site’s superior port, rail, and interstate access were intended to maximise the intermodal transit of raw materials.</td>
</tr>
<tr>
<td>Sites</td>
<td>Characteristics</td>
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</tbody>
</table>
| materials and waste streams, which facilitates the creation of an industrial "closed loop" production process. | 3. Brownsville Eco-Industrial Park, Texas [1, 62]  
Regional or virtual approach to waste exchange based on a regional approach to materials exchange that included connections to small businesses and agriculture. |
| Inner city, small scale green business incubator, with 600 industrial companies in the vicinity of its 3.5 acre site. The project has been used to promote material and energy exchanges among these existing companies and to focus the tenant recruitment and business development efforts of the Green Institute's incubator program. The building remains in use but it lost a key tenant in 2011 and no longer fits the definition of an EIP well [79]. | 4. Green Institute Eco-Industrial Park, Minneapolis, Minnesota [77]  
Four alternative waste processing companies operating under environmental schemata. The anchor for this EIP was a resource recovery cluster encompassing reuse, recycling, remanufacturing, and composting companies. |
| A residential, office, and retail model supporting green tech and consulting groups. | 5. East Shore Eco-Industrial Park, Oakland, California [80]  
The park within a second growth forest, focused on recycling of solid and liquid wastes. The site encompasses the entire upper drainage basin of Butte Creek, thus the water quality within the site can be uniquely managed. |
| 6. Coffee Creek Center, Chesterton, Indiana [60]  
7. Raymond Eco-Industrial Park, Washington [60] |
b) Eco-industrial Parks in Canada [81]

By the 1950s, larger industrial estates were being planned and developed in the USA and Canada [82]. Several EIPs already exist in Canada and a number of potential sites that have significant EIP potential have been identified [83]. The successful project -- Bruce Energy Centre was championed by Integrated Energy Development Corporation, a local industrial firm [83]. The project established waste linkage in the park involving the use of carbon dioxide from the fermentation plant in their agricultural process. It has resulted in substantial savings for the firms involved, an increase in local jobs and environmental benefits. Another successful project was described in a study conducted on firms located in Toronto’s Portland Industrial District. The research team recommended locating a carpet manufacturer in the area to take benefit of the plastic output collected and sorted at the local Municipal Recycling Facility [83]. There is also significant potential for a gas fired cogeneration facility in the area that would supply electricity to the downtown core of Toronto and steam to the local industries and for new district heating developments. Table 2.6 shows the characteristics of some EIPs in the Canada.

Table 2.6 Eco-industrial parks in the Canada. [72]

<table>
<thead>
<tr>
<th>Sites</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Burnside Industrial Park, in Halifax, Nova Scotia</td>
<td>Research and development subject of a university with cooperative partnerships among academic, government, owners, developers, and tenants.; creation of materials and energy cycles, imbedding into the natural environment, renewable energy use, information centre, communication loops.</td>
</tr>
<tr>
<td>2. Sarnia, Ontario</td>
<td>Industrial symbiosis between oil refineries, a synthetic rubber plant, petrochemical facilities and a steam electrical generation station.</td>
</tr>
<tr>
<td>3. Bruce Energy Centre, Ontario</td>
<td>Park organised around a nuclear power station in order to use its waste heat and steam generation capacity for processes such as dehydration, concentration, distillation etc.</td>
</tr>
<tr>
<td>4. Portland Industrial District, Toronto</td>
<td>Research and development on an industrial area involving enterprises in a variety of sectors in</td>
</tr>
</tbody>
</table>
manufacturing and services with the potential of material and energy exchange.

c) Eco-Industrial Park projects in other industrial countries
Table 2.7 shows the characteristics of some EIPs in other industrial countries.

**Table 2.7 Eco-industrial parks in other industrial countries.**

<table>
<thead>
<tr>
<th>Sites</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalundborg, Denmark [1]</td>
<td>Highly evolved industrial symbiosis, characterised by a network of inter-firm material exchanges and energy cascades. The main exchanges include water, heat, steam, fly ash and scrubber sludge - developed during the past 25 years without influence from outside.</td>
</tr>
<tr>
<td>Rotterdam Harbour Industrial Ecology Project, Netherlands [1]</td>
<td>Project to explore the potential of creating by-product exchange amongst 60 companies; training for participating companies.</td>
</tr>
<tr>
<td>Coolum Eco Industrial Park, Queensland Australia [84]</td>
<td>The largest sustainable industrial estate in Australia. It started as a new central agency in April 2012. The park has been awarded the maximum six leaf enviro-development certification from the Urban Development Institute of Australia (UDIA). The accreditation acknowledges the significant sustainability standards the park has achieved in the areas of: Ecosystems, Waste, Energy, Materials, Water, and Community.</td>
</tr>
<tr>
<td>Fujisawa Factory Eco-Industrial Park, Japan [62]</td>
<td>Combination of industrial, commercial, components, agricultural, residential and recreational, including technologies and features in energy conservation and cascading, renewable energies, solar greenhouses, waste water treatment</td>
</tr>
<tr>
<td>Sites</td>
<td>Characteristics</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Six industrial parks or complexes, Korea</td>
<td>using wetlands and reuse of treated water, reuse and recycling of materials etc.</td>
</tr>
<tr>
<td>1. Banwol and Siwha, Seoul</td>
<td>The Korea National Cleaner Production Center (KNCPC) and the Korea Institute of Industrial Technology (KITECH) started a 15-year, 3-phase project in 2006. The initiative links cleaner production and industrial ecology, seeking a comprehensive approach to improving environmental, social, and business performance in Korean industry.</td>
</tr>
<tr>
<td>2. Mipo and Onsan, Ulsan</td>
<td></td>
</tr>
<tr>
<td>3. Yeousu</td>
<td></td>
</tr>
<tr>
<td>4. Cheongju</td>
<td></td>
</tr>
<tr>
<td>5. Machun, Chilso and Sangpyeong in Jinhae, Haman and Jinju</td>
<td></td>
</tr>
<tr>
<td>6. Pohang [3, 85]</td>
<td></td>
</tr>
<tr>
<td>Tianjin Economic-Technological Development Area (TEDA), China [86]</td>
<td>TEDA is the largest industrial zone in China [87]. A combined industrial and residential project has transformed itself into one of the top three national eco-industrial parks in China. A network of 81 inter-firm symbiotic relationships formed in TEDA involves the utility, automobile, electronics, biotechnology, food and beverage, and resource recovery clusters.</td>
</tr>
<tr>
<td>Industrial parks or complexes, China [88-90]</td>
<td>The EIP concept was introduced to China in the late 1990s, and research capacity on related topics has been developing quickly, including EID theory [91, 92], design [93, 94], functions [95], framework [96], and modes [97]. Mathematical modeling of existing EIPs has included models of the input and output of material and energy flows among the industrial units, as well optimisation models for the economy and the environment.</td>
</tr>
</tbody>
</table>

Chiu and Yong (2004) [35] presented the difference between industrial ecology in the developing and developed countries in their case in Asian developing countries (ADCs) as follow:
Firstly, there are severe environmental problems and threats in these developing economies and they are rapidly becoming more severe, because unsustainable economic growth has been and continues to be speedy, resources are lacking and the population is increasing while poverty continues to be among the major problems of economic and social development.

Secondly, new perspectives and approaches are needed in ADCs to reduce the environmental burden of rapid economic expansion. Industrial ecology has emerged as such a potential practical approach during recent years.

Thirdly, it is important for the developing countries to try to avoid what seems to be the usual way of interpreting industrial ecology in the literature. As a technical tool or practical technique that is only used within the dominant economic model. Instead of such instrumental, end-of-pipe or clean-up efforts, industrial ecology must be used as the basic strategy of holistic and preventive national economic development of ADCs.

They argued that in developed countries, the environmental and sustainability concerns were perceived as being in conflict with the economic aims and prosperity, or they were not acknowledged at all. In other words, the economic value creation was partly seen as something to which environmental protection cannot be integrated. If ADCs adopt industrial ecology as the basic philosophy of economic development, it may be possible for ADCs to leapfrog and avoid the era of the kinds of economic expansion that rapidly increase the burdens on human health and on the broader environment. Some EID initiatives in various countries are listed in Table 2.8.
<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Projects</th>
<th>Location of some EID initiatives</th>
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<tbody>
<tr>
<td><strong>Developed Country</strong></td>
<td></td>
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<tr>
<td>Australia</td>
<td>3</td>
<td>Shenton Sustainability Park, Synergy Park Brisbane [35] , Coolum Eco Industrial Park [84]</td>
</tr>
<tr>
<td>Canada</td>
<td>4</td>
<td>Burnside Industrial Park, Sarnia Ontario, Bruce Energy Centre Ontario, Portland Industrial District Toronto [72]</td>
</tr>
<tr>
<td>Germany</td>
<td>4</td>
<td>The Bayer Chemical Park at Leverkusen, The Chemical Park Krefeld-Uerdingen [98], Value park, Schkopau [99]</td>
</tr>
<tr>
<td>Japan</td>
<td>26</td>
<td>Kitakyushu, Itabashi, Fujisawa, Toyota city, etc. [65]</td>
</tr>
<tr>
<td>Korea</td>
<td>6</td>
<td>Daedok Technovalley (DTV) Development Project [35, 100]</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>9</td>
<td>Crewe green business park, Dyfi eco-park, Green Park in Cornwall, Ecotech in Swaffham, etc. [98]</td>
</tr>
<tr>
<td>United States</td>
<td>35 projects have been identified, about 4 are operational with completed projects</td>
<td>Port of Cape Charles Sustainable Technologies Industrial Park at Cape Charles Virginia, Fairfield Ecological Industrial Park at Baltimore Maryland, etc. [77, 101]</td>
</tr>
<tr>
<td><strong>Developing Country</strong></td>
<td></td>
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</tr>
<tr>
<td>China</td>
<td>15 national demonstration EIPs and 45 national trial EIPs</td>
<td>Dalian, Yantai, Soo Chow, Tianjin, Guiping, Yixing,Taihu, Shanghai, Chong Yuan, Guiyang and Jiangsu, etc. [102]</td>
</tr>
<tr>
<td>Philippines</td>
<td>6</td>
<td>Laguna International Industrial Park, Light Industry and Science Park, Carmelray Industrial Park, LIMA, Laguna Technopark, Philippines</td>
</tr>
<tr>
<td>Country</td>
<td>Number of Projects</td>
<td>Location of some EID initiatives</td>
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<tr>
<td>National Oil Company Petrochem Industrial Park, Clean City Center project (USAID) [35]</td>
<td>National Oil Company Petrochem Industrial Park, Clean City Center project (USAID) [35]</td>
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<tr>
<td>Indonesia</td>
<td>3</td>
<td>Lingkungan (LIK), Tangerang; Semarang; Industri Sona Maris [35]</td>
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<tr>
<td>India</td>
<td>9</td>
<td>Nacharam, Mallapur, Shamshabad, Patancheru, etc. [103-105]</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1</td>
<td>BioXcell Ecosystem Industrial Park in Nusa Jaya [106]</td>
</tr>
<tr>
<td>Singapore</td>
<td>1</td>
<td>Jurong Island Industrial Park [107]</td>
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<tr>
<td>ADB supported major policy studies in 2002 [35]</td>
<td>ADB supported major policy studies in 2002 [35]</td>
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<tr>
<td>Taiwan</td>
<td>3</td>
<td>Tainan Technology and Industrial Park, Changhua Coastal Industrial Park; CSS II (Corporate Synergy System II) projects, Hua Lian and Kaohsiung [35]</td>
</tr>
<tr>
<td>Thailand</td>
<td>41 (Planning stage)</td>
<td>I-EA-T and DIW plans (See Chapter Three)</td>
</tr>
<tr>
<td>Vietnam</td>
<td>3 pilot EIPs</td>
<td>Khanh Phu in Ninh Binh, Hoa Khanh in Da Nang, and Tra Noc 1 and Tra Noc 2 in Can Tho [108]</td>
</tr>
</tbody>
</table>

Since each country is at a different stage of environmental policy especially in the focus on industrial ecology and regulatory development, the themes analysed in the EIP literature are listed in Table 2.9.
In addition, other aspects could be studied further, such as the organisational variables that favour or limit the implementation of such a management system, and the integration of the system into the management of a firm. The sector of activity and firm size conceivably condition the development of this management system. Finally, it would be interesting to study in more detail the process of technological and organisational innovation unleashed as a consequence of the improvement in the working conditions, as

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<td>Inter-firm interaction</td>
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<td>Social benefits</td>
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<tr>
<td>Definition</td>
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<tr>
<td>Initiative</td>
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<td>Waste/material recycling</td>
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<tr>
<td>Supply chains</td>
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<td>SWOT</td>
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<tr>
<td>Ecology</td>
<td>✓</td>
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<tr>
<td>potential</td>
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</tbody>
</table>
well as the EIP valuation and quantification of the effects of the safety management system.

### 2.5.3 Research into Eco-Industrial Park in industrialised countries

Several articles are available that discuss EID in different countries, regions, or business sectors. Table 2.10 presents some of the research areas identified in different areas.

#### Table 2.10 Topics investigated in EIP research studies.

<table>
<thead>
<tr>
<th>Country / References</th>
<th>Methods</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>The research identified a total of 34 EIPs in the USA.</td>
<td>The key problems and dilemmas that arise in the course of developing EIPs.</td>
</tr>
<tr>
<td>Gibbs, D., &amp; Deutz, P. (2005). <em>Implementing industrial ecology? Planning for eco-industrial parks in the USA</em>. Geoforum, 36(4), 452-464. [101]</td>
<td>The research was in two phases. An initial phase obtained basic background information through an email, fax and telephone survey. Next, they conducted in-depth face-to-face interviews, reliant upon secondary information. Semi-structured and open-ended interviews were conducted with a range of stakeholders.</td>
<td>The policy process explored in detail, the problems/barriers that have been encountered, the nature and extent of inter-firm interaction, issues of raising funding from investors and the role of local public and private institutions, as well as the environmental, economic and social benefits that have accrued.</td>
</tr>
<tr>
<td>Veleva, V., et al., (2015). <em>Understanding and addressing business needs and sustainability challenges: lessons from Devens eco-industrial park</em>. Journal of Cleaner</td>
<td>The study reports on key business needs and sustainability challenges of local organisations based on 29 interviews with local organisations (30% participation rate) from</td>
<td>The access to infrastructure such as rail, green buildings and roads was the most important factor followed by the lower cost of real estate and tax benefits. Top two sustainability challenges for companies</td>
</tr>
<tr>
<td>Country / References</td>
<td>Methods</td>
<td>Topics</td>
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<tr>
<td>USA / Canada</td>
<td>Literature reviews of some of the North America, European and Japanese experience in establishing EIPs and describes a number of initiatives, particularly in the USA and Canada.</td>
<td>Some of the definitions of EIPs, discussion of their characteristics, examples of guidelines based on 11 characteristics proposed by a number of authors.</td>
</tr>
<tr>
<td>USA / Europe</td>
<td>Analysis of result and experiences of Japan’s key effort to foster Eco-Town Program (the current set of 26 Eco-Towns).</td>
<td>Approximately 1.65 billion USD was invested in 61 innovative recycling projects, with an average government subsidy of 36%. In addition at least 107 other recycling facilities have been constructed without government subsidy. 14</td>
</tr>
<tr>
<td>Japan</td>
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<tr>
<td>Country / References</td>
<td>Methods</td>
<td>Topics</td>
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<tr>
<td><strong>Eco-Towns</strong> primarily contributed to improving industry's productivity, whilst 10 Eco-Towns primarily contributed to improving environmental amenity.</td>
<td></td>
<td></td>
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<tr>
<td><strong>China</strong></td>
<td>Literature review on a range of case studies (13 potential EIPs, one demonstration city, and one demonstration province for state-level circular economy; CE).</td>
<td>Provide a synthesis of the type and scale of experimental eco-industrial development; supply chains and symbioses in EID and the CE; and major constraints to EID.</td>
</tr>
<tr>
<td>Fang, Y., Cote, R. P., &amp; Qin, R. (2007). <em>Industrial sustainability in China: Practice and prospects for eco-industrial development.</em> Journal of Environmental Management, 83(3), 315-328. [110]</td>
<td>In-depth investigation of enterprises and the government in Rizhao Economic and Technology Development Area (REDA), three stages (1991–2002, 2003–2006, 2007–2011) of industrial symbiosis development were identified, 31 inter-firms symbiosis performances were formed since REDA was founded in 1991.</td>
<td>This article provides some unique characteristics of industrial symbiosis growth from enterprises and government aspects. The environmental benefits of industrial symbiosis performances, economic benefits, mainly resulted from stricter environmental standards, tax preference, benefits from material substitution, and financial subsidies were the critical driver for the stakeholders.</td>
</tr>
<tr>
<td>Country / References</td>
<td>Methods</td>
<td>Topics</td>
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</tr>
<tr>
<td><strong>Australia</strong></td>
<td>Research undertaken to investigate the application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: an Australian case study.</td>
<td>Develop a set of principles and planning guidelines for use by governments to facilitate the development of EIPs.</td>
</tr>
<tr>
<td><strong>Worldwide</strong></td>
<td>The comprehensive reviews, innovative policies, metrics and indicators, tools and methods and the implementation of sustainable production and consumption were analysed from forty-one articles to address both local environmental quality and global impacts and ways to track the improvements through the governance framework.</td>
<td>The tangible benefits can be achieved from initiatives performed at both local and national levels. The results and recommendations provide critical insights on how to promote innovative EID within different contexts. A wide array of expertise, experiences and lessons were reviewed and are contained in the articles so that the global EID practitioners can learn and share them.</td>
</tr>
</tbody>
</table>

Geng et al. (2016) commented that many countries are actively promoting eco-industrial development by enacting new regulations, initiating pilot projects, providing financial help, supporting research and development and by organising capacity-building activities...
For example, as the largest developing country, China developed and implemented the ‘National Circular Economy Promotion Law’, in 2008 and the ‘Cleaner Production Promotion Law’, in 2003. This used as a national policy to strive to achieve ecological civilisation as a national development strategy [112]. Japan has implemented eco-town projects since 1997 and has supported low carbon development since the 2011 which known as Fukushima crisis [113]. South Korea has operated an ambitious fifteen-year, three-phase EIP project under the leadership of the Korea Industrial Complex Corporation (KICOX) since 2005, and released their “low carbon green growth vision” in August 2008 in order to nurture green industry as a new growth engine through the development and diffusion of environmentally friendly technologies [114]. While the most well-known EIP [62], Kalundborg Park in Denmark, has its critics, it has clearly inspired a wide range of projects in a number of countries. Gibbs and Deutz (2005) insisted on this idea in their research in 34 EIPs of the USA [101]. They showed that the idea of making industrial ecology operational through EID is at an early stage of development. Yet in 2007, they identified EIPs in the USA and Europe. Using in-depth interview surveys of 16 EIPs, they discovered few examples of networking between firms or of processes using wastes and materials recycling. Agarwal and Strachan (2006) also suggested that there is very limited literature available that can guide the evaluation of industrial symbiosis initiatives [66]. 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 the 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 industrial ecology 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 [115]. The literature and commentators in the field have identified several criteria that are complimentary or contradictory to each other in order to evaluate the success of industrial symbiosis projects. Although every IS project is quite different from others, it is necessary to develop a set of generic criteria for evaluating their success.

Despite this lack of generic criteria, Chiu and Yong (2004) argue that there is some encouraging evidence that EIPs are beginning to yield positive benefits in the ADCs [35].
However, very few Asian studies have been reported in international scientific refereed journals. Hence, industrial ecology is usually presented in instructional materials and projects in Asian settings, instead of being presented in in-depth research studies.

The number of “Eco-Industrial Park” papers published in peer reviewed journals/books/online database increased more than seven-fold from the year 2000 to 2012 (See Figure 2.7). Subsequently, there was a slight decrease in the number of papers published after the year 2012. It is not yet known whether the number of articles in 2013-2015 is an outlier, but in general it is expected to continue to rise at least in the short to medium term (2-5 years) given the trajectory. Simultaneously, there is a similar trend in the number of articles using the word eco-industrial park in the title from the year 2000 until the year 2007. Then, there is a fluctuation and decline from 2010 to the present.

Figure 2.8 shows the publication of “Industrial ecology” papers over time and differentiates whether these articles appeared in journals or other sources. The number of industrial ecology papers published jumped from 1,000 papers in the year 2000 to 5,000 papers in 2012. In contrast, the papers which have “Industrial ecology” in the title decreased from 110 papers in 2003 to 60 papers in 2015. This finding reveals that more industrial ecology related research has emerged in a wider range of articles not just those focused on industrial ecology, indicating that industrial ecology research is reaching a broader readership. There is very little published literature that examines the relationship between the social, economic and industrial contexts in Thailand and the planned industrial areas.
Figure 2.7 Papers published with the words “Eco-Industrial Park” in the topic, abstract, keywords or in-text and in the topic.  
Figure 2.8 Papers published with the words “Industrial ecology” in the topic, abstract, keywords or in-text and in the topic. (2000–2016)

Source: Google Scholar, May 2016
The gaps in our knowledge about eco-industrial projects can be summarised as follows:

1. Eco-industrial seeks radical improvements. Much attention has been paid to innovation as a way for industry and policy makers to work towards more radical and systemic improvements in environmental performance. The term eco-industrial always underlines the positive contribution that industry can make to sustainable development and a competitive economy. Nevertheless, not every EIP project has been successfully implemented or sustained.

2. On the existing literature, EIP can be understood and recognised according to its targets (the main focus), its mechanisms (methods/strategies/criteria/stakeholders for implementing businesses to achieve the purpose) and its results (the benefits on environmental conditions). However, their innovative component in some EIPs is sometimes unclear. Thus, various strategies should be suggested as an alternative way in order to increase the efficiency of businesses realise environmental benefits.

3. Sustainable manufacturing involves changes that are facilitated by EIPs. Integrated initiatives such as by-product exchange can potentially enhance environmental improvement; however, it also requires appropriately combining a wide range of innovation targets and mechanisms. These targets and mechanisms have not yet been developed.

4. An appropriate combination of existing sets of indicators can help firms gain a more comprehensive opportunity for environmental effects across their benefit and product lifecycle. However, there is not yet a set of clear and consistent sustainable manufacturing indicators.

5. No existing measurement approach can clearly capture the overall trends and characteristics of EIPs. Further progress in benchmarking and indicators might include the development of an “eco-industrial mechanisms” which would combine different statistics or the design of a new dedicated survey. These could help improve understanding of the nature, drivers/barriers and impacts of EIPs and raise awareness among policy makers and industry.

6. Creating successful EIP policy requires more understanding of the interaction of supply and demand. The countries surveyed do not all have a specific eco-strategy, although various policy initiatives and programmes promote EIPs. While these include both supply-side and demand-side measures, a fuller understanding of the interaction of supply and demand for EIPs would help achieve more successful policy mixes.
2.6 Conclusion

The review of literature in this chapter shows that there are many issues that need to be considered to realise a potential EIP. These include location, material flows and waste management, technological innovation, improving the well-being of employees, environmental sustainability, public participation and collaboration. Several reviews of EIPs have shown that while many projects have failed to meet expectations, many EIPs have been successful. The current development of the various EIP pilot projects worldwide demonstrates that industrial ecology and EIP development have great promise for a more sustainable society, and that they could be useful to establish a new international standard in industry development. The lessons learnt from successful EIP cases can be used to help motivate other companies to follow their success. An ongoing international comparison of EIP projects could further help stimulate governments and companies to initiate EIP development projects. This is particularly useful for governments of developing countries such as Thailand, which are undergoing rapid industrial development and wanting to establish EIPs. The next chapter will review the history and progress of EIP development in Thailand.
Chapter Three

Eco-Industrial Park: History and Experiences in Thailand

A version of this chapter has been published as:


My contribution to the published manuscript involved:

- Initial concept and Overview of Eco-Industrial Park (EIP)
- Systematic Literature Review of EIP, both in the Global trend and Thai context
- Preparation of manuscript

Kultida Bunjongsiri

Corresponding author: Prof. Cordia Chu

Principal supervisor: Prof. Cordia Chu and Dr. Sunil Herat

In order to comply with copyright this article is not published here.
3.1 Introduction

The previous chapter provided an extensive literature review concerning the nature, purpose, historical development and achievements of EIPs. This chapter will focus on EIP progress which this concept is quite new in Thailand. It has been introduced as a way of achieving sustainable industrial development. Nonetheless, many firms or organisations have misunderstood the concept and treated it with suspicion [116]. The planning and development of an eco-industrial project is a significant challenge for the developers and public agencies in the nation.

This chapter shows the results relevant to the 2nd focus question of this thesis. The chapter starts from a brief overview of Thailand’s demographic and economic profile. It than describes the eco-industrial projects initiated by the government agencies of Thailand and discusses their progress according to concepts and ideas taken from the literature, from government reports as well as the criteria set by Thai government agencies. The chapter concludes by highlighting key issues identified by researchers concerning EIP implementation in Thailand.

3.2 A Brief Demographic and Economic Profile of Thailand

According to the United Nations Statistics Division, the total area of Thailand is 513,120 km² (51,312,000 hectares) [117] divided into 77 provinces. It lies in the middle of mainland Southeast Asia. Its neighbours are Burma (Myanmar) on the north and west, Laos on the north and northeast, Cambodia on the east, and Malaysia on the south. The nation's axial position has influenced many aspects of Thailand's society and culture. It controls the only land route from the rest of Asia to Malaysia and Singapore. During 2016 Thailand’s population was 68,342,659, projected to increase to 68,355,167 at the beginning of 2017. Women and girls comprise just over half of Thailand's population. In 2016, 34,762,996 females accounted for 50.9 percent of the total population while 33,579,664 (49.1 percent) recorded as male population. Thailand’s population density is 132.7 people per km² as of December 2016 [118].

Most of the Thai population lives in rural regions. It is crowded in the rice-growing areas of the central, north-eastern, and northern regions. The population is growing, principally in the Bangkok area. Accurate data are difficult to compile as millions of Thai people migrate from rural areas to the big cities, occasionally returning to their hometown to
support seasonal field work. Officially they have rural residency, but spend most of the year in urban areas.

From the economic perspective, the country's industry and agriculture sectors are ordinarily interrelated. However, the Asian financial crisis from 1997 to 1998 heavily impacted industries and caused 8,000 businesses to shut down. Since then, the manufacturing industry has become the main contributor to the national income, particularly the four sub-sectors of food processing, automobiles, electronics, and petrochemicals.

![Figure 3.1 Thailand geographic](image)

Birth rate: 11.26/1000  
Infant mortality rate: 9.86/1000  
Life expectancy: 74.18  
GDP by sector: Agriculture (8.4%), Industry (39.2%), Services (52.4%) (2012)

**Figure 3.1 Thailand geographic [119]**

The initial move into industrialisation in Thailand started from the 1960s. It was based on import substitution, which mainly involved the processing of its vast agricultural produce. In 1972, a new Industrial Promotion Act shifted government policy to an export-oriented economy. This significant new approach led to the growth of various industries: petrochemicals, textiles, transportation equipment, electronics, iron and steel, and minerals.

The manufacturing sector has become Thailand's main industry, producing a wide variety of goods such as textiles and garments, plastics, footwear, electronics, integrated circuits, computers and components, automobiles and parts, and cement. Most manufacturing facilities are located in Bangkok and on the Eastern Seaboard, which was designated in 1977 as the long-term zone for small, medium, large-scale and heavy industries.

According to the World Bank report, Thailand became an upper-middle income economy in 2011 [120]. Over the last four decades, Thailand has made remarkable progress in
social and economic development, moving from a low-income country to an upper-income country in less than a generation. Thereby, Thailand has been one of the widely mentioned development success cases, with sustained strong growth and impressive poverty reduction, particularly in the 1980s.

Thailand’s economy grew at an average annual rate of 7.5 percent in the late 1980s and early 1990s, creating millions of jobs that helped pull millions of people out of poverty. As of 2013, over 80 percent of the country’s 7.3 million poor live in rural areas. In addition, an additional 6.7 million were living less than 20 percent above the national poverty range and remained vulnerable to falling back into poverty.

The Thai economy faces difficulties: economic growth has been inconspicuous, at 2.8 percent in 2015 after 0.9 percent in 2014, partly on the basis of falling government consumption and investment, and partly on fading exports. The forecast for 2016 is 2.5 percent. There are opportunities in expanding trade through enhanced integration with the global economy, pushing growth by achieving transformative public investments to compete with private capital, stimulate domestic consumption, and improve the quality of public services across the entire country.

Industrial environmental problems can be related to energy use, resource use, water and air pollution, waste generation, environmental risks, biodiversity, transport, and so on. These environmental problems occur within the context of a rapidly changing world including in Thailand. [121]. The following section presents the EIP experiences which have been developed to enhance the environmental performance of industries, particularly in Thailand. Then, it will be followed by a review of recent conceptual innovations on the greening of industry and a brief description of the research about these issues.

3.3 Eco-Industrial Park Development in Thailand

Eco-industrial is a development of the industrial and human sectors along with the conservation of natural resources and the environment. It is concerned about the existence of social and cultural livelihoods. Eco-industrial development is a tool that has been internationally accepted and practiced in a number of countries with effective and concrete outcomes. Since approval of the concept by the Thai cabinet in 2010, eco-industrial projects have been set up in Thailand and development plans have been
regulated at both the national and regional levels. Two main agencies in Thailand have played important roles in different ways: the DIW developed the indicators for eco-industrial development covering the 5 dimensions to use with industrial parks.

In Thailand’s EIP initiative, there was an integrated approach at four policy levels: national level (Eco City / Eco Town), city level (Eco Industrial City / Eco Industrial Town), local level (Eco Industrial Zone/Estate) and factory level (Green factory). In the top–down view, at the national level the sustainable industry strategy assisted in upgrading cities to become environmentally sustainable cities and developing symbiotic networking opportunities in the industrial sector, tourism, services, and operations in other parts. At the city level, the municipality connected with industrial parks, local authorities, and surrounding communities to balance the economic, social, and environmental needs in the area. At the local level, the industrial park is responsible for the management and control of factories in the area. In order to serve the vision of the industrial zone, several environmentally related projects have been planned including (1) the Environmental Good Governance Project, (2) the Quality Factory Initiative, (3) the Green Industry Initiative, and (4) projects providing environmental knowledge to industry and the community. Finally, at the factory level, it is important to consider the critical role of the different sectors in terms of participating in and supporting the industrial network. Different sectors involved include communities, temples, households, schools, etc., where activities to reduce environmental impacts can be undertaken. The industrial ecology concept has recognized more complex interactions among community, industrial park, and individual factories, as it requires more complicated systems and shared support services [122]. EIP programs in the Thai initiative attempted to apply industrial ecology principles on the overall development from the national level to the factory level. The government managed the developmental activities, i.e. Eco meeting, project mentors and action plan for short-, medium- and long-term plans. In the bottom-up view, practically, the project should start from the development at the factory level, where the premises are located within the same zone/estate, moving towards the interconnection among factories within the same area and then expanding to different parks within the same district and further to the same province. The participation of all stakeholders is the key that can drive and sustain eco-industrial park development in the longer term. Table 3.2 shows the Hierarchy of eco-industrial development in Thailand.
To protect the environment from the adverse effects of pollution, many nations worldwide have enacted legislation to regulate various types of pollution as well as to mitigate the adverse effects of pollution. In environmentally aware societies, EID has received wide interest but with varying approaches. The cultural backgrounds and developmental experiences of the implementation of industrial estates in other countries may explain the different understandings of environmental sustainability, both as a policy tool and as a theoretical construct, especially in regard to EID.

Most industrial estates or industrial parks in Thailand are at a very early stage of development, where linkages are potential rather than real. The main ministry which is responsible for the promotion and regulation of industries is the Ministry of Industry. The development of EIPs has also received support from several authorities which are directly related to industry, such as the 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.
3.3.1.1 The development of Eco-Industrial projects by the Industrial Estate Authority of Thailand

When the concept of eco-industrial park emerged in Thailand in the 2000s, the subject of green factories or urban systems was at the first largely absent. In the year 2000, the I-EA-T was the first development agency to implement the concept of sustainable industrial development based on the principles of ecology. The project was named Development of Eco-Industrial Estates and Networks Project: DEE + NET under the collaboration of I-EA-T and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) of Germany [50, 123, 124].

The project, which operated October 2001 – June 2004, followed a multi-sectoral approach with its activities focussing on three areas: (1) development of the policy framework according to eco-industrial principles, (2) institutional capacity development for eco-industrial estate management and (3) implementation of pilot initiatives in selected industrial estates. The project’s aim was to develop the capacity of industrial estate developers, estate operators and enterprises in 5 selected (out of 29) industrial estates in the country – Map Ta Phut, Bang Poo, Northern Region Industrial Estate, Eastern Seaboard Industrial Estate, Amata Nakhon Industrial Estate – to apply the eco-industrial development approach to develop their businesses. The project’s activities were conducting studies, training and the development of concepts, training material and website contents among stakeholders. The formation of Eco-Forums in the Industrial Estates, the reduced number of complaints by residents and the integration of the principles of EID into the Industrial Development Plan of the Ministry of Industry and the national Economic and Social Development Plan have to be noted as significant successes of the DEE+Net Project [125].

In 2000, the Ministry of Industry also organised a workshop, Going Green to Eco-industrial park, to determine the direction of 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 determine criteria to measure the 5 dimensions and 24 indicators of EID. The key highlights were the announcement of intention of the meeting participants to work together to develop a sustainable industry in the future, and the signing of a memorandum of collaboration between the public and private sectors.
In the same year, the I-EA-T launched an eco-industrial project to transform three pilot industrial estates - Bang Pu Industrial Estate, Northern Industrial Estate and Eastern Seaboard Industrial Estate into eco-industrial estates.

In 2011, the I-EA-T made a Draft of Specification Standards for eco-industrial towns based on the development guidelines of 5 dimensions with 22 aspects as the indicators (developed from the former 24 indicators, See details in Table 3.1) [126]

In the same year, the I-EA-T launched a project to turn three more pilot industrial estates - Laem Chabang Industrial Estate, Amata Nakorn Industrial Estate and Nong Khae Industrial Estate – into eco-industrial estates & network. This included 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 (including Map Ta Phut Industrial Estate, Asia Industrial Estate, R.I.L. Industrial Estate, Eastern Hemaraj Industrial Estate and Port of Map Ta Phut) to eco-industrial estates.

In 2012, the I-EA-T reviewed the specification of indicators to drive the eco-industrial city. At that time, there were various factors such as the green industrial policy launched by the Ministry of Industry which affected the situation. The review aimed (1) to summarise the academic data and case studies, both international and in-country, about the development of eco-industrial cities to develop the first draft of the specification criteria and indicators; (2) to mobilise experts in various fields to develop the criteria and create indicators for a company to access an eco-industrial city; (3) to determine the criteria, the target values and indicators in each dimension to set the standards in the eco-industrial city; (4) to provide instruction about indicators and the assessment criteria of an eco-industrial city.

On 2012, the I-EA-T with the Petroleum Authority of Thailand jointly launched the PTT Eco-Industrial Park (PTT ECO-IP) for sustainable co-habitation [127]. The Petroleum Authority of Thailand (PTT) planned to develop a pilot Eco-Town industrial project on 192 hectares of its land in the Asia Industrial Estate located in Map Ta Phut in Rayong province. In the same year three more pilot industrial estates were launched at Banchan Industrial Estate, Samut Sakhon Industrial Estate and Amata City Industrial Estate.

In 2013, 12 industrial estates out of the 36 industrial estates in the country were in the process of becoming eco-industrial cities, including Bang Pu, North, Eastern Seaboard, Laem Chabang, Amata Nakhon, Nong Khae, Samut Sakhon, Bang Chan, Amata City,
Lat Krabang, Bang Plee, and Bang Pa-in. Six of the twelve industrial estates have passed the I-EA-T’s assessment to be “Eco-Champions” including North, Nong Khae, Laem Chabang, Bang Chan, Samut Sakhon and Amata City.

For 2014, I-EA-T set plans to turn four industrial estates into eco-industrial cities, including South (Songkhla province), Gateway City, Sin Sakhon, and those in the Map Ta Phut Complex (Map Ta Phut, Pha Daeng, Asia, East and R.I.L.). In addition, the I-EA-T launched the project called “Eco Symbiosis” to promote cooperation in line with the eco-industrial city master plan and the principle of inter-dependency between industrial factories, surrounding communities and the environment. The industrial estates are permitted to submit their Eco Symbiosis projects or activities to a competition.

The judging criteria include creativity, benefits to the communities, sustainability, and cooperation. Most importantly, the project encourages cooperation and unity among the I-EA-T, entrepreneurs in the industrial estates, communities, and local organisations so that they live harmoniously and help one another [128]. The Master Plan Development of eco-industrial estates & networks by I-EA-T is summarised in Figure 3.3.

Note: Eco-Champions*; The industrial estates which promote the economic development of the country can live together peacefully with the communities upon the principle of the good environmental governance. The industrial estates must use the Specification Requirements and the indicators of the Eco Industrial Town in 5 dimensions with 22 sides, which consist of 22 indicators (An indicator refers to the package of indicators which are the major impact of each side of the 5 dimensions) as the standard comparative criterion. This is to designate the issues / directions of the development in the Development Master Plan of the Industrial Estate Alleviation to the Eco Industrial Town [129].
It is important to note however that none of these projects has yet been fully realised. Most are still in the planning stages.

3.3.1.2 The development of Eco-Industrial projects by the Department of Industrial Works [130]

In the year 2010 the Ministry of Industry launched a new policy which includes “the promotion of industry with social responsibility, resources and environmental management in balance”. Part of that policy was Strategy 4.2 “Promotion and support of ecotourism industry (To promote establishment of Eco-Industrial, industrial waste management or complete residue industrial waste management)”. In line with the government’s policy, the DIW promoted pilot projects to develop 7 industrial park zones.
into an eco-industrial scheme in years 2010-2011. In 2010, the DIW launched two pilot industrial park zones for EID in Rojana Industrial Park zones and Bang Kra Dee Industrial Park.

In 2011, the DIW developed 5 dimensions of comprehensive management for industry: physical, economic, environmental, social and managerial. The policy of the Ministry of Industry also focused on the development of the entire operation. A seminar on January 27th, 2011 created the 5 dimensions and 20 aspects (developed from the former 24 aspects) of EID (See details in Table 3.2). In the meeting of the working group to consider indicators for eco-industrial park, the Ministry of Industry requested the group to develop indicators for eco-industrial park that followed the framework of EID to be a mechanism to drive the industry towards sustainable development and to gain competitiveness in the world market.

In 2012, the 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 area-based eco-industrial park projects indicated that each industrial zone has different problems, capacities and needs. The development of eco-industrial park thus requires the identification of the real problems and capacities of each area. In addition, industrial developers have to be the key drivers through the whole process. The developers also need to get full cooperation from all involved in the area, including firms within the premises, communities, public organisations and academic institutions, to monitor and support the move towards eco-industrial park in a sustainable manner [131].

In August 2014, eight industrial parks in six provinces (Ayutthaya, Pathumthani, Chonburi, Saraburi, Rayong and Prachinburi provinces) participated in the grand opening of the eco-industrial town 2014 organised by the Ministry of Industry, Department of Industrial Works. For this purpose, the DIW expanded the target areas to cover several provinces that have high-density industrial areas. With the progress of the operation in the industrial areas of the above six provinces, the eight areas have been set up for a mutual exchange of knowledge and strengthening the development of eco-industrial cities. The totality of EIEs and EIPs projects launched by I-EA-T and DIW since 2010 can be seen in Table 3.1.
Table 3.1 EIEs and EIPs projects launched by I-EA-T and DIW [130, 132]

<table>
<thead>
<tr>
<th>Year</th>
<th>EIEs launched by I-EA-T</th>
<th>EIPs launched by DIW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1. Bang Pu IE, Samut Prakan</td>
<td>1. Rojana IP zones, Ayutthaya</td>
</tr>
<tr>
<td></td>
<td>3. Eastern Seaboard IE, Rayong</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>1. Laem Chabang IE, Chonburi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Amata Nakorn IE, Chonburi</td>
<td>(No project launched by DIW this year)</td>
</tr>
<tr>
<td></td>
<td>3. Nong Khae IE, Saraburi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Samut Sakhon IE, Samut Sakhon</td>
<td>2. Saha Group IP – Kabinburi, Prachinburi</td>
</tr>
<tr>
<td></td>
<td>3. Amata City IE, Rayong</td>
<td>3. IRPC IP, Rayong</td>
</tr>
<tr>
<td>2013</td>
<td>1. Bang Pa – in IE, Ayutthaya</td>
<td>(No project launched by DIW this year)</td>
</tr>
<tr>
<td></td>
<td>2. Bang Plee IE, Samut Prakan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Lad Krabang IE, Bangkok</td>
<td>And the other 9 EIEs as mentioned above</td>
</tr>
<tr>
<td></td>
<td>2. Southern Region IE, Songkhla</td>
<td>2. Bang Kra Dee IP, Pathumthani</td>
</tr>
<tr>
<td></td>
<td>5. IRPC IP, Rayong</td>
<td>5. 304 IP, Prachinburi</td>
</tr>
<tr>
<td></td>
<td>6. I.P.P. Industrial community, Rayong</td>
<td>7. Saha Group IP - Kabinburi, Prachinburi</td>
</tr>
</tbody>
</table>

The timeline of EIEs and EIPs projects launched by I-EA-T and DIW since 2000 can be seen in Figure 3.4.
3.3.2 Strategies for handling and managing Eco-Industrial Park in Thailand

To achieve sustainable development of eco-industrial schemes, the two main departments – the I-EA-T and the DIW under the Ministry of Industry – have set up specification standards for eco-industrial cities. Factories and industrial estates that plan to develop into eco-industrial cities have to meet the eco-criteria in 5 dimensions and 22 aspects (I-EA-T) or 20 aspects (DIW).

The responsibilities of the I-EA-T are principally to create and organise industrial estates, grouping together industrial facilities in a synergistic manner. The authority also has the responsibility of decentralisation of industrial activity away from the capital to the outlying provinces of Thailand. The three main roles of the authority are

1) It has absolute ownership and controls directly some of the industrial estates.

2) It forms a partnership with private sector firms in managing some industrial estates.
3) It gains support from the government as a government body for private sector business setting up private industrial estates.

The role and functions of the DIW, however, are to manage corporate industries, including supervising and coordinating industrial business operation activities which are located outside industrial estates [133]. The DIW has been implementing a plan to develop the capability of the government service system by providing the organisation with effective work management to the satisfaction of industrial business operators and the people, under the strategy of environmental and natural resource management, social environmental development, human development promotion and support as well as the strategy of state development.

Both departments have been developing eco-criteria to achieve sustainable EID, but separately. The I-EA-T explained the specifications standard of an eco-industrial city for industrial estates and factories that want to be considered for an eco-industrial city, with 5 dimensions and 22 aspects, while the DIW stated that industrial parks and factories have to perform both in the 5 dimensions and in the 20 aspects. The 5 dimensions of comprehensive management for industry are physical, economic, environmental, social and managerial. An overview of each dimension is given below:

1. The physical dimension aims to achieve a proper landscaping plan for the surrounding area including infrastructure development under the industrial park.

2. The economic dimension 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 dimension is intended to facilitate a better quality of life for people who work in the estate and who live in surrounding communities.

4. The environmental dimension is focused on supporting the efficient use of resources, and effective emissions control 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, eco-efficiency, and environmental monitoring.

5. The managerial dimension aims to organise a systematic management process for the estate and to facilitate continuous improvement. This focuses on collaboration
among stakeholders, maintenance and improvement of the estate's management system, effective management of information and reporting, and continuous improvement in the capability of personnel.

Nevertheless, although the two departments share the same dimensions, there are some differences between them in the composition and development of the 20 or 22 aspects of the 5 dimensions. These can be seen in Table 3.2.

**Table 3.2 Eco-industrial project feature in 20 (22) aspects related to 5 dimensions of development proposed by DIW and I-EA-T [34, 130, 134].**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Department of Industrial Works, DIW (20 aspects)</th>
<th>Industrial Estate Authority of Thailand, I-EA-T (22 aspects)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td>1. Location and space layout</td>
<td>1. Industrial estate area</td>
</tr>
<tr>
<td></td>
<td>2. Building and surrounding area design</td>
<td>2. Public utility and infrastructure systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Buildings of factories in the industrial estate</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
<td>3. The economy of the industry</td>
<td>4. Economy of the industrial sector</td>
</tr>
<tr>
<td></td>
<td>4. The economy of local community</td>
<td>5. Local economy</td>
</tr>
<tr>
<td></td>
<td>5. Marketing</td>
<td>6. Community economy</td>
</tr>
<tr>
<td></td>
<td>6. Transportation and logistics</td>
<td></td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>7. Water management</td>
<td><strong>Eco Efficiency</strong></td>
</tr>
<tr>
<td></td>
<td>10. Energy management</td>
<td><strong>Production process &amp; Product</strong></td>
</tr>
<tr>
<td></td>
<td>12. Production process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. Eco-efficiency</td>
<td><strong>Pollution Control</strong></td>
</tr>
<tr>
<td></td>
<td>15. Environmental monitoring</td>
<td>11. Air pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Noise, odour, dust and smoke pollution and nuisance</td>
</tr>
<tr>
<td>Dimension</td>
<td>Department of Industrial Works, DIW (20 aspects)</td>
<td>Industrial Estate Authority of Thailand, I-EA-T (22 aspects)</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Safety &amp; Health</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Safety &amp; health</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Industrial Symbiosis</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Business linkage/inter-utilisation/ industrial symbiosis management</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>16. Quality of life and society of the surrounding community</td>
<td>16. Quality of life and society of employees</td>
</tr>
<tr>
<td></td>
<td>17. Quality of life and social life of workers</td>
<td>17. Quality of life and society of community around industrial estate</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>18. The management of the involved area</td>
<td>18. Area based cooperative management</td>
</tr>
<tr>
<td></td>
<td>19. Improvement and maintenance of international management system</td>
<td>19. Enhancement of regulations on factory operation</td>
</tr>
<tr>
<td></td>
<td>20. Information and reporting</td>
<td>20. Encouraging factories to apply the international and national management standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21. Promotion of innovation/ novel management tool/ system for application by factories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22. Information disclosure and reporting</td>
</tr>
</tbody>
</table>

Although the eco-criteria in Thailand developed by the two main government agencies are not exactly the same, the major concepts are aiming in same direction. Zoning design, infrastructure systems and other equipment and facilities are supposed to be adequately provided to support industrial operators. Their activities are based on the resources management with the highest possible efficiency and eco-friendliness. However, there is less clarity when it comes to measuring the level of sustainability of a company or the sustainable development. Whilst DIW only specify that industrial parks and factories
have to achieve in both 5 dimensions and 20 aspects of development with at least one aspect of the development dimension. The I-EA-T set up a “Manual of the Assessment of the Eco-Champion Class of the Eco-Industrial town” in June 2014. There are 3 parts of the assessment: [126].

Criterion Part 1: The preliminary requirement of being an EIE shows the readiness to become an EIE. The industrial estate must pass 3 primary requirements.

Criterion Part 2: The 6 compulsory criteria show the responsibility for the impacts arising from the operations of the industrial estate. The industrial estate must meet all 6 compulsory criteria.

Criterion Part 3: The score in the 5 dimensions and 22 aspects shows the potential to lift the industrial estate to the eco-champion class of the EIE. The industrial estate must pass all 47 indicator criteria in 5 dimensions with 22 aspects. There are three levels of the eco-champion class of the “Eco-Industrial town”.

According to the eco-criteria developed by the DIW, the specifications of Criterion 14: health and safety under the environmental dimension to meet the requirement of eco-industrial project status are detailed in Table 3.3.

**Table 3.3 Criterion 14: Health and safety [135]**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Objective</th>
<th>Target values (criteria)</th>
<th>Indicators for outcome evaluation</th>
</tr>
</thead>
</table>
| 14: Health and safety management | To secure the residents from negative impacts of the operation of industry in surrounding area | 1. Industrial Park has good security systems that prevent negative impacts on employees and on the community's health. | 1. Incidence of work-related injury and accident
2. The incidence of disease in the area compared to the national statistic. |
| | | 2. The incidence of disease in the area compared to the national statistic. | Number of severe accidents which affected the community. |
3.4 Research in Eco-Industrial Development in Thailand

An extensive search reveals that there is very limited literature in Thailand about the actual evaluation of EIPs initiative. There have been only six research projects in total. The first study was conducted by Chavalparit et al. (2006). The research analysed the nature of industrial ecosystems, divided into in-plant ecosystems and external waste exchange between crude palm oil industries and other economic activities [136]. Next, Khwanku and Charmondusit (2009) presented a quantitative technique to assess industrial waste generated from industrial group in the Map Ta Phut Industrial Estate (MTPIE). A quantification diagram of industrial waste in MTPIE was developed to identify the waste characteristics and amount of industrial waste generated [137]. Based on that report, another study was carried out by Charmondusit and Keartpakpraek (2011) [138]. They analysed eco-efficiency trends of the petrochemical group in the Map Ta Phut Industrial Estate by snapshot graph. With the availability of the data on environmental indicators, the water use indicator was selected to be a sample indicator for analysing the eco-efficiency trends of the PP group. The comparison of eco-efficiency values in the three industrial categories in the PP group demonstrates that factories in the downstream category obtained particularly good eco-efficiency results concerning material consumption, water use, and hazardous waste generation. Next, Aruninta (2012) analysed physical design and planning along with environmental measurements such as the Air Pollution Tolerance Index, which can be adapted for pollution protection as best practices of landscape architecture [139]. Panyathanakun et al. (2013) carried out a smaller scale study among stakeholders based on the community-based eco-industrial estate framework [140]. Recently, Teeravaraprug and Podcharathitikull (2016) have determined current problems and success factors for developing eco-Industrial towns in Thailand [141]. The research started with explaining the concept of Eco-industrial towns to stakeholders (participating companies and local residents) and conducting public hearings in order to elicit the problems of being eco-industrial towns. Then, factors affecting the development of eco-industrial town were collected. The results show that the most significant success criterion was management teams of industrial parks or groups, and the second most significant was governmental policies. These studies are compared for the dimensions they examined in Table 3.4.
Table 3.4 Thematic analysis of literature on EIPs in Thailand

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study details</th>
<th>Phy</th>
<th>Eco</th>
<th>Soc</th>
<th>Env</th>
<th>Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khwanku, U. &amp; Charmondusit, K.,(2009) [137]</td>
<td>Framework for quantitative evaluation of waste characteristics and amount of industrial waste generation</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charmondusit, K., &amp; Keartpak-praek, K. (2011) [138]</td>
<td>Eco-efficiency, water, waste and waste materials management</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teeravaraprug, J. &amp; Podcharathitikull, T.,(2016) [141]</td>
<td>Three factors with nine sub-factors were considered and categorised to find the significant success criterion in eco-industrial town development in Thailand.</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Phy = physical, Eco = economic, Soc = social, Env = environmental and Man = management
While current EIPs in Thailand tend to focus primarily on technological advances, organisational or institutional changes have often driven their development and complemented the necessary technological changes. Some advanced stakeholders needed to start adopting new models or alternative modes of provision to find the new way to success in EIPs. Clear and consistent indicators are also needed to accelerate corporate sustainability efforts. Improved benchmarking and better indicators would help deepen understanding of EIPs. Integration of innovation and environmental policies is a crucial part of promoting EIPs mainly through government environmental policies. Presently, the policy has so far not fully addressed environmental issues. Closer integration of innovation and environmental policies could benefit both policy areas and accelerate policy and corporate efforts towards sustainable development.

3.5 Problems Identified in Implementation of Eco-Industrial Park Projects in Thailand

Several problems have been identified in the implementation of EIP in Thailand. Varathorn and Plubcharoensuk (2013) stated that although the Thai Government has announced four national strategies to be applied by various government agencies to move the country forward [142], focusing on enhancing Thailand’s competitiveness for sustainable growth and on reducing the gap between low-income and high-income earners in the country, and emphasising the “green growth economy”, the strategies seem to be applied without considering the local setting. In this regard adjustment would need to be made in all areas, especially in national administration and the networking among various agencies, with the use of national strategies as guidance. All plans would have to be modified to deal with the local setting.

Jampanil et al. (2012) have suggested that eco-industrial development could not be driven by the central government only, but that the relevant local authorities or firms need to be involved [116]. They pointed out the other problems as the data or information of EIPs were not integrated or published. Moreover, there was no public forum or stage to share the information from the national master plan level to the level of each firm’s manager for developing the eco-industrial sector [116]. Panyathanakun et al. (2013) confirmed in their study about EID both at the individual firm level and the industrial estate and networking level [140] that in the wider scope of activities, transforming the traditional industrial estate into an EIE would depend on the support and cooperation of many
participants. Some activities could be carried out independently by firms using their own capabilities, whereas others need support from local and central government, government agencies, the community, and other institutions. However, data is hard to find to determine whether this transformation is happening.

Teeravarapru and Podcharathitikull (2016), in a public hearing study, found that the main problems of becoming an eco-industrial town in Thailand were environmental problems, especially air quality. Stakeholders commented that the main reason for these problems was lack of the governmental monitoring and inefficient law enforcement. The second problem was the physical aspect of heavy traffic in the surrounding community. The third problem was lack of information sharing and reporting among governmental agencies, industries, and surrounding communities. They also identified 9 factors in three sectors that determined the success of eco-industrial towns in Thailand [141]. The study listed the three sectors as Governmental (49.57 percent of comments), Industrial (30.03 percent of the comments), and Community (20.40 percent of the comments). The results show individual weights of factors as shown in Table 3.5.

Table 3.5 Success Factors in Descending Orders [141]

<table>
<thead>
<tr>
<th>Sub-factors</th>
<th>Scores (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laws and regulation enforcement</td>
<td>18.06</td>
</tr>
<tr>
<td>Laws and regulations</td>
<td>15.92</td>
</tr>
<tr>
<td>Governmental support with resources</td>
<td>13.51</td>
</tr>
<tr>
<td>Management of cooperation</td>
<td>11.76</td>
</tr>
<tr>
<td>Cooperation among government, private sector, and community</td>
<td>11.68</td>
</tr>
<tr>
<td>Information sharing with industrial and community sections</td>
<td>8.64</td>
</tr>
<tr>
<td>Information sharing (with Community sector)</td>
<td>8.46</td>
</tr>
<tr>
<td>Resource readiness</td>
<td>7.55</td>
</tr>
<tr>
<td>Level of awareness of Eco-industrial significance</td>
<td>4.42</td>
</tr>
</tbody>
</table>

It can be seen that the key success factors of developing eco-industrial town are laws and regulations and their enforcement, governmental support on resources, cooperation, knowledge sharing, resource readiness and level of awareness of eco-industrial significance.
To sum up, the primary problem of current EIPs is that implementation of the concept in Thailand tends to rely heavily on the government policies. Importantly, even with a strong desire to enhance the environmental performance, the progress of EIPs in Thailand still has a long way to go. To guide industry and policy makers towards more radical and system-wide improvements, a common vision of environmentally friendly systems needs to be developed to realise them. According to the existing eco-criteria that help industry and companies to track and benchmark different aspects of their environmental performance, there is a gap in considering and understanding all of the criteria as key drivers for these developments. Moreover, some industry players have also started exploring EIP projects through new business models and alternative modes of provision. Therefore, the success of an EIP cannot be guaranteed by an IP owner only. So, the participation and the awareness of firms in an IP which intends to transform into an EIP are very important but there has been little research on this point. The previous research has not dealt with a specific EIP strategy, although various policy initiatives and programme promotions have been proposed. While these include supply-side and demand-side measures, a fuller understanding of the interaction of supply and demand for EIP would help achieve more successful policy mixes.

3.6 Conclusion

This chapter describes the development and implementation of EIP in Thailand. Many policies have been designed to realise this concept. In the Thai context, the progress of EIP is still complicated and lengthy. The government has issued rules and regulations for the development of EIPs by addressing eco-criteria to achieve sustainable EID in the nation. However, there is less clearness in measuring the level of sustainability of a company or the sustainable development. Since 2000, more than 40 industrial parks or industrial estates have shown their interested to get involved in the EIP project by launching their pilot projects. Most of these pilot projects are focusing on limited criteria such as waste management and by-product exchange. Nevertheless, all of them are still standing at the initial stage and have yet to meet the minimum requirements. Moreover, knowledge and research about the development and implementation of EIP in Thailand is still lacking especially the research into the setting criteria. However, with biased understandings and ineffective and inefficient enforcement of related policies, many practitioners prefer to optimise one or two eco-criteria of EID without addressing other
criteria. Therefore, it is necessary to envision and to implement comprehensive and innovative eco-industrial development. So, rather than only paying attention to resources and finding a means to make resources ready for industries, industrial parks need to consider other eco-criteria such as health and safety as an alternative way to gain recognition as an EIP. The next chapter will focus on the background of OH&S in industrial ecology concept in Thailand, which includes the role of OH&S in the EIP paradigm.
Chapter Four

Overview of Occupational Health and Safety (OH&S)

Policies and Systems in Thailand

This chapter is based on one published article and one conference presentation. The bibliographic details of the papers, including all authors, are:


My contribution to the published manuscript involved:

- Initial review research concept of the integration among OH&S in the EIP
- Preparation of manuscript

Kultida Bunjongsiri

Corresponding author: Prof. Cordia Chu

Principal supervisor: Prof. Cordia Chu and Dr. Sunil Herat

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4.1 Introduction

The previous two chapters have explained the concept and history of EIP globally and in Thailand. Presently, although there is a lot of knowledge about EIPs, there is not sufficient practical experience to provide practical solutions for all of the barriers facing EIPs. Thus, health and safety is not only the concept of the safety and health of the people both inside and outside the work position but it is also set as a criterion to be considered for status as an EIP. Within that concept, occupational health and safety (OH&S) is concerned with protecting the safety, health and welfare of people engaged in work or employment. OH&S makes a significant contribution to industry efficiency through the prevention of injury, occupational diseases and adverse environmental impacts. Thai governments have put in place laws to harmonise OH&S laws across the nation, helping to provide equal protection and standards to workers in each jurisdiction. These laws are part of national reform to OH&S and are the result of extensive consultation and a national review.

This chapter shows the results relevant to the 3rd focus question of this thesis. This chapter reviews the current system and development of OH&S in Thailand in order to examine the feasibility of this research study. Through a literature review, this chapter presents the general background information on OH&S specifically in Thailand. It starts with a review of the characteristics of OH&S, and follows with the current situation of OH&S including systems, authorities and enforcement policy in the nation. Then, it describes the potential role of OH&S in EID in Thailand. The last section in this chapter clarifies the problems of OH&S practices in Thailand.

4.2 Overview of Occupational Health and Safety Policy

Occupational health and safety is a cross-disciplinary field concerned with protecting the safety, health and security of people engaged in work or employment. The goal of all OH&S programs is to support a safe work environment. As a secondary outcome, it may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are impacted by the workplace environment. It may involve interactions among many subject areas, including occupational medicine, occupational hygiene, public health, safety engineering, chemistry, health physics, ergonomics, toxicology, epidemiology, environmental health,
environmental engineering, industrial relations, public policy, industrial sociology, medical sociology, social law, labour law and occupational health psychology [143].

4.2.1 Occupational Health and Safety

Since 1950, the International Labour Organization (ILO) and the World Health Organization (WHO) have shared a common definition of occupational health. It was adopted by the Joint ILO/WHO Committee on Occupational Health at its first session in 1950 and revised at its twelfth session in 1995 [144].

The definition reads:

*Occupational health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention amongst workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities; and, to summarize, the adaptation of work to man and of each man to his job.*

They also set three key objectives of OH&S [145]:

1. The maintenance and promotion of workers’ health and working capacity;

2. The improvement of the working environment and work, to become conducive to safety and health; and

3. The development of work organisation and working cultures in a direction which supports safety and health at work, and also promotes a positive social climate and smooth operation, and may enhance the productivity of the undertaking [146].

The basic definition of a labour standard was adopted by Block, et al. (2003) in their study of the USA and Canada [147]. A labour standard was defined as [148]:

*A governmentally established procedure, term, or condition of employment, or employer requirement that is designed to protect employees from treatment at the workplace that society considers unfair or unjust. The common element across all the standards is that they are mandatory – they are imposed and enforced by government.*
The reasons for establishing good OH&S standards are frequently identified as [143] :

- **Moral** - An employee should not have to risk injury or death at work, nor should others associated with the work environment.

- **Economic** - many governments realise that poor OH&S performance results in cost to the State through social security payments to the incapacitated, costs for medical treatment, and the loss of the employability of the worker. Employing organisations also sustain costs in the event of an incident at work such as legal fees, fines, compensatory damages, investigation time, lost production, lost goodwill from the workforce, from customers and from the community.

- **Legal** - OH&S requirements may be reinforced in civil law and/or criminal law; it is accepted that without the extra "encouragement" of potential regulatory action or litigation, many organisations would not act upon their implied moral obligations.

Eventually, Thailand revised the laws concerning OH&S in Part II of the Safety, Health and Workplace Act (2011). This Act came into effect in July 2011 [149].

This Act applied to every employer, employee, subcontractor, executive, supervisor, safety officer, occupational safety health and environment committee, person or juristic person who to render services on occupational safety and health, specialist, owner or letter of a building, premises, tool, machinery, equipment or rental articles, government agency etc. [149].

Relevant definitions:

"Safety, occupational health and workplace environment" means acts or working conditions that do not cause injury to life, body, mind or hygiene and health as a result of or in connection with work.

"Employer" means an employer as defined in the LPA, including a business person who allows an individual to work or generate benefits for or inside a workplace, regardless of whether that work or earning of benefits is part of, or the whole of, a production process or a business under the responsibility of that business person.
"Employee" means an employee as defined in the LPA, including an individual permitted to work or generate benefits for or inside the workplace of an employer, regardless of how he or she is described.

"Executive" means an employee in a managerial position of that work department or higher.

"Supervisor" means an employee who controls, supervises, gives order or instructs employees to perform their duties in the work department.

"Work safety officer" means an employee appointed by the employer to carry out safety, occupational health and workplace environment duties under this Act.

"Workplace" means each work department of the employer where employees work.

Duties of employees: Employees have a duty to cooperate with the employer in matters relating to the promotion of safety, occupational health and workplace environment, in order to ensure the safety of employees and the workplace.

Duties of employers: Employers have a duty to arrange and ensure that the workplace and the employees have safe and hygienic work conditions and workplace environment; and provide support to the performance of employees to prevent them from suffering injury to life, body, mind, health and health.

The Act assigns an employer to one of several categories, depending on the number of employees or the kind of business. These categories determine the levels of liability and responsibility that the employer bears. The employees also have responsibilities under the Act. On the one hand, an employer shall administer, manage and engage in actions related to safety, occupational health and workplace environment in accordance with standards specified in ministerial regulations. For the determination of such standards, any document or report prepared by the employer shall be verified or certified, as determined in ministerial regulations. On the other hand, employees have a duty to comply with safety, occupational health and workplace environment criteria in accordance with the relevant standards.
4.2.2 Workplace Health and Safety (WHS)

The attempt to establish a business case for WHS has a long history, with seminal studies undertaken as far back as the 1930s [150]. Various definitions for the terminology have been proposed. Smith and Sainfort (1989) proposed a balanced model to integrate psychosocial and biological aspects of employee behaviour within an ergonomic framework which provides a holistic approach for designing workplaces that balance production and stress considerations [151]. Meanwhile DeJoy and Southern (1993) developed an integrative model, which identifies different levels of factors that can influence worker health, particularly those directed to resistant and high-risk workers [152]. In a similar way, a comprehensive model by Israel et al. (1996) incorporates multiple factors from diverse disciplines. The authors explored lessons learned from interventions based on their conceptual model such as the role of top management and the need for integrating research and intervention [153]. Andersson and Menckel (1995) compared eleven conceptual frameworks for prevention of accidents and injuries; five are general in nature, while six relate to injuries and accidents. They then developed a model integrating these factors [154]. Several researchers from National Institute for Occupational Health and Safety (NIOH&S) in the USA have incorporated organisational success in their models, tying worker health more thoroughly to a firm's whole commerce strategy [155, 156]. Amick et al. (1998) developed an ecological model of workplace health, which they viewed as necessary because of changing technology [157]. They suggested that health care costs are reduced by reducing musculoskeletal injuries through job redesign, ergonomics, or changes in work scheduling. [157].

The meaning of healthiness in workplaces has been adopted by experts based in several organisations, including the Wellness Councils of America (WELCOA), Safe Work Australia, European Network for Workplace Health Promotion, and Health Canada [158]. The achievement of workplace initiatives usually vary in their attempts to improve employee health and restrict health care charges, but many time-tested and acknowledged principles operate [159, 160]. While the relevance or applicability of these principles varies among workplaces, all principles are helpful for business supervisors and workplace health professionals to address when reconsidering an organisation's health promotion program, including its precepts, scope, and services [161-163].
4.3 Current Situation of Occupational Health and Safety and Related Research Priorities in Thailand

Global data estimates by ILO show that occupational health and safety problems are more serious than previously believed. In particular, the number of occupational fatal and non-fatal accidents in developing countries has been greatly underestimated [164]. Since Thailand became a newly industrialised country (NIC) in the late 20th and early 21st centuries [165], the labour force structure has continued to change speedily with higher proportions of the labour force in the industrial sector [166]. In Thailand, work-related injury and illness statistics are compiled and reported primarily by the Workmen's Compensation Fund in the Ministry of Labour. The labour market regulation and worker representation are much weaker than they are in developed countries, which underwent these transitions more slowly and sequentially, decades earlier [17]. Yet, the evidence also demonstrates that it is possible, in many business contexts, to construct a business case for providing a healthy and safe work environment beyond simply the minimum required under the new model OH&S law in Thailand.

In Thailand, OH&S has been recognised as important since the outbreak of severe manganese poisoning among 41 workers at a factory in 1964 [167]. In 1968, the Ministry of Industry promulgated the Thai Industrial Standards Act, which established the National Coordinating Committee on Occupational Health to set up the Thai Industrial Standards Institute as the national standards body responsible for standardisation activities in the workplace. Since then, a number of OH&S standards have been introduced in Thailand including ISO 9000 (1981), ISO14000 (1985), and TIS/ISO9000 series as National Standard for Quality Systems (1991). Further standards such as OHSAS18001 (1999) which is a framework for an OH&S management system and is a part of the OHSAS 18000 series of standards, along with OHSAS 18002 have also been launched [168].

4.3.1 Thailand’s work and health transition

When Thailand entered the transformative stage, its regulation of working conditions, social security and employment policies were obviously much less advanced than those of developed countries. Since then, regulations and policies have been applied but they apply only to specific segments of the labour force. Presently, most Thai workers are still employed in the informal economy, where work is contingent and conditions generally unregulated. Unionisation rates are poor and few workers are conscious of their rights.
Thailand’s economy, South-East Asia’s second largest, has shown remarkable resilience to economic shocks and political uncertainties, including the political crisis of 2010 and the floods in late 2011. Thailand’s employment level averaged 72.1 percent during the decade 2001-2010, and stood at 72.2 percent in 2010. It ranks as one of the highest among Asian economies, second to that of China [169]. In spite of the resilient economy, the Thailand labour market has been showing some signs of vulnerability. In terms of sector of work, the share of employment in industry has slowly risen, but the gradual move out of agricultural employment that was clearly observed up to 2010 has since experienced a reversal. The recent difficult political situation in 2013 could potentially exacerbate emerging signs of sluggishness in the labour market [170]. As a result of the historic vulnerability of the labour market, OH&S issues have sometimes been ignored, although the government of Thailand has acknowledged the seriousness of OH&S issues as various policies and relevant initiatives have been launched since 1966. The key events and Developments of OH&S in Thailand are as follow [167]:

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>An outbreak of 41 heavy manganese poisoning cases with various severity levels among workers in a battery manufacturing factory in Samutprakan province, bringing about the awareness of OH&amp;S.</td>
</tr>
<tr>
<td>1966</td>
<td>OH&amp;S issue and initiatives were incorporated into the 2nd National Economic and Social Development Plan (1967-1971)</td>
</tr>
<tr>
<td>1968</td>
<td>The government established the National Coordinating Committee on Occupational Health. This Committee is composed of representatives from relevant authorities such as Ministry of Public Health, Ministry of Interior, Ministry of Industry, Ministry of Agriculture and Cooperatives, Ministry of University Affairs, Bureau of the Budget, Office of the National Economic and Social Development Council.</td>
</tr>
<tr>
<td>1969</td>
<td>The Faculty of Public Health, University of Medical Sciences (presently named Mahidol University) started the degree program (B.Sc.) in Occupational Health. The first group of students graduated in 1970.</td>
</tr>
<tr>
<td>1972</td>
<td>Department of Public Health Promotion (presently named Department of Health), Ministry of Public Health set up “Division of Occupational Health”</td>
</tr>
<tr>
<td>1972</td>
<td>The first OH&amp;S law was promulgated as provisions under the “Announcement of the Revolutionary Party No.103 Re: Labour Protection”.</td>
</tr>
</tbody>
</table>
1974  “Occupational Safety Section” was established under the Division of Labour Protection, Department of Labour.

1976  Ministry of Interior released the “Notification on Safety and Health Welfare of Employees” under the “Announcement of the Revolutionary Party No. 103”.

1981  “Occupational Safety Section” was enhanced to become “Labour Standards Division” in charge of labour law administration.

1983  “National Institute for the Improvement of Working Conditions and Environment (NICE)” was founded in collaboration with the International Labour Organization (ILO).

1987  A set of 17 notifications of Ministry of Interior on various OH&S aspects.

1990  “Labour Standards Division” was expanded to “Occupational Safety Inspection Division”

1993  A huge industrial accident occurred at the Kader toy factory, where 188 workers were killed and nearly 500 workers injured. The tragedy was considered the worst industrial accident in the history of Thailand. This caused public pressure for better safety regulation.

1993  “Ministry of Labour and Social Welfare” was established together with the Department of Labour Protection and Welfare as the main agency in charge of OH&S administration.

1998  “Labour Protection Act, 1998” replaced the “Announcement of the Revolutionary Party No.103”.

2002  The “1st Master Plan on Occupational Safety, Health and Environment” was created for 2002 – 2006.

2007  The government published the policy on “Decent Safety and Health for Workers” as the National OH&S Agenda for all relevant agencies.

2009  OH&S Bureau was formed under the reconstruction of the Organization and the authority of Department of Labour Protection and Welfare by combining two agencies: the Occupational Safety and Health Inspection Division (OH&SID) and the National Institute for the Improvement of Working Conditions and Environment (NICE).
2010  The Labour Protection Act (No. 4) was passed. It came into effect in July 2011. This Act updates the Labour Protection Act (1999), and in consequence revises certain penalty provisions contained in the LPA.

2011  “Occupational Safety, Health and Environment Act, 2011” took effect as the main OH&S law of Thailand. The purpose of this Act is to impose duties upon employers for safety and health in places of work.

The following section will outline how the OH&S matters are regulated.

4.3.2 National policy framework of OH&S

4.3.2.1 Authorities for occupational Health and Safety

Presently, OH&S in Thailand is still mainly focused on the industrial sector. There are three main ministries involved in OH&S [166, 171].

1. Ministry of Labour: The Ministry of Labour has functions and responsibilities in enactment of legal issues, enforcement of OH&S standards as well as inspection and promotion of a safe working environment. The three major organisations under the Ministry of Labour relevant to OH&S are the Department of Labour Protection and Welfare, the Social Security Office, and the Occupational Safety and Health Committee.

2. Ministry of Public Health: The Ministry of Public Health is the main governmental organisation responsible for all public health in the country. It provides occupational health services covering occupational disease surveillance and health promotion. It is responsible for preventing and controlling factors causing sickness and injury at workplaces and for providing medical care through the technical department in the central region and the public health systems of all levels in other regions [172]. It also has roles and functions in OH&S such as the provision of occupational health services in all sectors through its technical units and health care network systems. The major technical unit that is responsible for occupational health activities is the Bureau of Occupational and Environmental Diseases under the Department of Disease Control (formerly Division of Occupational Health). The main functions include policy development, setting up standards and guidelines for occupational health services and management, and development of OH&S surveillance systems.
3. Ministry of Industry: The Ministry of Industry has roles and functions in issuing of permission for factory construction, enactment and enforcement of the Factory Act, setting up machine safety standards, and site inspection for permission of factory establishment. The major units regarding OH&S include the Department of Industrial Works (DIW), Office of the Permanent Secretariat, and Industrial Estates Authority of Thailand (I-EA-T). The Ministry of Industry is also responsible for issuing permits for a factory to set up and operate, enforcing laws on safety in industrial settings, carrying out inspections to ensure legal compliance and renewing business approvals. Through factory inspection, the DIW is authorised to ensure that industrial operations do not injure people’s health. Environmental impacts must be eliminated. The DIW plays an important role in assuring safety practices at the factory level because it has the authority to consider renewal of the business permits. The responsible agencies for these affairs are the Office of Safety Technology, the Office of Hazardous Substances Control and the Industrial Cluster Bureau.

4.3.2.2 Occupational health and safety administration in Thailand [167]

The Third National Master Plan on Occupational Safety, Health and Environment (2012-2016) integrated the OH&S Master Plan of the Ministry of Labour with the Action Plan for the National Agenda “Decent Safety and Health for Workers”. This 3rd Master Plan covers five strategies: promoting labour protection with effective OH&S standards; promoting and strengthening the capacity of OH&S networks; developing and managing OH&S knowledge; developing an information system for OH&S; and developing effective mechanisms for OH&S administration. The goals of the plan include: developing and enforcing OH&S standards consistent with the socioeconomic and OH&S situation; strengthening active participation in existing OH&S networks; establishing OH&S learning centres accessible to all age groups of the population; developing a database and networks to support OH&S administration and services; and establishing policy, administrative structure, plans, measures, work processes, procedures, tools and necessary resources for the development of effective OH&S administration. The main function of the Bureau of Occupational and Environmental Diseases is to set up and develop OH&S surveillance systems. The aims of the surveillance system are to identify high-risk groups, to describe the occupational disease situation, and to set up further disease control and prevention. The system focuses on eight groups of diseases: silicosis, byssinosis, asbestosis, lead poisoning, noise induced hearing loss, solvent poisoning,
pesticide poisoning, and occupational injuries [166]. In 2000, the “Healthy Workplace” project was developed to promote workers’ safety and health in every workplace around the nation. This integrated project is based on the WHO Healthy Work Approach. The aims of the project are to increase awareness about health promotion in all types of workplaces, to develop continuous workplace improvement, and to develop health and safety working environments. The ultimate goal of this project is to develop clean, safe, non-hazardous, and lively workplaces. Up to the year 2002, approximately 2,443 establishments had joined this project on a voluntary basis [166].

4.3.2.3 Changes in labour policy

The past two decades have been memorable in the political history of Thailand, bringing greater government attention to workplace conditions and workers’ health and safety [17]. Partly driven by a newly empowered civil society, a “People’s Constitution” was established in 1997. This Constitution’s provisions for individual and collective rights led to the establishment of a National Human Rights Commission [173]. One major incident illustrates the policy interest in workplace health and safety. The series of industrial accidents that occurred in the 1990s, especially the 1993 fire at the Kader toy factory, where 188 workers were killed and nearly 500 workers injured, alerted the media, and the public paid more attention to worker safety issues, putting pressure on policy-makers to take action [174]. The Kader industrial accident appeared to be a turning point in national attitudes towards worker safety in Thailand. In addition, over the last four decades, Thailand has made remarkable progress in social and economic development, shifting from a low-income country to an upper-income industrialised country in less than a generation. Policy makers have been concerned that all aspects of society, including health and safety, should reflect this new prosperity. Thailand has been a member of the ILO since 1919, it has ratified only a few of the ILO’s more than 180 Conventions. Nevertheless, Thailand hosts the Organization’s Regional Office for Asia and the Pacific, with which the Ministry of Labour and Social Welfare has developed a close working relationship.

An important channel for the implementation of Thailand’s new policy direction on labour has been its five-year National Economic and Social Development Plans, formulated by the National Economic and Social Development Board (NESDB). Since the eighth plan, 1997–2001, policy guidelines have emphasised the reduction of the incidence of occupational injuries and illnesses. The plans set incidence targets and
prescribe the measures to be implemented in order to achieve them. They also promote the registration of informal workers, and recognition of informal workers’ organisations, thus providing them with enhanced protection and security. The NESDB policy has also aimed at providing informal workers with social security benefits similar to those enjoyed by the formal workforce [175]. Since 1997, these issues have been specifically mentioned through the NESDB’s Labour Development and Welfare Plans, which also opens up avenues for collective bargaining on workplace conditions [176]. These plans have prepared new safety regulations, a national safety culture campaign, inspection systems, embedded safety management systems, improved reporting, and participatory training. These measures attempt to address both well-known occupational hazards and newly recognised biological, psychosocial and musculoskeletal risks [177].

The next change happened in the 1998 Labour Protection Act, which required all workplaces to set up an occupational safety committee, made up of management and worker representatives trained in workplace health and safety. This legislation also organised a reporting system for employees to report suspected breaches of safety rules to the employer, who reports to it the Ministry. The Ministry is then obliged to investigate it, and perform the general workplace inspection process more rigorously [178]. In addition, the 1998 Act specified working conditions and conditions of employment such as maximum working hours and minimum wages, and set up a separate reporting process for employees to report breaches of these conditions. Penalties for breaches were increased and independent third parties (such as workers’ unions) were allowed to investigate disputes [179].

In 2005, the Ministry of Labour and Social Welfare launched the new regulations that oblige organisations with 50 or more full-time workers to develop an OH&S management system [177]. The formation of new safety positions and training courses was required in order to improve worker safety. Together with the above methods, the Ministry of Public Health also carried out other nationwide campaigns and an active epidemiological surveillance programme. Later on, there was a joint commitment towards stronger cooperation to set up a comprehensive OH&S surveillance system pooling the resources of the Ministry of Public Health, the Ministry of Labour and Social Welfare and the Ministry of Industry with a view to monitoring the incidence of target occupational diseases, identifying high-risk groups and developing policy interventions [166].
Nevertheless, the figures of reported occupational disease cases in Thailand may not represent the real situation in the country because many surveys conducted by the Bureau of Occupational and Environmental Diseases showed levels of hazardous exposure in working environment that were higher than reported and many cases of early abnormalities in workers’ health. The high number of unreported cases may be due to the lack of work history taken from patients, the physicians’ lack of awareness, and difficulty in making diagnosis of the diseases. This is one of the major topics in relation to occupational health that needs to be improved [166].

At present, there are a number of laws specifically dealing with OH&S in Thailand. However, some regulations are inconsistent and out of date, revision of existing regulations is slow, any enforcement of these laws is virtually ineffective and many establishments ignore current regulations. This situation is partly caused by inadequate and poorly compiled government safety inspections. Fundamental research in industrial ecology has focused on the long-term relationships between materials and energy use, the environment and human health, and economic well-being, and has not addressed health and safety issues [31]. However, the situation in countries that have developed recently, such as Thailand, is relatively unclear largely because accident and disease awareness, record-keeping and reporting mechanisms are still evolving [180]. Prior to this study, the OH&S systems in EIPs were virtually unexplored.

### 4.3.2.4 Government agencies responsible for OH&S in Thailand [181]

Among the responsibilities of various governmental agencies, there are some overlapping roles and responsibilities. These roles can be separated into three parts as follow:

1. **The Role of Providing Technical Knowledge:**

1.1 At a National level

   The National Institute for the Improvement of Working Conditions and Environment (NICE), the Division of Occupational Health, and the Industrial Safety Technology Centre are three main agencies responsible for conducting studies, research and developing OH&S programs as well as disseminating OH&S information to enterprises. Although the agencies' names are different, the overall responsibility of each of them is almost the same.
<table>
<thead>
<tr>
<th>The National Institute for the Improvement of Working Conditions and Environment (NICE)</th>
<th>The Division of Occupational Health</th>
<th>The Industrial Safety Technology Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proceeding studies, research and developing OSH programs as well as disseminating OH&amp;S information to enterprises.</td>
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</table>

1.2 At a regional level,

At a regional level, the Regional Centre for the Improvement of Working Conditions and Environment (RICE) and the Regional Environmental Health Centre have a similar responsibility in supporting and disseminating OH&S information nationwide.

<table>
<thead>
<tr>
<th>The Regional Centre for the Improvement of Working Conditions and Environment (RICE).</th>
<th>The Regional Environmental Health Centre.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting and spreading OH&amp;S information widely.</td>
<td></td>
</tr>
</tbody>
</table>

There are overlapping roles and responsibilities among government organisations, both at national level and regional level. Moreover, the coordination among them is not well organised.

2. The Role of Regulatory Enforcement:

2.1 Under the Department of Labour Protection and Welfare

Under the Department of Labour Protection and Welfare, there are overlapping responsibilities between the Occupational Safety and Health Inspection Division and the Provincial Office of Labour Protection and Welfare
2.2 Under the Department of Industrial Works

Under the Department of Industrial Works, there are overlapping responsibilities between the Office of Factory Control and Inspection and the Provincial Office of Industry.

These ministries have their own ministerial regulations; the agencies are trying to enforce laws upon enterprises under their own responsibility. However, there are inconsistencies between these regulations, causing inefficiency in the usage of personnel and resources and confusion for enterprises.

3. The Role of Providing OH&S Services:

3.1 The Division of Occupational Health and the Department of Labour Protection and Welfare have the same responsibility to carry out environment and health checks in workplaces.
These three roles are enforced by many agencies, so that OH&S personnel, time, money, equipment and other resources are consumed with low efficiency and the overlapping responsibility often confuses the personnel involved. Furthermore, there is very limited cooperation about OH&S programs between these agencies.

4.3.3 Research in occupational health and safety

Occupational health is a basic element and constitutes a social and health dimension of the principle of sustainable development. In Thailand, a number of researchers have studied numerous work-related injuries, illnesses, property damage, and production losses that are reported from different workplaces to help the workplace to deal with these problems. Table 4.1 shows some of the research areas identified.

Table 4.1 Subjected investigated in OH&S research studies.

<table>
<thead>
<tr>
<th>References</th>
<th>Objectives</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krungkraiwong, S., Itani, T., and Amornratanapaichit, R. (2006). Promotion of a healthy work life at small enterprises in Thailand by participatory methods. Industrial health. 44(1): p. 108-111. [182]</td>
<td>To examine the effects of heat barriers on reducing heat stress, measure environmental temperatures in small enterprises which applied WISE (Work Improvement in Small Enterprises) methods to manage work environment problems.</td>
<td>The introduction of WISE methodology can improve working conditions effectively. It is expected that if firms focus on the improvement at the source of occupational injuries, they can reduce the number of occupational accidents and diseases. The WISE methodology thus represents the participatory methods that are very effective tools for promoting a healthy work life in small enterprises in Thailand.</td>
</tr>
<tr>
<td>Langkulsen, U., Vichit-Vadakan, N. and Taptagaporn, S. (2010). Health impact of climate change on occupational health status and productivity in two</td>
<td>To examine the relationship between climate condition and health status and productivity in two</td>
<td>It was found that four out of five study sites had heat indices of ‘extreme caution,’ and one site showed a value that falls into the category of</td>
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<td>References</td>
<td>Objectives</td>
<td>Findings</td>
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<td><strong>health and productivity in Thailand. Global Health Action, 3. [183]</strong></td>
<td>main categories of the occupational setting – where one setting involves heat generated from the industry and the other with heat in a natural setting.</td>
<td>‘danger,’ where sunstroke and heat exhaustion are likely and prolonged exposure may lead to heatstroke. Productivity in the construction industry (heat from natural setting) fell by 10% - 66.7% and in the pottery industry (heat generated in the industry) fell by 15%.</td>
</tr>
<tr>
<td>Manothum, A., Rukijkanpanich, J., Thawesaengskulthai, D., Thampitakkul, B., Chaikittiporn, C., and Arphorn, S. (2009). A Participatory Model for Improving Occupational Health and Safety: Improving Informal Sector Working Conditions in Thailand. International Journal of occupational and environmental health, 15, 305-314. [184]</td>
<td>To evaluate the implementation of an OH&amp;S management model for informal sector workers in Thailand. The participants consisted of four local labour groups from different occupations, including wood carving, hand-weaving, artificial flower making, and batik processing workers.</td>
<td>The working conditions of the four informal sector occupations in this study were improved by implementing the OH&amp;S management model. The local network’s strength depended on several factors which were: the self-awareness and duty awareness of each stakeholder, knowledge and understanding about the relationships and ways to cooperate among the related firms, understanding of the OH&amp;S problems of the informal sector groups.</td>
</tr>
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</table>
| Yamakawa, M., Sithisarankul, P., Yorifuji, T., Hengpraprom, S., Hiransuthikul, N., Doi, H., and Takao, S. (2013). Industrial distributions of severe occupational injuries by using data on workers who made claims for occupational injuries. | To evaluate the industrial distributions of severe occupational injuries by using data on workers who made claims for occupational injuries. | The number of workers in manufacturing industries making claims for severe occupational injuries was the largest among all industrial categories, even though the
<table>
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<th>Objectives</th>
<th>Findings</th>
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<tr>
<td>severe occupational injuries among workers in Thailand. Journal of occupational health. 55(5), 415-421. [185]</td>
<td>injuries from 2007 to 2009. It examined the associations between industry and those injuries, using proportionate ratios (PRs) between each industrial category and the overall distribution of occupational injuries. Additionally, workers in manufacturing experienced severe occupational injuries more frequently than the overall rate of occupational injuries. After adjusting for individual characteristics of the workers, the results did not substantially change.</td>
</tr>
<tr>
<td>Siriruttanapruk, S., &amp; Anantagulnathi, P. (2004). Occupational health and safety situation and research priority in Thailand. Industrial health, 42(2), 135-140. [166]</td>
<td>To review occupational health and safety situation and to describe current planning and activities, particularly in research development, from relevant organisations in the country. High risk occupations are in both agricultural and industrial sectors. Occupational injuries seem to be the leading problem but occupational diseases, especially pesticide and other chemical poisoning, are still a major concern. Diagnosis and reporting systems need to be improved.</td>
</tr>
<tr>
<td>Langkulsen, U., Vichit-Vadakan, N. &amp; Taptagaporn, S. (2011). Safety and health in the petrochemical industry in Map Ta Phut, Thailand. Journal of occupational health, 53(5), 384-392. [186]</td>
<td>To identify and specify the main health and safety issues faced by petrochemical workers at the Map Ta Phut industrial estate as well as their risk perceptions. Most workers were aware of OH&amp;S management in their companies. Some companies revealed that they had not been performing biological monitoring of blood or urine for their health examination reports and that workplace exposure monitoring had not correlated well with health examination of workers.</td>
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</table>
During the past two or three decades, research activities have continued to play an important role in the development of OH&S in Thailand. Such research activities have been conducted by several government agencies as well as academic institutions offering OH&S programs. Most of these studies have been conducted with the objective of identifying OH&S problems in Thailand and of developing appropriate measures or new technologies/innovations in OH&S. For the government sector, the main agencies that are involved in OH&S research include the Bureau of Occupational and Environmental Diseases in the Department of Disease Control (formerly the Division of Occupational Health, Department of Health) and the Occupational Safety and Health Bureau in the Department of Labour Protection and Welfare (formerly, this research unit was the National Institute for the Improvement of Working Conditions and Environment) [167].

A large number of research projects have been launched for the development of OH&S in Thailand and many projects are still ongoing. Unfortunately, OH&S research activities conducted by the government sector have had a less important role since 2012. Obviously, this decline in importance is associated with the reconstruction of the organisation and authority of the Department by merging the National Institute for the Improvement of Working Conditions and Environment with the Occupational Safety and Health Inspection Division, to establish the Occupational Safety and Health Bureau. Administrative policy and strategies have also been changed to focus on the development and implementation of OH&S laws as well as the OH&S promotion by means of conducting OH&S activities and campaigns. In addition, the Bureau has been facing some limitations on budget and internal facilities, which have significantly affected its capacity to conduct OH&S research during this period.

Overall, OH&S management has attracted interest as far as the top academic management journals are concerned, although OH&S has received a small amount of attention in the workplaces. However, the gap in OH&S management research from an organisational management point of view has begun to be recognised by leading organisational scholars. In recognition that there may be a gap between the provision of the understanding of OH&S and the implementation of changes to work organisation, further work is needed to assess the effectiveness of the current approach.
4.4 Occupational Health and Safety and Its Potential Role in Eco-Industrial Development

Occupational Health and Safety is a basic element and constitutes a social and health dimension of the principle of sustainable development. OH&S practices constitute a set of key activities for such development. Unfortunately, few studies have focused on the role of OH&S in sustainable development [187-190]. Studies exploring the role of OH&S in sustainable development are either fragmented or their relationships only glossed over in an endeavour to make arguments regarding OH&S in a certain particular agenda [189]. In Sarnia (Ontario, Canada), eco-industrial networking projects that improve the level of environmental quality, health and safety have also generated significant returns on investment [191]. To integrate eco-industrial concerns across diverse dimensions of environmental performance, a number of weighted environmental metrics have been developed. For instance, a scoring system called eco-indicator is a measure of overall environmental impact; human toxicity potential has been developed as a measure of the toxicity of chemical compounds over a range of human health end points; and the “triple bottom line” is a measure being used by some industrial companies to combine business, environmental, and social accounts [192, 193].

In terms of sustainable development, a framework is needed in which the various environmental, economic and social factors and components can be considered in a balanced way [189, 194, 195]. Schirnding (2002) cited a framework for presenting the linkages among factors that affect health in the context of environment and development. It has been adapted from the “pressure-state-response” (P-S-R) model (See Figure 4.1) developed by the Organization for Economic Cooperation and Development (OECD) [194].
The P-S-R framework is especially used worldwide as a reporting tool to describe human activities in which pollution affects the environment, by pointing out the different pressures on the environment, changing the quality and quantity of natural resources. Human management responses to the changes include any form of organised behaviour that seeks to reduce, protect or accommodate undesirable changes [194, 195]. The OECD uses the P-S-R framework to provide the basis for a classification of indicators using a number of environmental issues which reflect major environmental concerns in OECD countries [195]. In the causal chain, social and economic developments are considered driving forces that exert pressure on the environment, leading to changes in the state of the environment. In turn, these changes lead to impacts on human health, ecological systems and materials that may elicit a societal response that feeds back on the driving forces, pressures, or on the state or impacts directly [196].

The literature on the triple bottom line (TBL) was reviewed by Amponsah-Tawiah in 2013. She analysed how the TBL is affected by OH&S policies and the effects of work related hazards on sustainable development (See Figure 4.2) [189].
The TBL comprises three Ps: profit, people and planet. It refers to the economy, social and environment performance of the corporation over a period of time. ‘Planet’ refers to the environment and addressing this aspect of the TBL encourages industry to be eco-efficient. The environment is the most extraordinary arena that sustainable development literature appears to have been written on actively for the past two decades. The environment is exquisitely coordinated with every single human action and the sustainability of human species has so much to do with the environment. ‘Profit’ is linked to a sustainable labour force in the business’s quest to optimise profitability. Various descriptors such as compensation claims, employee turnover, and accidents arising out of disregard for OH&S issues have severe impacts on productivity and shareholders’ asset maximisation. Finally, the bottom line of ‘people’ was described by Willard (2002) as the concept that employees need to be able to rely on a safe work environment that continuously reduces risk of injury and OH&S protection [197]. This is the basis for maintaining a sustainable workforce.

Good safety performance can reduce the accident rate, the personal injuries and material damage, and simultaneously improve working conditions which raise employees’ motivation and reduce their absenteeism. Hence, OH&S indicators can be seen as an opportunity to promote environmental sustainability in the EID. Table 4.2 is a summary
of the OH&S roles in EIPs. These roles include OH&S as a benefit for the company, and OH&S as a criterion for inclusion in an EIP.

**Table 4.2 OH&S role in various eco-industrial parks.**

<table>
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<tr>
<th>Role / References</th>
<th>Descriptors</th>
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<td><strong>Benefits</strong></td>
<td>In Ontario, a number of projects have generated significant returns on investment as well as improved the level of environmental quality, health and safety. The result of meeting the environmental criteria was that this industrial park improved the health and safety of the workers.</td>
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<tr>
<td>Canadian Eco-Industrial Networking (n.d.) <em>Benefits of Eco-Industrial Networking</em>. [191]</td>
<td>The evaluation of products with regard to their features is being done primarily as a result of customer demands. The international concept of &quot;Extended Producer Responsibility&quot; is quickly establishing itself as a modern consideration in identifying, organising and minimising safety, health and environment risks on a product’s entire life cycle, from the procurement of raw materials to production, use and disposal.</td>
</tr>
<tr>
<td>Chiu, S. &amp; Tseng, M. (2004). <em>Production management toward sustainable development</em>. Proceedings of the Fifth Asia Pacific Industrial Engineering and Management Systems [87].</td>
<td>By concern with public health, safety and environmental protection, industry has been at the centre of the debate on sustainability.</td>
</tr>
<tr>
<td>Deog-Seong, O., Kim Kyung-Bae, &amp; Jeong Sook-Young. (2005). <em>Eco-industrial park design: a Daedeok Technovalley case study</em>. Habitat International, 29, 269-284 [100].</td>
<td>In the Tuscany case, the criteria were drafted and approved through the involvement of a group of experts. The criterion of fire prevention equipment and measures was used as a health and safety criterion in addition to the measures required by the law and already present in the enterprises.</td>
</tr>
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95
The clearest link between industrial ecology and OH&S studies has come through the World Health Organization (WHO) since 1994. According to the recommendation of the second meeting of the WHO Collaborating Centres in Occupational Health in China, sustainable development was set as a key process and the workplace as a critical site for efforts towards sustainable development [200].

Moreover, in the agreement of the Rio Summit, sustainable development is defined as a strategy to

"meet the needs of the present world population without causing adverse effect on health and on the environment, and without depleting or endangering the global resource base, hence without compromising the ability of future generations to meet their needs". [200]

The Declaration further stated:

"Human beings are at the centre of concern for sustainable development. They are entitled to a healthy and productive life in harmony with nature". [201]

According to a manual for primary health care workers offered by the World Health Organization, in terms of occupational health, the above principles mean the satisfaction of material needs through work and other production processes without causing danger
to human health, the ecosystem, the resource base or the health of the community either in the short term or the long term. Occupational health is a basic factor and realises the social and health dimension of the principle of sustainable development [202].

Occupational health is at the basis of sustainable development in the following ways:

1. The prevention of occupational accidents, injuries and diseases and the protection of workers against physical and psychological over-load imply an economical use of resources, minimising the unnecessary loss of human and material resources.

2. The objective of healthy and safe work environments calls for the use of safest, low-energy, low-emission, low-waste technology and in many countries occupational health legislation requires the use of the optimum available production technology.

3. The occupational health approach has been suggested to facilitate the systematic production that increases the quality of products, productivity and process management and also helps to avoid unnecessary loss of energy and materials and to prevent unwanted impacts on the environment.

4. Many environmental hazards and burdens are derived from occupational settings, e.g. industry, agricultural practices or transportation and services. Experts and other specialists in the field of OH&S are well informed of processes and agents that may be hazardous to the environment. This information is available to them at a very early stage of the problem, hence enabling primary prevention, which would no longer be possible once the hazardous elements are released into the general environment. In many industrialised countries there is a movement to make closer links between occupational health and environmental health approaches.

5. Occupational health services aim to endorse the health, safety, working capacity and well-being of the workers. A healthy, productive and well-motivated workforce is the key agent for overall socio-economic development. Furthermore, high-quality and productive work can ensure healthy production of materials, goods and services, and the consideration and practical implementation of the principles of sustainable development.

6. Most environmental health hazards that have been found to affect the health of the general population were first detected in the work environment and/or in the working populations. Thus the occupational environment provides an early warning system for certain environmental health hazards just as it also provides effective exemplars for preventive action.

7. For more than half of adults the work environment is the most demanding environment in terms of physical, chemical, ergonomic or psychological stresses and
physical workload. The requirement of the Rio Declaration on healthy and productive life is particularly relevant to the work environment and asks for occupational health action.

8. The status of the general environment and the ecosystem has an impact on the health of workers both indirectly and directly in the occupations of agriculture, mining, fishery and manufacturing. For this reason, there is a two-way relationship between OH&S on the one hand and environmentally sound sustainable development on the other.

9. Equally important for personal well-being and for socio-economic development of communities and countries is an employment policy that ensures access to work for everyone and enables individuals to sustain themselves and their family by their own work. The highest possible level of employment is also a key element in the safe, stable and sustainable social development of countries, while high unemployment rates and other associated problems endanger such development.

10. Specifically in developing countries, the health and well-being of the family is critically dependent on the health and productivity of its working members, thus making several members of the community dependent on the health of the worker. In a situation where organised social protection is lacking, the loss of health, life or working capacity of a major member of the family often means a severe crisis for the rest of the family, affecting indirectly the well-being, health and economy of communities at large and of the next generations.

To accomplish all this, enterprises need to integrate OH&S into the management system. Organisations all over the world have been accomplishing various management systems proportionate with the scope of their operations and specific needs. To achieve the aim of integrating OH&S into their management systems, businesses have been using the following benchmarking systems: ISO 9001: Quality Management Systems; ISO 14001: Environmental Management Systems; OHSAS 18001: Occupational Health and Safety Assessment Series [203]. There is also a growing trend for integrated management systems, which incorporate all the above management systems under one umbrella. Branch and Pallen (2001) showed that OH&S practices in small-scale enterprises (SSE) are a cost-effective way of improving the workplace from a health, environmental and economic standpoint. The approaches and institutional arrangements could be established to reach out to, train and educate SSE workers and entrepreneurs in occupational health and safety practices. Improved OH&S standards help improve overall environmental standards through fairly straightforward inputs, such as redesigning work space and basic
Lastly, the varied economic opportunities offered by the largely unregulated SSE sector may be a critical strategy in the struggle against poverty [204].

4.5 Problems in Occupational Health and Safety Practice in Thailand

Chaikittipom, C. (2002) surveyed a number of small and medium enterprises on the OH&S issue in Thailand in 2002. The results indicated that the big worries in OH&S situations are [181]:

1. Thai employees are working in high risk environments of physical, chemical, biological and ergonomic hazards. Some enterprises have high potential to develop major hazards. For instance, fire hazards in the garment industry and the discharge of hazardous matters in the plastic products industry.

2. Workers are poorly protected from workplace hazards. Even basic safety facilitations such as emergency exits, safety signs and first aid equipment are in poor condition. Personal protective equipment is not adequately provided or explained for all workers.

3. Both employers and employees have inadequate knowledge about OH&S. Most are failing to acknowledge the hazards in their workplaces. Hazard information from external sources such as labour unions, government agencies and other enterprises is not generally disseminated.

4. Enforcement of OH&S laws is ineffective. One of the reasons for this is the inadequacy of inspection by government agencies. Most of the surveyed enterprises said that they had not been inspected for a long time. Some enterprises had never been inspected.

Chaikittiporn (2013) stated that most establishments in Thailand are considered small and medium enterprises, which are increasingly playing an important role in the socio-economic development of the country [205]. However, there is a high incidence of accidents and occupational diseases in these establishments. There is an urgent need to provide practical support to SMEs to establish safe, healthy and productive workplaces. This can be done through establishing clear long-term strategies for strengthening and accelerating OH&S standards for the country. There are five main occupational health related issues that have resulted in unsafe behaviour of the workers and poor environment of workplaces:
1. No continuous surveillance programs either in environmental monitoring or in health examinations undertaken for physical hazards in workplaces.

2. Lack of technical services for related government agencies to monitor the working environment and conduct medical examinations of workers.

3. Lack of information or research into OH&S management for the specific needs of each industry.

4. Lack of research into prevention of occupational accidents and diseases as well as promotion of better working environment and workers’ health.

5. Low awareness among workers of their safety and health because of the lack of knowledge about preventing occupational diseases and accidents.

Moreover, there is another issue related to the OH&S reports from individual firms. In theory, data of OH&S should be an important elementary and readily available data from every company, the basis for any useful research. However, in reality, the reports that provide this data are not always sent to the Labour Protection and Welfare Office. These reports are also often inaccurate, stemming from either intentional or unintentional misinterpretation of the guidelines set by the Ministry of Labour. Then, even if the reports are sent to that office, the data are kept but not analysed, and no further actions are usually taken [186]. This results in inaccuracy in the data available to the government. Thus, the critical issue that seemed to be overwhelmingly indicated by the stakeholders was a need for the development and maintenance of a database that integrates information with regard to OH&S and the environmental quality within industry work sites in the nation. The stakeholders recognised the importance of the OH&S of the workers and the need for an effective and efficient monitoring and surveillance system, which must be based on a comprehensive and integrated database system. It is imperative for Thailand to further strengthen its national policy for enterprises to improve safety and health [181]. Efforts are needed to identify priority action areas to accelerate the improvements in enterprises.

**OH&S and EIP**

As mentioned earlier, despite the existing problems in OH&S practices, specific OH&S problems vary depending on the specific sector and industry. OH&S may be one of the biggest, and in the future, most influential factors affecting the workplace both financially and from a human resource perspective, if not planned and addressed properly. In the EIP,
OH&S plays its important role under several headings: as an important benefit to workers and industry, as a basic need in every enterprise and as a criterion for sustainability. Although most of the EIPs recognise the process of environmental management as the main element of the EIP, the use of OH&S as an indicator of sustainability has not been widely applied over time. The Thai government has recognised these problems and realised that health and safety has the potential to increase profits for the employer, as well as protect the well-being of the employee. However the intention has always been to value human life over profit. These OH&S laws and regulations have been developed and been addressed as a criterion for the EIPs for good reasons. OH&S in EIPs is not only about ensuring health and safety working conditions in the workplace but also concerning the safe and healthy of the residents in the surrounding area. So, at the most basic level, the employer is required to provide a safe workplace but at the upper level, OH&S can be promoted as a part of EIP to enhance the sustainable development and reduce safety risks to owners, workers and communities.

4.6 Conclusion
The occupational health and safety issue is becoming more important in Thailand. Although all government organisations need to collaborate to solve or alleviate the problems, other effective control measures, particularly suitable measures at the enterprise level, are also essential. Thailand has performed the OH&S in the country for over five decades; nevertheless, certain problems still persist. There are some overlapping roles and responsibilities among different government agencies in the regulations with similar content. These situations indicate the need for the strengthening of cooperation between these agencies. Other problems are the confusion in the enterprises regarding OH&S regulations and the inadequacy of inspection by government agencies. In the workplace, workers are poorly protected from workplace due to the inadequate provision of personal protective equipment and inadequate knowledge about OH&S. Such an approach, if focused on developing policies to protect and support industrial sector, would ensure Thai remained a sustainable industry, while at the same time protecting both the environment and human health.

As the final chapter of Part I, Literature Review, this chapter has discussed OH&S characteristics and identified the approach to their implementation in EIP projects. All these features will be examined in the case study of this research. Part II, Research
Methodology and Key Results and Findings, will identify and discuss the details of the research design and methodology and present the findings.
Part II: Research Methodology, Results and Key Findings

Chapter Five

Research Design and Methodology
5.1 Introduction

Part I provided background information about this research drawn from the literature review. It critically reviewed the contextual fields of this research – namely, eco-industrial park (EIP), the Thai organisational setting and occupational health and safety (OH&S).

This chapter, Chapter Five, the first chapter of Part II, describes the conceptual framework and methodology used in this study. The chapter shows how the research question was developed based on the research background and rationale, presents a conceptual framework, and provides an overall picture of the study design and the rationale for the particular methodologies used. The chapter then describes the implementation of fieldwork and the data analysis process. The approaches used to improve validity and reliability of the data is explained. And lastly, issues of rigour and ethics associated with the study are addressed.

5.2 Research Location and Site

This research was undertaken in the Saha Group Industrial Park, Sriracha, Chonburi province, Thailand. Chonburi is an eastern province of Thailand. Surrounding provinces are Chachoengsao, Chanthaburi, and Rayong (from north clockwise). The west side of province is the Gulf of Thailand. Chonburi is very well known as Thailand's largest tourist oriented city, Pattaya. It is the only province outside the Bangkok Metropolitan Area to be connected by an eight-lane motorway to Bangkok, 80 km distant. It is also acknowledged as Thailand's largest and primary seaport. The province's population is growing speedily. Chonburi is subdivided in 11 districts (amphoe) as Mueang Chon Buri, Ban Bueng, Nong Yai, Bang Lamung, Phan Thong, Phanat Nikhom, Ko Sichang, Sattahip, Bo Thong, Ko Chan, and Sriracha. These are further subdivided into 92 subdistricts (tambon) and 691 villages (muban).
Saha Group Industrial Park is an industrial area project founded by Sahapatana Inter-Holding Public Company Limited (SPI) to support the development of the factories in the group and in support of the government’s policy of income distribution in the rural areas. Presently, the company (SPI) has a policy of selling land to general investors and the company [209]. At present, the company operates three Industrial Parks, one in Sriracha District, Chonburi Province; one in Kabinburi District, Prachinburi Province; and the third in Lamphun District, Lamphun Province. From the pilot projects launched by DIW in 2012, Saha Group Industrial Park, Sriracha is one of seven potential Industrial Park zones which plan to develop into eco-industrial parks.

The company has invested in share capital in several businesses with a goal of adding value to the company in the long term. The company has invested in the businesses that enhance other businesses undertaken by the companies in the group or in business that will possibly be undertaken in the future due to its potential benefits. The company will hence get a return in the form of dividends. The company currently invests in three major
lines of businesses: production, distribution, and services. As of 2013-2015, the company has investments in the shares of companies as shown in Table 5.1.

Table 5.1 Investment in Share Capital in Saha Group Industrial Park during 2013-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Business</th>
<th>No. of Companies</th>
<th>Net Investment Amount</th>
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<td></td>
<td></td>
<td></td>
<td>Unit: Thousand Baht</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>1. Production</td>
<td>84</td>
<td>9,087,207</td>
</tr>
<tr>
<td></td>
<td>2. Distribution</td>
<td>17</td>
<td>5,464,911</td>
</tr>
<tr>
<td>[209]</td>
<td>3. Service and other Business</td>
<td>47</td>
<td>823,277</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>148</td>
<td>15,375,395</td>
</tr>
<tr>
<td>2014</td>
<td>1. Production</td>
<td>80</td>
<td>10,466,124</td>
</tr>
<tr>
<td></td>
<td>2. Distribution</td>
<td>25</td>
<td>5,891,345</td>
</tr>
<tr>
<td>[210]</td>
<td>3. Service and other Business</td>
<td>46</td>
<td>903,463</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>151</td>
<td>17,260,932</td>
</tr>
<tr>
<td>2015</td>
<td>1. Production</td>
<td>80</td>
<td>10,757,730</td>
</tr>
<tr>
<td></td>
<td>2. Distribution</td>
<td>25</td>
<td>6,199,348</td>
</tr>
<tr>
<td>[211]</td>
<td>3. Service and other Business</td>
<td>48</td>
<td>966,656</td>
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<tr>
<td></td>
<td>Total</td>
<td>148</td>
<td>17,923,734</td>
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Saha Group Industrial Park, Sriracha was constructed on 632 acres (255 hectares) of land in the Laem Chabang area of Sriracha, (see Figure 5.1). There were approximately 24,000 workers in 2014. It presently offers various facilities and infrastructure services as follows:

- A 174 - Megawatt Power Plant capable of providing adequate power backup 24 hours a day. The power plant is operated by Sahacogen (Chonburi) Public Company Limited with an electricity sales license issued by the Energy Regulatory Commission Office, the Ministry of Energy. The excess steam from the generation of electricity is also sold to factories located inside the industrial park.

- The standard centralised wastewater treatment which was certified by Siam Environment Group in 1993. Its capacity can treat daily 12,000 cubic meter waste water to the effluent standard of the DIW.

- Air - field with the private license from the Commercial Aviation Department.
• Reservoir with raw water storage capacity of 850,000 cubic meters.
• The daily water supply capacity of 20,000 cubic meters.
• Business supplementary service sector, which is a centre for selling products from Saha Group under the symbol “Thailand Best”, operated by Kabin Pattanakij Co., Ltd.

Figure 5.2 Map of Saha Group Industrial Park, Sriracha [210, 212]

With its awareness of the beneficial effects from business operation and other operations in the industrial park, the company (SPI) has seriously complied with all the laws and regulations regarding occupational health, safety and environmental impact [213]. The company has been continuously improving the environmental management system to reach international standard. All through the operational years, Saha Group Industrial Parks have considered the importance of any emergency which may occur and significantly affect the industrial parks’ overall operations. Consequently, due to the risk assessment of factories within industrial parks, the company has prepared foam extinguishers in sufficient quantity and purchased a fire truck ready to control the unexpected situation or emergency situation.
5.3 Research Conceptual Framework

5.3.1 Background and rationale

The rapid development of EIPs in most parts of the world indicates that there are numerous benefits attached to them and there are more beneficial opportunities that industries could pursue. The exploitation of those opportunities, however, is limited by the lack of a comprehensive method to measure the success of EIP projects. The research rationale provides the justification for this research, including its overall goal. It describes how the research helps fill gaps in existing knowledge or solve a particular problem. The main issues in the rationale for this study are

- Although there is growing recognition of the importance of EIP in the interdependent world, and they have been researched in other parts of the world, research regarding the current and future direction of EIPs is not desirable especially in the Thai context.

- EIPs are new and still at a very early stage in Thailand, a developing country with a large population and imbalanced development. The literature provides recommendations for effective management to support projects and specific criteria for measuring effectiveness, but there is still limited research on the effective implementation of EIP projects in Thailand.

- In 2012, Thailand launched specific criteria for assessing their effectiveness, and kicked off some pilot projects in critically polluted areas. Unfortunately, all pilot projects only focused on 'wastes' and 'by-products' management in the environmental dimension, and no EIP has met even those criteria. Other criteria have not been addressed in the research to date.

- Apart from the waste and by-product criteria, “health and safety” is one of the criteria which is also proposed as an aspect in environmental dimension for companies wishing to enter an EIP. Nevertheless, there are few published articles to guide the EIP implementation projects in Thailand and none concern this criterion even though by law the data is readily available from every company.

Finally, EIP needs to consider a combination of other criteria. To achieve status as an EIP, an IP needs to meet various eco-criteria in physical, economic, social, cultural and management dimensions. These include not only energy efficiency, waste management, land use, and material / chemical flow, etc. but also OH&S and other non-physical eco-
criteria. Eco-industrial development is not limited to the types of activities which focus on a group of companies implementing physical environmental technologies. Evaluation of an EIP needs to consider these non-physical criteria as well. Integrating H&S into a method of evaluation for EIPs in Thailand is a new challenge. Ordinarily, H&S, particularly OH&S, has not achieved a high profile in discussions of sustainable development. Many studies have identified the place of OH&S in sustainable development as a small part in an attempt to make arguments regarding OH&S in a particular agenda. The purpose of this study is to examine the feasibility and utility of applying the eco-criterion of health and safety to assess enterprises performance towards developing into an EIP by reviewing the status of OH&S in the IP case study and its role in the development of EIPs.

5.3.2 Research question and focus questions

The main research question in this study is

“What are the feasibilities and challenges of utilising OH&S performance to assess and guide eco-industrial parks development in Thailand?”

To answer this question, this study will propose five focus questions.

The existing EIPs throughout the world have evolved primarily through developing complementary bilateral relationships between companies. Although many of the enabling processes for EIPs have been used in different contexts worldwide, their application to industrial ecology is new. Thus the first focus question is: “What have been the reasons for and achievements of eco-industrial parks globally?”

Developing and managing EIPs will require applying new and significantly improved strategies both in developed and developing countries such as Thailand. Thus, the second focus question to identify the practices of eco-industrial parks in Thailand is the following: “What have been the experience and progress of eco-industrial parks in Thailand?”

There have been a number of EIP projects in Thailand launched by the government agencies since 2000. Almost all of them try to apply eco-criteria such as waste exchange and water or waste water management in the environmental dimension to help the industrial firms to attain eco-industrial status. Nevertheless, no industrial parks in Thailand have yet been recognised as successful in the EIP paradigm. Alternatively, the DIW has proposed the appropriate management of OH&S as one of 20 aspects of EIP
development that can be used for evaluation of eco-industrial status. So, clearly understanding the current implementation of OH&S in a selected IP must be addressed in the third focus question. Thus the third focus question is: “What is the current system and development of OH&S in Thailand particularly within IP?”

The requirements for fully meeting the criteria for OH&S in industrial ecology are a new challenge for evaluation of EIP performance. Barriers and challenges concerning OH&S issues relating to the personal safety and protection of workers are a very important health concern for industry. The challenges include awareness of and participation of firms in OH&S. Thus, the fourth focus question is the following: “What are the feasibilities and challenges of using OH&S performance of the Saha Group Industrial Park as a case example to assess its progress towards the EIP requirements in Thailand?”

Besides the feasibilities, barriers and challenges in meeting the requirements of OH&S regulations are an essential concern for industry. In order to effectively utilise OH&S to assess how well an enterprise meets the requirements and to guide the development of EIPs in Thailand, the fifth focus question must be “What are the strategies needed for government and industry stakeholders to consider concerning using OH&S performance to guide the EIP development in Thailand?”

The findings of this study should provide guidance to the policy makers and stakeholders for the use of OH&S as a criterion for the future development of EIP in Thailand.

5.3.3 Contextual fields and conceptual framework of the research

**Contextual fields**

This research draws upon three contextual fields – namely, eco-industrial park (EIP), the Thai organisational setting and occupational health and safety (OH&S). Firstly, eco-industrial parks (EIP) form one of the strategies to implement the concept of industrial ecology by inter-company collaboration. The overall concept is that EIP development combines business success, environmental excellence, and community relationships to create economic opportunities and promote environmental sustainability. Secondly, occupational health and safety is a cross-disciplinary area concerned with protecting the safety, health and security of people engaged in work or employment. The goal of all OH&S programs is to support a safe work environment. Integration of OH&S objects into environmental management systems can avoid duplicate measures and can lead to optimal solutions, because the regulations for prevention of harm are identical in environmental
protection and safety management. Thirdly, Thailand is set as the research site. Its cultural and regulatory framework is unique, but also typical of several other newly industrialised countries. These contextual fields are theoretically and practically linked and they guide and inform the research.

**Conceptual Research Framework**

The conceptual research framework for this study, which is based on the contextual fields, is shown in Figure 5.3. It explains the various relations between the different concepts used in this study. It depicts the linkages between OH&S and EIP concepts which are influenced by several factors.

This study of the driving factors behind the emergence of eco-industrial projects in a developing and newly industrialised country aims to provide a base of knowledge and insight for better understanding the framework of EIP and for promoting the future development of eco-industrial projects in Thailand.

To examine the implementation of OH&S in EIP, this study focuses on OH&S issues which related to the EIP regulations in a potential eco-industrial park. To present the OH&S management of a group of companies operating in the area in EIP case study, secondary data from IP report are gathered to describe the practice and operation of the IP. Then, a questionnaire survey of the safety officers in participating factories is used to evaluate the level of awareness and participation of IP members in OH&S implementation through industrial ecology schemes. In addition, in-depth interviews with the manager or the personnel in charge of IP businesses and observation are used to identify the problems, barriers, and needs that hinder the good operation and more effective OH&S management in line with EIP regulations in Thailand.
Figure 5.3 Conceptual Research Frameworks
5.4 Research Design and Methodology

This research utilised mixed methods in order to gain complementary views about the same phenomenon. The research basically used qualitative methods, while engaging quantitative methods to supplement the findings obtained from the qualitative methods. The researcher started by exploring the key influencing factors and challenges in EIPs worldwide and in Thailand by using the qualitative approaches of a document review and analysis and in-depth interviews. Then, based on the qualitative findings, a case study was conducted. Both qualitative and quantitative data were collected and analysed concurrently and then merged to present a more complete understanding of the research aims, or to compare the different results.

5.4.1 Research design

Research design is the argument for the logical stages which will be taken to connect the research question and issues to data collection, analysis and explanation in a coherent way [214]. As Yin (1989) states, research design deals with a logical problem and not a logistical problem [215]. It is a “logical plan” for getting the “initial set of questions to be answered” to “some set of conclusions (answers) about these questions” [216]. Between the “questions” and “answers”, there are a number of major steps, including the collection and analysis of relevant data. A research design introduces the investigator into the process of collecting, analysing, and interpreting observations [217]. The aim of this section is to develop a research method for this study. This section draws the processes of the research design and discusses the theory and rationale of methods chosen in this research. The research design provides the stages of the study, including qualitative techniques, data collection methods, and data analysis techniques. The research methodology explains why and how the methods in this research were chosen. The approach to answering the research questions is to develop a case study of a potential EIP. This study utilises Saha Group Industrial Park, Sriracha, which has been involved with the EIP Project since the year 2012, as a case study to explore the implementation of OH&S in the Park. At the end, guidelines for developing, and managing the operation of OH&S in industrial park to meet the requirement of EIP regulations in Thailand will be offered. These guidelines identify the problems; awareness and participation of industrial park factories, and provide examples of how actual EIPs have handled each issue. The method used to carry out the EIP case study is divided into three stages:

The first stage: Develop a research protocol
This research started by reviewing relevant literature and documents of the research contextual fields. The activities performed were: definition of the problem, definition of research goals, and definition of inclusion and qualification criteria and definition of the search methodology and generating a research protocol.

The second stage: Fieldwork and data collection

In this stage, the data were collected from the survey questionnaire, observation, in-depth interviews and focus group discussion to respond to the first, second and third focus questions by using qualitative and quantitative techniques and tools. To address the focus question, the initial data was collected by document reviews from IP records to create a picture of the current situation in OH&S as well as the implementation of EI systems in line with EIP regulations. The main objective was focused on gathering data concerning barriers and challenges, awareness and participations of participating IP enterprises.

The third stage: Data analyses

This stage comprised synthesis and interpretation of the findings from articles, summary of results and content analysis. Finally, the factors needed to develop OH&S management along with EIP regulation in Thailand were proposed in order to answer the fourth focus question. Results from the collected data were summarised to propose guidelines for developing and managing the OH&S aspects of EIPs.
Figure 5.4 Research design in this study
5.4.2 Data collection and analysis

This research utilised mixed methods in order to gain complementary views about the same phenomenon. The research mainly used qualitative methods, while engaging quantitative methods to complement and enlarge the qualitative methods. The combination of methods was used to achieve a comprehensive collection and analysis of data. Further, the specific findings were explored through structured interviews, in-depth interviews, questionnaire survey, and focus group discussions with different stakeholders in the factory (e.g., safety officer, workers, and HR officer), as well as through direct observation and relevant document review. Data Collection (DC) Matrix in this study can be seen in Table 5.2.

Table 5.2 Data Collection (DC) Matrix

<table>
<thead>
<tr>
<th>Research Aim</th>
<th>Research Question/Focus Question</th>
<th>Data Collection</th>
<th>Data Analysis</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ: What are the feasibilities and challenges of utilising OH&amp;S performance to assess and guide eco-industrial parks development in Thailand?</td>
<td>Document review / 2nd Data</td>
<td>Content Analysis</td>
<td>Literature concerning EIP Development Worldwide</td>
<td></td>
</tr>
<tr>
<td>To understand the nature, purpose, and historical development and achievement of EIPs globally</td>
<td>FQ1: What have been the reasons for and achievements of eco-industrial parks globally?</td>
<td>Document review / 2nd Data</td>
<td>Content Analysis</td>
<td>Literature concerning EIP Development Worldwide</td>
</tr>
<tr>
<td>To examine the history and progress of EIPs in Thailand</td>
<td>FQ2: What have been the experience and progress of EIPs in Thailand?</td>
<td>Document review / 2nd Data / in-depth interviews</td>
<td>Content Analysis</td>
<td>Literature concerning EIP development</td>
</tr>
<tr>
<td>To assess the current system and historical management in IP.</td>
<td>FQ3: What is the current system and 2nd Data</td>
<td>- Content Analysis</td>
<td>-OH&amp;S</td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>Research Question/ Focus</td>
<td>Data collection</td>
<td>Data Analysis</td>
<td>Indicators</td>
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</tr>
<tr>
<td>development of OH&amp;S in Thailand particularly within IPs</td>
<td>development of OH&amp;S in Thailand particularly within IP?</td>
<td>observation / Questionnaire survey from 44 factories/ FGD/ in-depth interviews</td>
<td>- Descriptive statistics</td>
<td>- Level of awareness, participation of firms in OH&amp;S management through IE schemes.</td>
</tr>
</tbody>
</table>

To investigate the feasibilities, barriers and challenges for using OH&S as an indicator of EID achievement through examining OH&S performance of a Saha Group Industrial Park as a case example to assess its progress in meeting the requirements and guiding EID in Thailand?

<table>
<thead>
<tr>
<th>Question</th>
<th>Analysis</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>FQ4: What are the feasibilities and challenges for applying OH&amp;S performance of the IP towards the EIP?</td>
<td>- Content Analysis of descriptive statistics</td>
<td>Feasibilities and challenges for applying OH&amp;S performance of the IP towards the EIP</td>
</tr>
</tbody>
</table>

To provide recommendations to assist the implementation of EID in Thailand?

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Synthesis of Results from collected data</td>
<td>Suggestions for implementation by Saha</td>
</tr>
<tr>
<td>Aim</td>
<td>Research Question/ Focus</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Thai government agencies, the IP and relevant organisations in developing policies and strategic plans for promoting more effective EIPs in Thailand</td>
<td>government and industry stakeholders to consider concerning using OH&amp;S performance to guide the EIP development in Thailand?</td>
</tr>
</tbody>
</table>

### 5.4.2.1 Document review

A document review is a data collection technique which is commonly used in the qualitative research. A document review aims to provide background to the research to determine the research gap (known and unknown). The purposes of a document review are to learn the history of the problem, to become familiar with the theoretical background of the problem, to assess the strengths and weaknesses of previous studies, to identify promising ways to study the problem and to develop a conceptual framework and rationale for the present study [218].

At least three problems can occur when documents are being assembled for content analysis. First, when a substantial number of documents from the population are missing, the content analysis must be abandoned. Second, inappropriate records (e.g., ones that do not match the definition of the document required for analysis) should be discarded, but a record should be kept of the reasons. Finally, some documents might match the requirements for analysis but just be not codable because they contain missing passages or ambiguous content [219].
Review of documents was conducted particularly to answer the FQ numbers 1, 2 and 3. The document review in this research focuses on several aspects of existing partnership such as EIPs experiences worldwide and in Thailand including current system and development of OH&S in Thailand. Because this section relies on the literature via industrial park reports, documents or other sources both in published and unpublished sources, the quality of data obtained is also determined heavily by the quality of available sources. This research aims to identify the implementation and challenges of EIPs project in Thailand (research question refers to “what” in depth) from a world context and needs to collect data in natural settings. Consequently, conducting a case study is necessary. The research selected Saha Group Industrial Park, Sriracha as the case study.

A document review was undertaken according to the two main contextual fields: EIP in Thailand and OH&S in workplace. The data was conducted by using the annual report and report on OH&S from IP and government agencies such as Chonburi Industry Office. Major databases and academic search engines were used for finding and accessing articles in academic journals, repositories, archives, or other collections of scientific and other articles. Moreover, various published and official webpages including the webpage of the site selected were also sited. These include:

- Safety and Health at Work Promotion Association (Thailand), http://www.shawpat.or.th/
- Occupational Safety and Health Bureau, http://www.oshthai.org/
- Department of Industrial Works, http://www.diw.go.th/
- Saha Pathanapibul PLC, http://www.sahapat.co.th/

The review drew on a large data source including books, journal articles, conference papers, government documents, policy reports, and company annual reports. Searches were varied and were derived from different sources. Most books were searched from the library catalogue. Journal article searches were made from the library catalogue, and reference lists of retrieved articles and textbooks, and electronic literature databases, including Science Direct, John Wiley and Sons, EVISE or Elsevier. All sources were searched for the period covered by the databases up to the present. Publications in all
languages were sought, although for non-English-language publications, only abstracts in English and Thai were evaluated. Google Scholar was used to search for sources from the internet. The internet web sites of international organisations and governments, as well as any of their relevant documents were accessed. Websites in English and Thai were accessed. Documents and reports regarding Thailand were of particular interest. Google was also used to search Thai web sites and documents. Publications and documents both in English and Thai were sought. The unpublished papers of oral reports and presentations, which came from Thai formal and informal academic conferences and government meetings, were also considered. The key search words varied depending on the topics of the different contextual fields. They included: eco-industrial park, eco-industrial development, industrial ecology, occupational health and safety. The initial search produced hundreds of sources related in some way to the research. All the sources were first screened for relevance from their titles and abstracts. The relevant articles were then evaluated for their content from the introductions and conclusion sections to decide whether they were worth selecting for further study. Only sources that addressed some aspects of this research were included. Based on the literature thus selected, the researcher developed the research question and designed the research plan. The literature review went through the every part of the research.

5.4.2.2 Plant observation

Observation is the active acquisition of information from a primary source. Observations are interpreted and accredited by theories, and theories are devised by human scientists [220]. In practice, observers do not only make direct measurements (observations), but also conduct interviews and surveys using questionnaires. They might also be involved in data processing and analysis. The tasks of an observer are difficult and adequate training and supervision is therefore essential. Clear decisions need to be made about the extent of data collected during any one trip. Often, the amount of data and frequency of collection can be established analytically with preliminary data [221]. Preferably, observers should only collect data, not carry out other activities. This should help to minimise bias by reducing the incentives to lie. Problems in terms of conflicts between data collection and law enforcement, for example, can be reduced by clear demarcation, separating activities by location or time.

Observational analysis involves watching, listening to, monitoring and interacting with workers in factories, to determine the way in which they carry out tasks [222]. Direct
observation involves looking at user behaviour during task execution and recording user actions as they occur. An evaluator making notes of user actions during task completion is one example of direct observation; recording the task using a video camera and then analysing the tape for user actions, is another example of direct observation. Direct observation is useful in that it allows the observer to focus on specific aspects of the task; however, direct observation can cause users to alter their behaviour, according to how they think they should be acting, conscious that they are being observed.

In this study, besides collecting qualitative data, the researcher also collected quantitative data. During the field work, the researcher observed all the relevant project management in the industrial park by attending management meetings, with permission from the park owner, SPI. She also monitored the IP activities by listening to the workers chatting in their breaks, and then recording the important comments. She also took photos of the site and the waste-water management operation. Observation was conducted particularly to support the FQ numbers 3 and 4. Moreover, the researcher interviewed all the key informants using the semi-structured interview which focused on the same topics. The observer is also the researcher; she coded and analysed all the data. The researcher kept all the detailed transcriptions of interviews and notes of participant observation in a secure place.

5.4.2.3 Quantitative survey and data analysis

The quantitative data collection used a questionnaire and also provided interview questions to obtain deeper information. A very important aspect of research work is a survey or questionnaire. A questionnaire is usually composed of one or more questions, answered by a number of people normally called potential clients or the target market. A survey is a tool used by employers to measure employees' attitudes about their workplace environment. Its general purpose is to pinpoint problems and make improvements within the company or organisation, with the goal of enhancing employee morale and productivity. Descriptive statistics is the discipline of quantitatively describing the main features of a collection of information or the quantitative description itself [223]. Descriptive statistics are distinguished from inferential statistics, in that descriptive statistics aim to summarise a sample, rather than use the data to learn about the population that the sample of data is thought to represent. This generally means that descriptive statistics, unlike inferential statistics, are not developed on the basis of probability theory [224]. Even when a data analysis draws its main conclusions using inferential statistics,
Descriptive statistics are generally also presented. Some measures that are commonly used to describe a data set are measures of central tendency and measures of variability or dispersion. Measures of central tendency include the mean, median and mode, while measures of variability include the standard deviation (or variance), the minimum and maximum values of the variables, kurtosis and skewness.

This approach is used to address the focus question number 3 and 4. Respondents were safety officers or personnel in charge who are involved actively in OH&S management in the factories in Saha Group Industrial Park, Sriracha. A questionnaire was sent to the factories officially, and 44 out of 65 factories responded. For the questionnaire details see Appendix A. In this research, the questionnaire survey was conducted by self-check, self-correction and rectification by the factory’s safety officer or personnel in charge of OH&S. The indicators cover the implementation of OH&S management in the enterprise and the questions were pretested before the survey was conducted. The questionnaire was designed based on the OH&S and EIP indicators with input from experienced experts in these disciplines. Before the survey was applied, the questionnaire was also reviewed by several relevant experts and was pretested. The researcher was involved in questionnaire collection, analysis and reporting.

In this study, the survey results were analysed by using descriptive statistics and direct comparison with the EIP regulations. The results for each topic are presented as a table of results and/or a graph or pictogram. A comprehensive questionnaire was completed by the safety officers/personal in charge of OH&S at each factory (Appendix A). The researcher was involved in this questionnaire survey process and data analysis. The field investigation collected data consisted of 3 groups as follow:

Group 1: Factory safety officers
The survey questionnaire was sent to the factories by the parent company. Out of 65 factories, 44 responded by requesting the safety officer or person in charge of OH&S to fill in the form. The indicators cover the implementation of OH&S management in any business and the questions were pretested before the survey was conducted. The survey tool used to collect data consisted of 5 parts:

Part 1 General Data comprised of Factory Data and Personnel Data.

Part 2 Health and safety Data such as Management Systems Accident Record, Occupational Health Care, Emergency plan and Personnel Data.
Part 3 The awareness of the enterprise about occupational health and safety through the requirements of eco-industrial regulations.

Part 4 Opinions on occupational health and safety management in industrial ecology schemes. The questionnaire is a five-point scale where 5 means ‘strongly agree’ and 1 means ‘strongly disagree’.

<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Moderate/Undecided</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

Part 5 Problems, obstacles, and suggestions

The survey data, information sheet, and informed consent form for questionnaire surveying are presented in Appendices A to C respectively.

Group 2: Key leaders and managers

The leaders and managers group consist of the manager or the personnel in charge of the industrial park (1), safety officer of the industrial park (2), specialists (3), local politician (1), I-EA-T and DIW officers (2). The in-depth interview was used to get more specific data to identify the opportunities to improve OH&S in the prototype EIP from the point of view of professionals or decision makers. It provides data to answer research questions 1, 2 and 4, as well as answering those objectives covered in all other aspects, including the points of view of the various agencies involved.

The draft of Interview questions, information sheet, and informed consent form for in-depth interviews are presented in Appendices D to F respectively.

Group 3: Workers

The workers from the IP factories were invited to participate in focus group discussions (FGD). There were three groups of 6-8 employees who participated voluntarily. The participants came from each factory or enterprise group in the IP. The two main issues of discussion were problems and obstacles in the implementation of OH&S in their unit and the participation of workers in the IP in eco-industrial issues, especially OH&S.

The Ethical issues and informed consent form in focus group discussion are provided in Appendices G and H.
According to Neuman (2011), researchers do several things to the quantitative raw data: reorganise them into a form that fit for computers, figure them in charts or graphs to summarise their features, and interpret or give theoretical meaning to the results [225]. In this study, the researcher analysed some secondary data from the field work. For these quantitative data, the researcher first coded the raw data. Then using software SPSS 19 analysed the data and described the numerical data with a frequency distribution, percentages, mean and standard deviation.

5.4.2.4 Qualitative survey and data analysis

Focus Group Discussion (FGD)

A focus group discussion (FGD) is a good way to gather together people from similar backgrounds or experiences to discuss a specific topic of interest. The group of participants is guided by a moderator (or group facilitator) who introduces topics for discussion and helps the group to participate in a lively and natural discussion. The strength of FGD relies on allowing the participants to agree or disagree with each other so that it provides an insight into how a group thinks about an issue, about the range of opinion and ideas, and the inconsistencies and variation that exists in a particular group in terms of their beliefs, experiences and practices. FGD can be used to explore the meanings of survey findings that cannot be explained statistically, the range of opinions/views on a topic of interest and to collect a wide variety of local terms [226].

There are several technical aspects which have to be considered while undertaking effective FGD in this research. The first is duration of FGD, normally a focus group discussion does not take more than one and a half hours [227]. However, sometimes it depends on participants and on the level of interest in the issues discussed. The second aspect is focus group interaction; a focus group discussion is not a group interview. To gain maximum results with accurate and valid data, the moderator plays an important role [227]. Moderators need to have experience in guiding focused discussion. The characteristics of a good moderator are sensitivity to the participants’ needs, respect for the participants, and open-mindedness [226]. In addition, a moderator needs to have knowledge, good listening skills, strong leadership and observation skills, and patience and flexibility [227]. In this research, the moderator was the researcher herself, since she has experience in undertaking qualitative research, in particular FGDs. The third consideration is language issues. The most effective FGD can be obtained if the focus
Discussion is conducted in participants’ own language, in this case, in the Thai language. Participants can explore their ideas more fully if they use their own language [227]. The fourth aspect which was considered in obtaining an effective focus discussion in this research is whether the group should be a homogeneous group or a heterogeneous group. The fifth aspect is number of participants, basically the number of participants for an effective focus group is between six to ten participants session but some sessions may have up to twelve participants [228, 229]. The participants were chosen deliberately based on IP worker’s participation considering all the aspects of an effective FGD.

Any observations during an FGD should be noted and included in the report. Thus, an important aspect of an effective FGD is the note-taker. A moderator has to focus on guiding participants in order to run the discussion well so a moderator cannot be a note-taker. Therefore, this research also provided a note-taker (called assistant moderator) for the discussion groups.

In this study, FGD was undertaken in Saha Group Industrial Park, Sriracha and used to answer the focus question number 3 and 4, particularly to assess the awareness and participation of the workers about OH&S management in their workplaces and EIP in IP. The researcher team also conducted three focus group discussions by using the opportunities of a workshop meeting. The participants were officers from the factory who participated voluntarily; each group included six participants. The two main issues of discussion were problems and obstacles in the implementation of OH&S in their unit and the participation of workers in IP concerning EIP issues. Box 5.1 shows the outline of focus group note-taking summary that was used in this study.

The researcher, as a moderator, introduced the topic and assisted the participants to discuss it, encouraging interaction and guiding the conversation. Each focus group discussion lasted around one hour.
Box 5.1 Focus group note-taking summary

<table>
<thead>
<tr>
<th>Date of Focus Group</th>
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<tbody>
<tr>
<td>Location of Focus Group</td>
<td></td>
</tr>
<tr>
<td>Number of Participants</td>
<td></td>
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<tr>
<td>Category of Group</td>
<td></td>
</tr>
<tr>
<td>Moderator Name</td>
<td></td>
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<tr>
<td>Asst. Moderator Name</td>
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</tbody>
</table>

Responses to Questions

Q1. What are the problems and obstacles in the implementation of occupational health and safety in your agency? What are they?

<table>
<thead>
<tr>
<th>Brief Summary/Key Points</th>
<th>Notable Quotes</th>
</tr>
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</table>

Q2. Have you ever heard about the participation of Saha Group Industrial Park Sriracha in eco-industrial project? What do you think?

<table>
<thead>
<tr>
<th>Brief Summary/Key Points</th>
<th>Notable Quotes</th>
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*In-depth interviews*

In-depth interviews have various terminologies. In depth interviews are also described as focused interviews, instructed interviews, non-directive interviews, open-ended interviews, active interviews and semi-structured interviews [230-234]. These terms are
usually interchangeable. However, this researcher prefers to use the terms focused interviews or in-depth interviews because these interviews aim to obtain deeper information and understanding regarding the OH&S and EIP.

Before interviews can be conducted, it is essential to prepare some important components of this research. The first is to form a research team made up of research coordinators and team members. This team will work together to achieve the aim of this research. The second requirement is to provide a question guide for unstructured in-depth and semi-structured in-depth interviews, which are common formats in qualitative research [227]. The third aspect is to develop an in-depth interview which accounts for culture and language aspects. To obtain more accurate data, this research used the Thai language.

Another important consideration is data collection recording tools. The research team has to make records such as audiotapes of the discussion, notes taken by the note-taker during the interview, notes taken by observers and written or visual exercises and attitude statements completed by respondents. The equipment for all these has to be prepared before the research begins [235]. These tools are not only used during in-depth interviews but also during Focus Group Discussions.

In this study, in-depth interviews were used to answer focus questions number 2, 3 and 5. The researcher interviewed the decision makers (key persons) in relation to the OH&S and EIP partners in Saha Group Industrial Park, Sriracha. These interviewees included governmental bodies, local politicians, academics and other relevant stakeholders. These in-depth interviews were also used to obtain deeper information regarding the existing partnerships and a number of success factors for developing the OH&S management in line with EIP regulations.

Moreover, semi-structured in-depth interviews were conducted with key informants from various organisations who were associated with the EIP project, such as government officials at national and local levels, experts/heads of Industrial Park member, and experts/private sector informants from university (See Table 5.3). Interview guides were adapted to reflect the knowledge and experience of different sub-groups of key informants. Informed consent was obtained from all respondents. The information sheet and informed consent form for in-depth interview are presented in Appendices E and F. The interviews lasted between 50 and 90 minutes each and they were tape recorded and transcribed.
<table>
<thead>
<tr>
<th>Organisation of Key informants</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saha Group Industrial Park, Sriracha, Chonburi</td>
<td>12</td>
</tr>
<tr>
<td>Facility Manager</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Engineer in charge of OH&amp;S</td>
<td>1</td>
</tr>
<tr>
<td>Safety officers from Eastern Thai Consulting 1992 Co.Ltd. (Environmental agency responsible for Saha Group Industrial Park, Sriracha)</td>
<td>2</td>
</tr>
<tr>
<td>Chonburi Industry Office</td>
<td>1</td>
</tr>
<tr>
<td>Local industrial officer</td>
<td>1</td>
</tr>
<tr>
<td>Department of Industrial Work (DIW)</td>
<td>2</td>
</tr>
<tr>
<td>EIP staffs members from Bureau of Public Participatory Promotion</td>
<td>2</td>
</tr>
<tr>
<td>Industrial Estate Authority of Thailand (I-EA-T)</td>
<td>1</td>
</tr>
<tr>
<td>Research institute</td>
<td>1</td>
</tr>
<tr>
<td>The Joint Graduate School of Energy and Environment (JGSEE), King Mongkut University of Technology Thonburi (KMUTT)</td>
<td>1</td>
</tr>
<tr>
<td>Head of Environmental Engineering Department, Southeast Asia University</td>
<td>1</td>
</tr>
<tr>
<td>Faculty of Environment and Resource Studies, Mahidol University</td>
<td>1</td>
</tr>
<tr>
<td>Business Development Manager, Siam Cement Group (SCG)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>
For data analysis, Creswell’s (2009) [236] general procedure was used, as shown in Figure 5.5. In this research, the researcher analysed qualitative data in the following steps:

1. Transcribing Interviews: all relevant parts of the recorded interview data were transcribed from an audio to a text format.

2. Reading through the Data: in order to get the overall meaning of the data, all transcribed interviews were read through. This in-depth reading provided the foundation for the identification of relevant codes and themes.

3. Generating Codes and Themes: reading through all the data and coding to generate a small number of themes or categories. These themes are the ones that appear as major findings and are used to create headings in the findings sections of the research.

4. Interpreting the meaning of the themes: After having structured and presented the interview data, the researcher interprets the meanings of the coded data and compares these findings with information gleaned from the literature or theories.

Figure 5.5 Steps of qualitative data analysis (adapted from Creswell 2009:185) [236]

The individual steps of this procedure are listed and described below:

1. Transcribing Interviews: all relevant parts of the recorded interview data were transcribed from an audio to a text format.

2. Reading through the Data: in order to get the overall meaning of the data, all transcribed interviews were read through. This in-depth reading provided the foundation for the identification of relevant codes and themes.

3. Generating Codes and Themes: reading through all the data and coding to generate a small number of themes or categories. These themes are the ones that appear as major findings and are used to create headings in the findings sections of the research.

4. Interpreting the meaning of the themes: After having structured and presented the interview data, the researcher interprets the meanings of the coded data and compares these findings with information gleaned from the literature or theories.
The four steps of data analysis described here represent ideal abstractions. In practice, qualitative research procedures do not always follow this strict hierarchy as there is considerable iteration between the different stages throughout the research process [236].

**Recording the data**

**Writing field notes**
Field notes are the qualitative research equivalent to quantitative researchers’ raw data. During the field work, the researcher chose the important data to record and saved it to the hard drive and external drive.

**Transcription**
It is important to transcribe everything that is said during the interviews, including the interviewer’s own questions and probes, because these shape the respondent’s answers [237]. It is also important to transcribe everything the respondent says, including things that do not seem important or relevant to the topic, because what seems irrelevant at one stage of interviewing might seem much more relevant at a later time during the analysis phase [237].

In this research, all interviews and the focus group discussions were recorded with a digital recorder and then transferred to the computer. The in-depth interviews and group discussions were transcribed and downloaded electronically into the researcher’s personal laptop. The transcription includes everything that was recorded during the interviews and focus groups discussions, including the researcher’s own questions and remarks, and everything the respondents said. Key themes were identified in the interview transcripts.

**Coding**
This research follows the general processes to code qualitative data: Open Coding which examines the data to condense them into preliminary analytic categories or codes; Axial Coding which organises the codes, links them, and discovers key analytic categories; and Selective Coding which examines previous codes to identify and select data that will support the conceptual coding categories that were developed [225]. The open coding focused on the actual data and on assigning code labels for themes. It then organised ideas or themes and identified the axis of key concepts in analysis.

Finally the researcher reorganised specific themes identified in earlier coding during the selective coding. Based on the coding, the case descriptions were formulated. The
The researcher first imported all the data, including interview transcripts, field notes, memos into the computer, then created nodes as storage devices for ideas, coding, and the results of searches. Almost all information and data were managed and analysed during the fieldwork. The translation of the information from Thai to English, and the final analysis, were completed in Australia.

Like most types of research, the amount of analysis required varies with the purpose of the research, the complexity of the research design, and the extent to which conclusions can be reached easily based on simple analyses [238]. The most common analyses of focus group results involve a transcript of the discussion and a summary of the conclusions that can be drawn. There are occasions, however, when a transcript is unnecessary. When decisions must be made quickly and the conclusions of the research are rather straightforward, a brief summary may be all that is necessary. Nevertheless, some type of report is almost always helpful, if only to document what was done for historical and auditing purposes. Table 5.4 shows the summary of research conduct of study.

Table 5.4 Summary of Research Conduct of Study

<table>
<thead>
<tr>
<th>Data Collection Method</th>
<th>Instrument</th>
<th>Informants</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review/</td>
<td>Search engine,</td>
<td>Document review</td>
<td>The practices, nature, purpose, and historical development and achievement of EIPs globally and Thailand, OH&amp;S in Thailand. (FQ1, FQ2, FQ3)</td>
</tr>
<tr>
<td>Secondary Data</td>
<td>Annual report and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Report on OH&amp;S from IP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observation</td>
<td>Note taking and</td>
<td>General observation in OH&amp;S operation</td>
<td>Overview of Industrial Park implementations. (FQ2, FQ3)</td>
</tr>
<tr>
<td></td>
<td>digital camera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td>Questionnaire</td>
<td>OH&amp;S officer or the personnel in charge of OH&amp;S section of the</td>
<td>OH&amp;S Data, opinions acknowledgement, problems, obstacles, and suggestions of</td>
</tr>
<tr>
<td>Questionnaire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Collection Method</td>
<td>Instrument</td>
<td>Informants</td>
<td>Information</td>
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<tr>
<td>------------------------</td>
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<td>-------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>organisations on OH&amp;S in factory level through the requirements of EIP regulations. (FQ2, FQ3)</td>
<td></td>
</tr>
<tr>
<td>Focus group discussion (FGD)</td>
<td>Moderator, Note taking and digital camera</td>
<td>3 groups of 6 workers who participated voluntarily.</td>
<td>1. Problems and obstacles in the implementation of OH&amp;S in their unit 2. The participation of workers in IP over EIP issue. (FQ3, FQ4)</td>
</tr>
<tr>
<td>In-Depth Interviews</td>
<td>Interview schedule and tape recording</td>
<td>Representatives from various agencies involved - Manager or personnel in charge of OH&amp;S in IP (1) - OH&amp;S Operation at IP level: safety officer of IP (2) - Safety officer of Industrial Park in Sriracha - Specialists - I-EA-T officers - DIW officers - Local politician 3. EID opportunity from professional point of view: specialists (3) 4. National level decision making from major policy: I-EA-T and DIW officers (2) 5. Local level decision making from major policy point of view: local politician (1) (FQ2, FQ3, FQ5)</td>
<td></td>
</tr>
</tbody>
</table>
5.5 Issues of Rigour and Ethics

5.5.1 Issues of rigour in mixed methods research

Research rigour is assessed in different ways depending whether the research is quantitative or qualitative [239, 240]. In quantitative research, the criteria for rigour include validity, reliability, replicability and generalisability [241]. In qualitative research, the issues of reliability and validity are not as readily codified, so the criteria for rigour need to address reliability and validity differently. However, varieties of methods do exist and are used including the use of counting in qualitative research, the development of systematic coding schemes with the aid of computer programmes, and the use of the transcription techniques of conversation analysis [242]. Given the differences between quantitative and qualitative methodologies in evaluating rigour, establishing rigour in mixed methods research is complex and requires additional consideration [243].

5.5.2 Typologies of mixed-methods research

The integration of quantitative and qualitative research benefits from a formalised approach [244]. Creswell et al. (2003) argue that giving names to types of mixed-methods research has certain advantages [245]. It informs a point of the rigour of the research and provides guidance to others about what researchers expect to do or have done. In an attempt to simplify researchers’ design choices, several researchers have developed typologies [246-249]. Naming the typologies of mixed-methods or multi-strategy research can be supportive to researchers and/or writers in explaining their intentions or achievements. It is an exercise in logically possible types of integration, rather than building something entirely new. Nevertheless, it is not possible for a typology of mixed methods designs to be meticulous [247] because ‘the actual diversity in mixed methods studies is far greater than any typology can adequately encompass’ [248]. Fully mixed method designs demonstrate the highest degree of mixing research methods and research paradigm characteristics [250]. Once a study combines quantitative and qualitative techniques to any degree, the study no longer can be viewed as utilising a mono-method design. Collins, Onwuegbuzie, and Sutton (2006) identified four rationales for conducting mixed research: participant enrichment (e.g. mixing quantitative and qualitative research to optimise the sample by using techniques that include recruiting participants, engaging in activities such as institutional review board debriefings, ensuring that each participant
selected is appropriate for inclusion), instrument fidelity (e.g. assessing the appropriateness and/or utility of existing instruments, creating new instruments, monitoring performance of human instruments), treatment integrity (i.e. assessing fidelity of intervention), and significance enhancement (e.g. facilitating thickness and richness of data, augmenting interpretation and usefulness of findings) [251, 252]. Further, Guba and Lincoln (1994) confirmed that ‘Both qualitative and quantitative methods may be used appropriately with any research paradigm’ [253].

5.5.3 Reliability and validity in research

5.5.3.1 Reliability and validity in qualitative methods

The issues of reliability and validity are common concerns in quantitative research and now they are also addressed in the qualitative research paradigm [254]. To understand the meaning of reliability and validity in qualitative research, it is necessary to present the various definitions of reliability and validity given by many qualitative researchers from different perspectives.

**Reliability**

Reliability in qualitative methods is concerned with the question of whether the results of the study are repeatable, whether the measures that are devised for concepts are consistent [255]. Reliability in qualitative research includes external reliability and internal reliability. A good qualitative study can help us “understand a situation that would otherwise be enigmatic or confusing” [256]. Seale (1999) also endorsed the concept of dependability with the concept of consistency or reliability in qualitative research [257].

The consistency of data will be achieved when the steps of the research are verified through examination as raw data, data reduction products, and process notes [258]. In this research, the researcher interviewed all the key informants using the semi-structured interview which focused on the same topics. The researcher coded and analysed all the data, then kept all the detailed transcriptions of interviews and notes of participant observation to assist in evaluation of the research.

**Validity**

Validity is concerned with the integrity of the conclusions that are generated from a part of research [259]. The core of the concept is truthfulness. It refers to the bridge between a construct and the data [225]. Neuman (2011) clarified that qualitative researchers aim
to create a tight fit between their understanding, ideas, and a statement about the social world and what is actually occurring in it [225]. This research adopts a triangulation approach to address the issue of validity. In this research, the key informants come from varied organisations with different backgrounds. The researcher used a variety of data collection techniques -- document reviews, participant observation, focus groups discussion, and in-depth interviews to ensure validity. All the information came from real cases.

5.5.3.2 Reliability and validity in quantitative methods

Reliability
Quantitative research engages experimental methods and quantitative measures to test hypothetical generalisations [260], and it also emphasises the measurement and analysis of causal relationships between variables [261]. Kirk and Miller (1986) identify three types of reliability in quantitative research: (1) the degree to which a measurement, given repeatedly, remains the same (2) the stability of a measurement over time; and (3) the similarity of measurements within a given time period [262]. In this research, the questionnaire survey was conducted for utilising health and safety performance in examining the EID. The indicators cover all the aspects of the OH&S implementation in an IP. The questions were pretested before the survey was conducted.

Validity
Wainer and Braun (2013) describe validity in quantitative research as “construct validity” [263]. The construct is the initial concept, notion, question or hypothesis that determines which data is to be collected and how it is to be gathered. They also assert that quantitative researchers actively cause or affect the interplay between construct and data in order to validate their investigation, usually by the application of a test or other process. In this sense, the involvement of the researchers in the research process can also largely reduce the validity of a test. In this research, the quantitative data were collected after the qualitative data. The questionnaire which was used in this research was designed based on the findings of focus groups and in-depth interviews of researcher and developed by experienced experts. Before the survey was applied, the questionnaire was also reviewed by several senior OH&S officers and relevant experts and was pretested.
5.5.4 Ethical Issues

Ethical issues are acknowledged as a crucial element in health research [264]. Ethics is a set of moral principles that aim to prevent research participants from being harmed by the researcher and the research process [265]. Hence the five principles of research ethics as outlined are universally recognised [266].

1. Minimising the risk of harm: Dissertation research should not harm participants. Normally, to minimise the risk of harm the researcher should:

   - obtain informed consent from participants.
   - protect the anonymity and confidentiality of participants.
   - prevent deceptive practices when designing research.
   - provide participants with the right to withdraw from research at any time.

2. Obtaining informed consent: Informed consent means that participants should be informed both (a) that they are taking part in research and (b) what the research requires of them. Information has to include the purpose of the research, the methods being used, the possible outcomes of the research, as well as associated demands, discomforts, inconveniences and risks that the participants may face.

3. Protecting anonymity and confidentiality: Participants will typically be willing to provide information, especially information that is private or sensitive, if the researcher agrees to hold such information in confidence. Thus it is important that the researcher takes effective steps to protect the anonymity of all informants or subjects.

4. Avoiding deceptive practices: Deception is generally not accepted in ethical research unless it is necessary for specific purposes. This research did not include the need for any deception.

5. Providing the right to withdraw: Research participants should always have the right to withdraw at any stage in the research process. When a participant chooses to withdraw from the research, they should not be pressured or forced in any manner to convince and stop them from withdrawing.

In this research, before the interviews, all the key informants read and signed a written information sheet and informed consent. After the researchers had explained the research procedure, interviewers were able to ask for full informed consent. The researcher
provided a full disclosure of the nature of the research. For the survey, the researcher stated clearly the purpose at the outset and let people know that they had the right to refuse to participate and could withdraw from the research at any time.

This research also guaranteed anonymity and confidentiality to conform to ethical procedures. The data collected through questionnaire survey, individual interviews and focus group sessions was rendered anonymous by coding the participants, so that no individual can be identified in any related reports, presentations, or publication.

Finally, the research design, the research methods, the interview and questionnaire guidelines were approved by the Griffith University Human Research Ethics Committee (HREC) on Human Research Ethics (Protocol Number ENG/13/14/HREC) (Appendix I).

5.6 Conclusion

This chapter has presented the study design and methodology of this research through explanations of the rationale for the research and objectives, which led to the conceptual framework for the research. The research question asks “What are the feasibilities and challenges of utilising OH&S performance to assess and guide eco-industrial parks development in Thailand?”. Five research focus questions are examined:

1. What have been the reasons for and achievements of eco-industrial parks globally?

2. What have been the experience and progress of eco-industrial parks in Thailand?

3. What is the current system and development of OH&S in Thailand particularly within IP?

4. What are the feasibilities and challenges of using OH&S performance of the Saha Group Industrial Park as a case example to assess its progress towards the EIP requirements in Thailand?

5. What are the strategies needed for government and industry stakeholders to consider concerning using OH&S performance to guide the EIP development in Thailand?

The description of the three research processes was develop a research protocol, fieldwork and data collection, and data analyses then followed. At the end of this chapter, issues of rigour and ethics have been discussed. The following chapter will focus on the results
relevant to the research questions of this dissertation. Results from quantitative findings will be discussed in the same chapter.
Chapter Six

Results from Quantitative Research: The Health and Safety Practices of Saha Group Industrial Park

This chapter includes material presented in a conference presentation. The bibliographic details of the paper, including all authors, are:


My contribution to the published manuscript involved:

- Initial concept
- Collection and analysis of data
- Preparation of manuscript

Kultida Bunjongsiri

Corresponding author: Prof. Cordia Chu

Principal supervisor: Prof. Cordia Chu and Dr. Sunil Herat

In order to comply with copyright, the presentation is not published here.
6.1 Introduction

The previous chapters have reviewed the three contextual fields of this study, namely eco-industrial park (EIP), the Thai organisational setting and occupational health and safety (OH&S). The Ministry of Industry has given a lot of attention to developing eco-industrial parks (EIPs) in Thailand. A study of their implementation can serve to identify successful models and methods of engagement for EID in Thailand. The planning and development of EIPs has been a significant challenge to the developers and public agencies. Nevertheless, firms or organisations involved have frequently misunderstood the concept and performed with uncertainty. The development of corporate sustainability is one of the most important issues for the companies involved. In specifying the issues of sustainable development, the selected industrial park has commenced implementing the guidelines for analysing development issued in accordance with the EIP regulations. These regulations aim to address the issues of sustainable development in specific concrete ways so as to develop an action plan for each company’s sustainable development, as described in this chapter. This research provides an attempt to determine factors that would lead to success in developing an EIP in Thailand.

This chapter shows the results relevant to the 3rd and 4th focus question of this thesis. The study starts from an overview of the selected industrial park. Afterwards, a data set of OH&S activity in Saha Group Industrial Park is explored and described. Then, the evolution of EIP practices in the Park is presented. Lastly, the role of health and safety criterion in the Saha Group Industrial Park is described at the end of this chapter.

6.2 General Data about Saha Group Industrial Park, Sriracha

6.2.1 Background and monitoring data of the Park

Saha Group Industrial Park, Sriracha was established in 1977 in the municipality of Laemchabang Subdistrict, located in Moo.11, Tambon Nong-kham and Moo.1, Tambon Bueng, Sriracha District, Chonburi Province. It presently covers an area of approximately 255 hectares and offers various facilities and infrastructure services. Saha Group sells or leases land and utility services (electricity and water) with the purpose of accommodating the growth and enhancing the competitiveness of all companies in the Park. The plan is to support the expansion of production capacity of the companies in the Park and to
support the government’s policy of income distribution to rural areas. However, the Company plans to sell lands to general investors to increase its revenue [210].

As of September 2014, there are 65 companies located in Saha Group Industrial Park, which can be divided into 10 industrial groups. The main groups are textiles and miscellaneous items, plastics/rubber/paper/metal, food & beverages, footwear, electrical products and IT, and garments. The plastics/rubber/paper/metal group is the biggest group, comprising 15 factories or 23.08 percent of the total number of factories in the IP. It is followed by the services group (8 factories), textiles and miscellaneous items and food & beverages group (7 factories) as indicated in Table 6.1. All companies in this Park can use “Saha” as a brand. The main products under “Saha Group brand” are consumer products which are daily necessities such as men’s, ladies’ and children’s clothing, underwear, cosmetics, instant noodles, detergent, leatherwear and food. Their products have been well received for their quality and ability to satisfy the demands of consumers

Table 6.1 Type of industrial cluster in Saha Group Industrial Park, Sriracha.

<table>
<thead>
<tr>
<th>Type of Cluster</th>
<th>Number of Firms</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products coating (decorating, interior auto parts)</td>
<td>6</td>
<td>13.6</td>
</tr>
<tr>
<td>Cosmetics</td>
<td>4</td>
<td>9.1</td>
</tr>
<tr>
<td>Automobile parts made from rubber and plastic</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>Plastic products</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>Electric Sewing Machine Parts</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Environmental Consultant</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Wastewater treatment Design/Start up/Operating</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Fiberglass reinforced plastics</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Electric equipment</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Plastic coating and molding</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Plastic injection</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Textiles</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Others; Hair dye, Transportation, Automobile parts, Processed foods/drink, Noodle, etc.</td>
<td>12</td>
<td>27.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Of the 44 companies that responded, 56.8 percent (25 out of 44) require office workers to work six days a week. 54.5 percent of company offices work from 8 am till 5 pm as
displayed in Figure 6.1. In the manufacturing sections, the work schedule ranged from one to three shifts; 9.1 percent of the companies used only one shift, 61.4 percent two shifts, and 6.8 percent three shifts as presented in Figure 6.2. Each shift worked an average of 8 hours.

**Number of workdays (days/week)**

```
25 - 5
12 - 6
17 - 5
```

**Office Hours**

- Others: 10
- 8 am - 6.05 pm: 3
- 7.30 am - 5.30 pm: 3
- 7.30 am - 5.50 pm: 5
- 8 am - 5 pm: 26

**Number of shifts to be operated**

- No data: 10
- 3 shifts: 3
- 2 shifts: 27
- 1 shift: 4

**Figure 6.1 Operating hours in office section**

**Figure 6.2 Operating hours in manufacturing section**

The Industrial Park contains various sizes of companies/factories. According to the IP record, there were 24,000 employees in 2014, of whom 15,000 were men and 9,000 women [267]. Of these, small (1–100 employees) and medium enterprises (100–500 employees) made up 15.91 percent and 47.72 percent of the total number of enterprises, respectively. 15.91 percent of companies employed over 1000 employees. The other factories of Industry Park did not mention the number of employees. See Figure 6.3 for the breakdown.
Thailand’s low labour productivity generates its own health risks, as employers demand longer hours and pay lower rates. The average working week is 48 hours in manufacturing, and up to 54 hours in trade and service industries. Almost 70 per cent of the labour force spend more than 40 hours a week at work [268]. In comparison, Australian workers in the 1980s were working on average less than 35 hours per week (34.8 hours), but over the first decade of the 2000s, the average work week decreased to 733 hours. The long hours in Thai workplaces clearly exacerbate the health risks facing workers, particularly women, who have to combine long hours at work with family responsibilities [269].

6.2.2 Occupational health and safety performance of the Park

Apart from providing business consultation, the Saha Group encourages all of the firms located in the Industrial Park to follow the regulations and policies on Occupational safety consistent with the laws. In companies, it is important to focus more often on specific prevention activities such as workplace health checks, threat level indicators and other health promotion projects to support employers to promote health in the workplace. In the new approach to workplace health management, policy development is motivated by both legislative requirements and by health targets set on a voluntary basis by the companies and the community around the enterprises. Industrial enterprises and other
organisations have to provide workplace health management that actively manages the workers’ health, environment and safety performance. Almost all firms take good care of health and hygiene of workers. If an accident happens or if a worker feels sick or develop occupational diseases, they can ask for compensation according to the law. Besides, some enterprises provide healthcare services such as a bed for basic treatment available during working hours (68.18 percent), health care room (75 percent), ambulance (15.9 percent), occupational medicine physician (11.36 percent), and occupational health nurse (34.09 percent) (Table 6.4). Most firms provide personal protective equipment (PPE) for workers in the workplaces. 90.9 percent of firms provide ear plugs for workers, 88.6 percent arrange safety shoes to protect workers from foot injuries. Other equipment includes a wide range of clothing and safety equipment: boots, face masks, hard hats, respirators, gloves, safety harnesses, high visibility clothing etc. (Table 6.5). Regarding the promotion of healthy supporting activities for workers, firms arranged various kinds of activities such as workplace health check, and assessment of threat level indicators (Table 6.6). The sets of occupational health concerns in companies are presented as follow.

6.2.2.1 OH&S personnel at the workplace

The Occupational Safety, Health and Environment Committee Notification (1995) administered by the Ministry of Labour and Social Welfare prescribes that workplaces with more than 50 workers must set up an occupational safety, health and environment committee and hold meetings at least once a month. In practice, the survey results showed that there were OH&S committees in most workplaces but the meetings were not held regularly and rarely brought initiatives from the meeting to improve the working environment. In addition, as required by the Ministerial Regulation of the Ministry of Labour, 2006, on standards for administration and management of occupational safety, health and environment, an OH&S practitioner “Safety Officer” must be appointed at the workplace to perform duties relating to occupational safety, health and environment. There are currently five levels of safety officer with the number of each level in the firms in the Park as follow.
Table 6.2 Number of Safety officer in several levels

<table>
<thead>
<tr>
<th>Number of Safety Officers</th>
<th>Number of Firms</th>
<th>Percent of Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supervisor level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10</td>
<td>9</td>
<td>20.4</td>
</tr>
<tr>
<td>11-20</td>
<td>7</td>
<td>15.9</td>
</tr>
<tr>
<td>21-30</td>
<td>5</td>
<td>11.4</td>
</tr>
<tr>
<td>➢ 30</td>
<td>10</td>
<td>22.7</td>
</tr>
<tr>
<td>No data</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

| **Management Level (Executive Level)** | | |
| 1-10                                   | 24             | 54.6             |
| 11-20                                  | 7              | 15.9             |
| 21-30                                  | 0              | 0                |
| ➢ 30                                   | 2              | 4.5              |
| No data                                | 11             | 25               |
| **Total**                              | **44**         | **100**          |

| **Technician Level**                  | | |
| 1                                      | 1              | 2.3              |
| No data                                | 43             | 97.7             |
| **Total**                              | **44**         | **100**          |

| **Advanced Technician Level**         | | |
| No data                                | 44             | 100              |
| **Total**                              | **44**         | **100**          |

| **Professional Level**                | | |
| 1                                      | 23             | 52.3             |
| 2                                      | 13             | 29.5             |
| 3                                      | 1              | 2.3              |
| 5                                      | 2              | 4.5              |
| No data                                | 5              | 11.4             |
| **Total**                              | **44**         | **100**          |
According to the survey, there were no safety officers at technician level or advanced technician level, which suggests that the firms are almost totally unconcerned with these positions. The results indicate that OH&S personnel at the workplace are ignored in the firms and the enforcement of the law was not effective enough. Reasons for this problem were that there were little understanding of the importance of OH&S, not enough governmental inspections and a lack of government support, both technical and financial.

Safety officers at different levels have different qualifications and duties. The numbers appointed of safety officers classified by level are based on the type of industries and workplace size. Training of safety officers in each level is performed by registered OH&S training institutions with the curriculum that has been endorsed by the Department of Labour Protection and Welfare.

The successful and effective safety performance of a company relies heavily on the entire support provided by its management. The responsibility of the executive is considered very important for making any activities and hazard prevention complete. The executive is expected to have a positive attitude and show responsibility for safety, and all levels of subordinates are also expected to perform in the same way.

Additionally, according to the type of industry, an establishment having 50 or more employees is required to organise a Committee of Occupational Safety, Health and Environment to perform duties as prescribed by the Ministerial Regulation. In Saha Group Industrial Park, there are currently a number of OH&S committees in the companies as shown in Table 6.3.

Table 6.3 Number of Occupational health Safety and working environment committees

<table>
<thead>
<tr>
<th>Number of committees</th>
<th>Number of companies</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>9</td>
<td>20.4</td>
</tr>
<tr>
<td>11-20</td>
<td>7</td>
<td>15.9</td>
</tr>
<tr>
<td>21-30</td>
<td>5</td>
<td>11.3</td>
</tr>
<tr>
<td>≥ 30</td>
<td>10</td>
<td>22.7</td>
</tr>
<tr>
<td>No data</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
The survey results indicate that there is no OH&S policy or OH&S committee in some enterprises. The OH&S rules and procedures are rarely established. However, some employers mentioned that they had consulted with workers on OH&S matters.

6.2.2.2 Workplace healthcare services

Workplace healthcare services and facilities inside the factories in Saha Group Industrial Park include several functions, such as bed for recuperating, health care room and occupational medicine professionals, as listed in Table 6.4. These services can make a significant contribution to support health equality in the workplace and reduce absenteeism for sickness. These services were set up due to the demands and expectations from employers and employees as they recognise the economic, social and health benefits achieved by providing these services at the workplace [270]. Nevertheless, the number of companies that provide these services is still small. The law requires the provision of such facilities depending on the number of employees.

For large enterprises, qualified health care personnel must be on-site in working hours. An establishment with more than 200 employees requires a nurse and a part-time physician while one with more than 1,000 employees requires at least two nurses and a part-time physician who work at least 2 hours a day. There must also be a clean health care room and ready-to-use healthcare supplies.

For small and medium enterprises, if there are no qualified health care personnel, at least one and preferably more employees on each shift must be sufficiently trained to use first aid. First aid kits must be readily available and kept in sanitary containers with basic materials such as gauze, bandages, dressing and some basic medicines as the regulation requires.

Table 6.4 Preliminary health facilities available in Saha Group Industrial Park

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of companies</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed for recuperating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- one bed</td>
<td>9</td>
<td>20.5</td>
</tr>
<tr>
<td>- two beds</td>
<td>10</td>
<td>22.7</td>
</tr>
<tr>
<td>- four beds</td>
<td>9</td>
<td>20.5</td>
</tr>
<tr>
<td>- five beds</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>68.18</strong></td>
</tr>
<tr>
<td>Variable</td>
<td>Number of companies</td>
<td>Percent (%) of companies</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Health care room</td>
<td>33</td>
<td>75</td>
</tr>
<tr>
<td>Ambulance</td>
<td>7</td>
<td>15.9</td>
</tr>
<tr>
<td>Occupational Medicine physician</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Full-time Consultant physician</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>- Part-time Consultant physician</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>11.36</strong></td>
</tr>
<tr>
<td>Number of Occupational Health Nurse (Full-time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- one Nurse</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>- two Nurses</td>
<td>8</td>
<td>18.2</td>
</tr>
<tr>
<td>- four Nurses</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>34.09</strong></td>
</tr>
</tbody>
</table>

Generally, the employers provide various benefits to ensure their employees’ welfare. In some companies, welfare assistance is available to staff members who experience disasters such as fire, storm, or floods; accidents; and illnesses, as well as financial support in the event of the death of their parent, spouse, or children, although the specific assistance varies from company to company. Larger companies also offer further benefits, which include

- **Infirmary:** An infirmary facility is available to provide employees with preliminary medical treatment, provide initial care to ill staff members and provide health advice by certified physicians and nurses.

- **Medical check-up:** Employees may be entitled to medical check-up and assessment of their circumstances, and advice on how to engage in preventive measures and conduct themselves properly. However, the annual health check of workers has not always been carried out.
6.2.2.3 Workplace safety services and managing risks

By law, business owners are responsible for supporting OH&S services in the workplace. Most companies in the Park provide some workplace safety services, managing risks for instance by providing personal protective equipment (PPE) and other health supporting activities for the workers. These services aim to give their employees a safe, healthy, and positive place to work and are in compliance with established OH&S laws.

- **Personal Protective Equipment, PPE**

Thai law states:

*Duties regarding protective equipment: An employer shall arrange for and ensure that their employees wear personal protective equipment of the standards set in regulations. Employees have a duty to wear personal protective equipment and care for such equipment in order for it to remain in working condition, in accordance with the nature of the work, throughout the work period. Where an employee fails to wear such equipment, the employer shall instruct such employee to stop work until he/she wears such equipment [149].*

PPE includes a wide range of clothing and safety equipment: boots, face masks, hard hats, ear plugs, respirators, gloves, safety harnesses, high visibility clothing etc. as shown in Table 6.5. Nevertheless, even though PPE was provided, there was not always enough for each worker and it was often not appropriate for the job. The OH&S scores for some equipment were at a poor level. The problems were not only in the quantity of PPE provided but there were also problems of enforcement. Some of companies said that although PPE was provided to the workers, the workers would not use them. These meant that the workers were not adequately protected from harm in their workplaces.
Table 6.5 Personal Protective Equipment, PPE

<table>
<thead>
<tr>
<th>PPE</th>
<th>Number of companies</th>
<th>Percent (%) of companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear plugs</td>
<td>40</td>
<td>90.9</td>
</tr>
<tr>
<td>Particulate-filter respirators</td>
<td>10</td>
<td>22.7</td>
</tr>
<tr>
<td>Ear muffs</td>
<td>31</td>
<td>70.5</td>
</tr>
<tr>
<td>Vapor-filter respirators</td>
<td>31</td>
<td>70.5</td>
</tr>
<tr>
<td>Goggles</td>
<td>34</td>
<td>77.3</td>
</tr>
<tr>
<td>Masks</td>
<td>29</td>
<td>65.9</td>
</tr>
<tr>
<td>Gloves</td>
<td>36</td>
<td>81.8</td>
</tr>
<tr>
<td>Aprons</td>
<td>34</td>
<td>77.3</td>
</tr>
<tr>
<td>Safety shoes</td>
<td>39</td>
<td>88.6</td>
</tr>
<tr>
<td>Others: helmet, Safety belt, Safety gloves, Thick soles sneakers</td>
<td>12</td>
<td>27.3</td>
</tr>
</tbody>
</table>

There was some basic first aid equipment in the workplace. However, in some enterprises the equipment was not placed close to the working area, often stored in the office area. The first aid person was often not near the workplace. When an injury occurred, the workers had to perform first aid by themselves even though they had never been trained in the subject.

The Occupational Safety, Health, and Work Environment Act 2011 states that

*It is the employer’s duty to manage and maintain safe and healthy work conditions and environment including protecting employees from occupational health and safety hazards of all forms. It is also an employee’s duty to cooperate with the employer in managing and maintaining safe and healthy work conditions and environment* [271].

In accordance with the law, activities should be organised annually to encourage employees to be aware of health care and learn to protect themselves. New employees should be given a safety and health induction. These activities include Workplace health check, Pre-placement medical examinations, and Pre-assignment medical examination,
etc. as seen in Table 6.6. The revised law concerning health and safety at work Part II – The Safety, Health and Workplace Act (2011) [149] states:

*Duties in the case of a serious accident: Where a serious accident occurs at a workplace or an employee is injured by work, the employer shall act as follows:*

(1) Where the employee dies, the employer shall notify the safety inspector immediately upon learning of the incident by phone, fax or any other method where reasonable details can be provided. The details and cause of the incident shall be indicated in writing within seven days from the date of death.

(2) Where the workplace is damaged or has to cease production or where an individual in the workplace is injured or damaged as a result of fire, explosion, chemical leakage or other serious accident, the employer shall notify the safety inspector immediately upon learning of the incident by phone, fax or any other method where reasonable details can be provided. The cause of the accident, the damage, remedy and preventive measures shall be indicated in writing within seven days from the date of the incident.

(3) Where an employee is injured or made ill, once the employer has notified the Social Security Office of the injury or the illness, the employee shall also submit a copy of that notification to the safety inspector within seven days.

Any written notification as above shall be in the form specified. Once the safety inspector has received the notification, he or she shall conduct an inspection and identify preventive measures without delay.

However, most workers are on casual conditions, which are largely outside regulation, and few workers are aware of their OH&S rights or responsibilities. Some workers said they learned how to work safely by themselves.
- Occupational health supporting activities

Table 6.6 Occupational health supporting activities in companies.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of companies</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workplace health check</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-placement medical examinations</td>
<td>39</td>
<td>88.6</td>
</tr>
<tr>
<td>Pre-assignment medical examination</td>
<td>4</td>
<td>9.1</td>
</tr>
<tr>
<td>Medical check after an injury</td>
<td>9</td>
<td>20.5</td>
</tr>
<tr>
<td>Health risk factors check : Chemical, Heat, Noise, Lung X-ray, Urine test, Ear test</td>
<td>31</td>
<td>70.5</td>
</tr>
<tr>
<td>Others: Urinalysis for drugs</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td><strong>The threat level indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>41</td>
<td>93.2</td>
</tr>
<tr>
<td>Heat</td>
<td>31</td>
<td>70.5</td>
</tr>
<tr>
<td>Chemicals: Toluene, styrene, MIBK, Formaldehyde, NaOH Xylene, Total Hydrocarbons</td>
<td>30</td>
<td>68.2</td>
</tr>
<tr>
<td>Others: Total dust, Respirable dust</td>
<td>8</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Health Promotion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“White Factory” (drug-free)</td>
<td>28</td>
<td>63.6</td>
</tr>
<tr>
<td>Physical activity</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Quality control of cafeteria</td>
<td>15</td>
<td>34.1</td>
</tr>
<tr>
<td>Smoking cessation program</td>
<td>18</td>
<td>40.9</td>
</tr>
<tr>
<td>Others: Standards on Drug Use Prevention and Solutions</td>
<td>8</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Emergency plans</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical leak</td>
<td>29</td>
<td>65.9</td>
</tr>
<tr>
<td>Flooding</td>
<td>12</td>
<td>27.3</td>
</tr>
<tr>
<td>Others: Radiation leaks, Gas leak, Transportation of hazardous waste, Garbage / Waste fire, Sewage sludge spill</td>
<td>13</td>
<td>29.5</td>
</tr>
</tbody>
</table>
• **Workplace health check**

A total of 88.6 percent of participating firms provided pre-placement medical examinations which helps to manage risks in the workplace with the aim of avoiding illness or injury to the applicant or fellow employees. Approximately 70.5 percent of companies provided health risk factor checks in the workplaces covering the key risk factors of chemicals, heat, and noise. They also conducted lung X-rays, urine tests, and ear tests to monitor other health risks. However only 20.5 percent of participating firms required medical checks for an employee after an injury and only about 9 percent required a pre-assignment medical examination.

• **The threat level indicators**

Under Thai law, where a threat has been reported by an employee, implementation of safeguards to help prevent and detect incidents in the workplaces should be carried out. However, survey results show that the law is not always followed. The number of organisations that have basic indicators checked for noise, heat, and chemicals are 93.2, 70.5, and 68.2 percent of participating companies respectively. It is also important to determine other threat indicators, like total dust and respirable dust, to help identify the insider-risk which affects employee’s health. However, only about 18 percent of companies conduct such a check.

• **Health Promotion**

A variety of health promotion projects are carried out by firms located in Saha Industrial Park. The most popular project, named “White Factory” (63.6 percent of companies), aims to prevent drugs getting into businesses and to lower the number of drug abusers. While employers knew skilled workers were misguided in abusing drugs, they were giving them a chance to reform their behaviour and return to work and not be a burden on society. Other projects launched to encourage health promotion in the workplaces are: Smoking cessation program (40.9 percent of companies), Quality control of cafeteria (34.1 percent of companies), Standards on Drug Use Prevention, and Solutions Physical activity (18.2 percent of companies).

• **Emergency plan**

Saha Group Industrial Parks have considered the importance of any emergency which could significantly affect the industrial parks’ overall operations. The most likely risk is
flooding, since the industrial park is located on a coastal plain along the eastern seaboard. It is possible for water to overflow from the public canals or the reservoirs into the industrial park for a short period, particularly during a period of heavy rain or flooding. Other emergencies that might occur in the workplace include radiation leaks, gas leaks, transportation of hazardous waste, garbage/waste fire, and sewage sludge spill (13 firms). However, most of the factories (29 firms) had an emergency plan only to deal with chemical leaks. Only 12 firms had prepared an emergency plan for flooding. The managers of the industrial park regularly provide practices in emergency response plans and provide reports to government of emergency training plans. The practices include flood prevention and mitigation plan and emergency action plan in case of chemical spill / fire. Retraining and revision is carried out every year. The factories are advised to follow the emergency plan training session in the Park to prepare security teams for any emergency incident with related government experts from local government authorities. Some of the factories take part in the emergency response practices, but participation is not compulsory.

6.2.2.4 Management systems

In the year 2009, Saha Group Industrial Park was certified for the highest level of Thai Labour Standard Management (TLS 8001-2546) by the Department of Labour Welfare and Protection, the Ministry of Labour. This is a certificate that they have complied with the social responsibility standard of Thai businesses. For the individual firms in the Park, a variety of management system evaluations is in force as shown in Table 6.7.

Table 6.7 Management Systems Evaluations in Saha Group Industrial Park.

<table>
<thead>
<tr>
<th>Type of Management System</th>
<th>Number of Users</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 9000</td>
<td>38</td>
<td>86.4</td>
</tr>
<tr>
<td>ISO 14000</td>
<td>30</td>
<td>68.2</td>
</tr>
<tr>
<td>GMP / HACCP</td>
<td>8</td>
<td>18.2</td>
</tr>
<tr>
<td>OHSAS 18000</td>
<td>7</td>
<td>15.9</td>
</tr>
<tr>
<td>TS 16949</td>
<td>6</td>
<td>13.6</td>
</tr>
<tr>
<td>ISO 5001</td>
<td>2</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Most companies in Saha Group are certified by ISO 9001 for their production standard. The Company takes into account the environmental impact of its business operation in terms of resource use, energy consumption and pollution by considering direct and indirect economic, environmental, and social factors. By doing that, Saha Group Industrial Park has therefore been certified Multisite ISO 14001:2008, an environmental management standard, by the Office of Certification Body (OCB) under the Thailand Institute of Scientific and Technological Research (TISTR). It is noteworthy that the Saha Group Industrial Park is also Thailand’s first industrial estate certified for an energy management standard (ISO 50001) [209]. However, smaller companies do not tend to be certified under these schemes.

6.2.2.5 Safety and occupational hygiene in Saha Group Industrial Park

From 2015, the Board of Directors committed to safety and occupational hygiene as can be seen as follow [211]:

1. Business undertakings shall comply with laws, regulations and policies on safety, occupational hygiene and working environment with regard to the safety of life and properties which might impact on the health of employees, trading partners and stakeholders. Regular monitoring and safety assessments must be conducted.

2. Business undertakings are expected to promote occupational safety. Work regulations, procedures and standards are specified to assure that safety risk, working environment and safe work procedures are improved. Tools and equipment for safety protection must also be provided to employees.

3. An emergency plan has been set up and there shall be regular practices and improvements. This is to prevent or minimise any loss of lives or property of the company, employees, trading partners and related persons.

4. A safe working culture shall be created for the whole organisation to ensure sustainable safe work operations.

Regarding the policy, the Saha company has arranged a regular activity named “5S” S1: SEIRI (Clearing Up), S2: SEITON (Organising), S3: SEISO (Cleaning), S4: SEIKETSU (Standardising) and S5: SHITSUKE (Training & Discipline). This activity aims to promote work safety performance, such as by establishing a chemical spill emergency plan that follows the international standards, or monitoring and maintaining lighting and
fire alarm systems to ensure their good working condition. Moreover, the company also enhances knowledge about the prevention of disasters, by clarifying guidelines according to new laws regarding fire evacuation and fire fighting. Employees are educated in the use of fire extinguishers to support safe and effective use. Furthermore, non-toxic fire extinguishers using clean substances have been installed in various areas throughout the factories. However, even though most of the factories had some fire extinguishers, not all companies train the workers how to use them properly. The fire extinguishers are not always checked regularly.

6.3 Evolution of Eco-Industrial Project in the Park

In 2012, Saha Group Industrial Park commenced implementing the guidelines for analysing development issued in accordance with the Eco Industrial Town Project which was launched by the DIW. In the first project, named “Green Factory”, only 18 firms have been involved. Participation is voluntary. The objective of this project was to enhance environmental sustainability of Thai industry in such a manner that all concerned parties were involved [272]. Focus group discussions and brainstorming activities involving all stakeholders were conducted in order to analyse project goals. Importantly, an area based working group was set up to implement the plan towards Eco-industrial park within the five year period (2012-2017) from the initial stage.

The current focus of the SPI is on central wastewater management from the source of wastewater before flowing into the central wastewater treatment system, to control and prevent possible damage that could occur in the central wastewater treatment system which is the last treatment unit before flowing to public water source and canals. However there is no clear documentation of the outcome.
Table 6.8 Summary of planned projects in Eco-industrial development of Saha Group Industrial Park (Sep. – Nov.2012).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Project List</th>
<th>Length of Project</th>
<th>Action (completed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>The White Road for traffic safety</td>
<td>Urgent</td>
<td>-</td>
</tr>
<tr>
<td>Economic</td>
<td>The Promotion of environmentally friendly production. (Eco product/clean technology/carbon footprint)</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Development of a comprehensive industrial environmental management centre. (Eco Centre)</td>
<td>Lengthy</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Encouraging the use of Zero Discharge in the industry.</td>
<td>Lengthy</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Promoting the use of Zero Waste to Landfill in the industry.</td>
<td>Lengthy</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Green energy in Eco-industrial.</td>
<td>Lengthy</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Guidelines for the water management in the industrial sector.</td>
<td>Lengthy</td>
<td>-</td>
</tr>
<tr>
<td>Social</td>
<td>Development of community networking for Eco-industrial.</td>
<td>Lengthy</td>
<td>✓</td>
</tr>
<tr>
<td>Management</td>
<td>Promotion of a factory to international standard.</td>
<td>Moderate</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Development of Communication and Management of Eco-industrial.</td>
<td>Moderate</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Promotion of all sectors in the management of eco-industrial park.</td>
<td>Lengthy</td>
<td>✓</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Percentage</td>
<td>45.5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>of the eco-industrial park 2012 Master Plan Projects completed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Urgent – immediate implementation; the project processed to be completed within 1-3 years.

Moderate; the project processed to be completed within 1-4 years.

Lengthy; the project processed to be completed within 3-5 years.
Thematic Summary of outcome and operational performance under the Eco-industrial park Development Project

The results of the 2012 Master Plan Project focus group discussions that contributed to the concept, framework, plan and activities can be summarised below.

1. A Project on Advancement towards International Standard Industries: To enable industries to apply international standard on environmental management for economic competitiveness and environmental friendliness. A training course was conducted on Environmental Management of ISO 14001, with ten industries participating. Out of ten, three industries requested comprehensive advice on environmental management, accounting for 10 percent of the total number of industries within the Park.

2. A Project on Promoting Zero Discharge Principle in Industries: To increase the adherence to zero discharge in industries. During August and September 2012, comprehensive advice was provided by mentors from the DIW on waste water treatment system to ensure the discharge remained within the standard level of an Industrial Park, to five industries, accounting for 83.3 percent of the total number of industries having a problem of wastewater management.

3. Activities conducted jointly with communities: To develop proactive social activities that would enhance better understanding between industrial operators and surrounding communities. A training course was conducted by mentors from the DIW on how to sort household solid waste and how to make use of the waste in order to minimise the volume of the waste that goes to landfill. There were 13 communities participating in the training, accounting for 100 percent of the total communities nearby. However, the representation from the communities was small – about 1-2 people from each community.

Approach to development:

“Eco Centre” – a learning centre to promote Eco Industrial Management

The Project is to serve as a centre for environmental management with a focus on providing advice on environmental management to industries and communities. A green area is also saved in the Park, where communities can use. Additionally, a meeting hall has been allocated to serve as a centre for information and knowledge exchanges, as well as a place where industrial operators and community members can do activities collaboratively.
Activities towards Eco Industrial Town Development (The DIW with the Saha Industrial Park)

- Encouraging all industries within the Park to get ISO 14001 certification
- Promoting the treatment of waste water from the production process
- Developing a learning centre or Eco-centre
- Collaborating with others to monitor the quality of water through activities like water patrol, canal drainage, etc.
- Supporting training in community solid waste management

Table 6.9 Summary of outcome and operational performance under the Eco-industrial Development Project

<table>
<thead>
<tr>
<th>Activities within the Industrial Premises</th>
<th>Activities related to environmental management that meets international standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal: to enable industries to apply international standard on environmental management for economic competitiveness and environmental friendliness.</td>
<td></td>
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<tr>
<td>Outcome and operational performance: On September, 2012, a training course was conducted on Environmental Management of ISO 14001, with 10 industries participating. Out of 10, three industries requested comprehensive advice on environmental management, accounting for 10 percent of the total number of industries within the Park.</td>
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<tr>
<th>Activities within the Industrial Premises</th>
<th>Activities under the environmental dimension on the management of water quality</th>
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<tr>
<td>Goal: to increase the application of zero discharge in industries</td>
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<tr>
<td>Outcome and operational performance: During August and September, comprehensive advice was provided on waste water treatment system to ensure that the</td>
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Activities within the Industrial Premises

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<th>Activities within the Industrial Premises</th>
<th>discharge remained within the standard level of an Industrial Par. This advice gave to five industries, accounting for 83.3 percent of the total number of industries having a problem of wastewater management.</th>
</tr>
</thead>
</table>
| A Project on the Development of Community Network For Eco-industrial park (Community Solid Waste Management) | Activities under the social dimension on the quality of life and society of surrounding communities  
Goal: to develop proactive social activities that would enhance better understanding between industrial operators and surrounding communities.  
Outcome and operational performance: During August, 2012, a training course was conducted in order to enhance knowledge on how to sort household solid waste and how to make use of the waste in order to minimise the volume. All 13 communities in the surrounding area participated in the training. |

The implementation of the development of area based eco-industrial project has indicated that the Saha Group Industrial Park has different kind of problems and needs. The development of eco-industrial therefore requires an investigation to identify the real problems and capacities in the area. Apart from the first stage in 2012, many activities were planned but had to wait for funding support from the government realise them in the next stage. Additionally, industrial holders have to be the key drivers through all the whole process. Although they have already set up an Eco centre to serve the whole park as a central management centre, the activities under the centre were not yet as effective as expected. They also need to get full collaboration from all involved in the area, including factories within the premise, communities, public organisations and academic institutions, to monitor and support the move towards eco-industrial project in a sustainable manner. The level of participation so far has been very low, with most firms and community members ignoring most of the project.
6.4 Health and Safety Criteria in Saha Group Industrial Park

To achieve sustainable EID in Thailand, the specifications standard for industrial parks and factories that plan to be recognised as an eco-industrial park have to follow eco-criteria in 5 dimensions consisting of 20 aspects. The requirements under the environmental dimension for health and safety management are shown in Table 3.3. The objective of this criterion is “To secure the residents from negative impacts of the operation of industry in surrounding area”. The target values were set up as two main points.

6.4.1 Target values 1: Security systems that prevent negative impacts on employees’ and the community's health.

The company has provided healthy working conditions to enhance good working conditions and environment in the workplace for employees. The IP has provided safety control systems inside and around the head office such as CCTV system with a digital recording system, fire alarm system and automatic fire extinguishing system, entry and exit control system and around the clock security officers etc. Moreover, self-inspection is carried out for the stability, strength and safety of the building structure, systems, basic equipment and the requirements by law.

Chemical Risk

Chemical agents are a part of advanced industrial technological. All factories located in Saha Group Industrial Parks use chemicals in their industrial production process, including maintenance. The appropriate use of chemicals can lead to a great deal of benefits, whereas, the lack of accurate understanding and good preventive measures can result in serious accidents, such as explosions, leakage, contamination of the environment, and other unexpected incidents. These incidents result in risk to human life, property, and the ecological system, both in the short and long term. Consequently, according to the company report [211], the IP has applied control measures, detailed below, for the handling of all chemicals entering and exiting Saha Group Industrial Parks in order to address relevant risks. These measures have been in effect from 1 December 2012.

Because chemical incidents could cause significant damage to individuals, properties and business operation, to mitigate those risks, the IP, in 2015, has arranged to upgrade the chemical emergency response to meet international standards and to conduct training sessions of chemical leakage emergency plan with the objective of training the security
teams in Saha Group Industrial Park. Training programs, such as “Preparation and Response to Chemical Leakage Emergency (Sodium Hypochloride 10 percent) with 1 Victim Injured” (see Figure 6.4), are carried out each year by simulation and conducted with the assistance of related government offices.

Moreover, regarding the safety of factory workers in the IP, the security team who would be the first responders to a chemical emergency is required to prepare necessary equipment such as self-contained breathing apparatus (SCBA), chemical response tools, respirator masks and others to get into the area once on the scene. In addition, the company has a chemical control policy to strictly control movement of chemicals into and out of the industrial parks, resulting in no chemical leakage incidents over the past few years [210, 211].

Figure 6.4 The training program: In case of emergency chemical spill/fire in Saha Group Industrial Park, Sriracha [273]
**Community Relations and corporate social responsibility (CSR) Activities**

To create good relations with the surrounding community, Saha Group Industrial Park has set up a corporate social responsibility (CSR) section to create activities with nearby communities for good relationship between the IP and communities. The activities sponsored by Saha Group as part of its corporate social responsibilities (CSR) are listed below:

1. Survey economic and social conditions to explore opinions and community concerns and to assess and analyse the social needs.

2. Visit communities constantly in order to hear their opinions and suggestions for project development and bring them into the analysis and defining an action plan to reduce the negative impact on their way of life.

3. Regularly publicise, disseminate information relating to the Company’s business operation in nearby communities in order to relieve community concerns.

4. Coordinate with local authorities to present the results of the measurement of environmental quality to communities so that villagers can understand.

5. Hold consultation with communities to clarify the information that villagers, community leaders, village headmen, are still concerned about, and to set an action plan to educate the communities.

6. Support the activities of nearby communities for good relationship between the IP and communities, for example, a project to distribute quality rice seeds to the communities and schools around the area.

7. Follow up the outcome of solutions of the problems caused by the action of the IP as promised to communities to ensure their confidence and acceptance of the project.
Figure 6.5 CSR Activity to distribute quality rice seeds to the communities and schools around the area [210]

*Surrounding community activities roles in accordance with the Industrial Park’s sustainable development*

1. Consider suggestions of communities and enhance mutual understanding between communities and the IP as well as to cooperate with other entities or concerned persons.

2. Acknowledge the process and result of environmental measurement by visiting the IP, in order to realise the transparency of environmental management of the IP.

3. To jointly consult and define countermeasures and solve the problems that may have an effect on the environment and health.

4. To jointly negotiate and find out the solution for any disputes over environmental problems between the IP and communities.

5. Investigate and consider the compensation for the damages emerging from the industrial park’s activities that affect the community’s natural resources and environment, agricultural products, health and sanitation, provided that they are really affected by the IP.

6. Present and jointly consider encouraging the projects for developing community, social and education.
Emergency plan for flooding

The industrial park is located on a coastal plain along the eastern seaboard. It is a high risk for water to overflow from the public canals or the reservoirs into the industrial park for a short period, particularly during a period of heavy rain or a flooding situation [211]. As for these risks of flood, the prevention and mitigation plan has already been developed for Saha Group Industrial Parks. The plan comprises a monitoring team to monitor the water level in a radius of 5 kilometers around Saha Group Industrial Park for 24 hours (during the high risk period). The monitoring levels are divided into three levels which are “Normal Level”, “Watching Level” and “Alert Level”. If the alert level is reached, the factories are advised to follow the emergency plan set up by the Saha Group Industrial Park following government guidelines. Additionally, the Saha Group Industrial Park conducts a training session of its emergency plan every year. Moreover, Saha Group Industrial Park has invested 12 million baht (AU$ 446,370) to improve the drainage system in order to optimise the drainage capacity to the public water supply areas and solve the flooding problem within the local area, including providing the dredging of drainage systems within the Industrial Park on an annual basis. The practices for flood prevention are shown as Figure 6.6.

Figure 6.6 The prevention and monitoring plan for flooding [274]
Training plan in case of emergency

Saha Group Industrial Parks have considered the importance of any emergency which might significantly affect the industrial park’s overall operations [211]. In this regard, the Company consequently has conducted compulsory training for emergencies to prepare security teams for any emergency incident, in accordance with the guidance from related local government experts. The practices, including evacuation of the site, are shown as Figure 6.7.

Figure 6.7 Training plan in case of emergency including evacuation of the site [274]

6.4.2 Target values 2: Have zero fatal accidents in one year.

An accident is an unexpected and unplanned incident that cannot be prevented before it has been recognised and acted upon. Accidents during the carrying out of work or arising out of it are recognised as work accidents. Many factors contribute to accidents' occurrence; significant losses and also bodily injury can result following each incident. These consequences are obvious, yet accidents continue to occur, property damage accumulates, work schedules remain interrupted, and injuries reduce personal income. All accidents are caused: they are most likely consequence of human error, and they involve unsafe action or unsafe condition, or both. Unfortunately, the inherent characteristics of the environment or action that caused the accident are rarely addressed.
For traffic accidents, Saha Group Industrial Park have taken their responsibility in preventing the accidents that might occur in the industrial park [211]. The company report states that they manage the truck routes in the intense traffic area during peak hours [210]. Moreover, additional exits of the IP are used to relieve traffic congestion in cooperation with responsible agencies in the area. The local authorities have also recommended measures to control traffic both within and outside the IP, and this has helped improve the traffic flow effectively during peak hours and reduce the possible accidents. In addition, the SPI together with PTK Multiservice Co., Ltd., a private traffic and security agency responsible for traffic in the IP have trained their employees to implement the knowledge and skills required for the traffic management. However, there are still many minor accidents.

Industrial accidents, on the other hand, may occur at a workplace or are a direct result of working. The accident statistics from the IP report in year 2013-2014 do not show any serious industrial accidents [267]. However, the report does not cover all the companies in the IP, so the data is not complete.

Despite the positive description above, some current OH&S practices in the industrial park are not adequate in practice. There is a lack of qualified safety officers, limited financial resources, weak infrastructure, and insufficient attention to OH&S issues, inconsistent reporting of accident cases in the firms and so on. It is essential that firms are fully supported by government, both financially and technically. OH&S problems in the IP are all related to the level of development, education, unemployment rate, informal economy and so on. The overall issues for businesses include firms and IP’s owner, and the policy’s makers are as follows:

1. There is a continuing lack of expertise and information about OH&S and risk assessments.

2. There are some problems in the actual number of the accident’s records. The IP itself does not have the complete report about the work-related injuries, accidents and disease in the area. In practice, it is also hard to get the complete reports from the individual firms in the IP. They ignore this procedure because of the lack of the governmental monitoring and inefficient law enforcement.

3. The best practices of OH&S have not been disseminated to and shared by all enterprises in national wide.
4. The indicators for outcome evaluation are not quite clear and reasonable to reach. For example,

- The first target values was “Industrial Park has good security systems that prevent the impact on employees and on the community's health.”. The outcome for evaluation focused on incidence rates of work-related injuries, accident and disease in the area compared to the national statistic. It is a clear setting but there is not a clear enough system for measuring the indicators. According to the “National Profile on Occupational Safety and Health of Thailand, 2015” page 6 [167], there are two different measures of the number of employed workers. A total of 13.63 million employed workers are registered with the Social Security Office – Department of Labour, while 9.13 million employees are registered under the workmen’s compensation coverage. So, it is not clear which “National statistic” is the benchmark.

- The second target value is “There are zero fatal accidents for the year”. The outcome for evaluation is defined as fatal accidents which affected the community in one year. This criterion aims to protect individual and communities surrounding safety but it does not address other kinds of accidents, which might cause serious injury or severe property damage. No one can guarantee a zero risk. Workplace accidents are far too common and possibly occur at any time. An example from the SPI Annual Report 2015 page 44 reported that

“\textit{In 2015, a major fire incident occurred in the factories and power plants within Saha Group Industrial Park Sriracha, whose safety division and the security officials could not control the incident in a timely manner due to coordination, technical and management problems. Therefore, there was damage to the properties of the power plant for an amount of more than 30 million baht.}”. [211]

So, that is a good concerned to put “fatal accidents” in the sustainable development in EIP model. However, the criterion of "no fatal accidents" is very narrow. It does not address other serious accidents that cause a great deal of harm. In addition, the concept of “sustainable” should better be considered in the long-term period rather than only focusing on year-by-year outcomes.
6.5 Conclusion

This chapter has described the general data about Saha Group Industrial Park and explained the implementation of OH&S in the IP. As part of the case study of this research, the evolution of EIP experienced in the Park has been discussed. The evaluation of application of health and safety criteria in the Saha Group Industrial Park is also presented at the end of this chapter. A number of important results and key findings from the qualitative finding will be identified and analysed in the next chapter.
Chapter Seven

Results from Qualitative Research:
The Level of OH&S Awareness and Participation in OH&S of Firms in Saha Group Industrial Park

This chapter consists of one conference presentation. The bibliographic details of the paper, including all authors, are:


My contribution to the published manuscript involved:

- Initial concept
- Collection and analysis of data
- Preparation of manuscript

Kultida Bunjongsiri

Corresponding author: Prof. Cordia Chu

Principal supervisor: Prof. Cordia Chu and Dr. Sunil Herat

In order to comply with copyright regulations this presentation is not published here.
7.1 Introduction

The previous chapter gave the general data and outlined the implementation of occupational health and safety (OH&S) in Saha Group Industrial Park. OH&S could play an important role in an Industrial Park (IP) in line with the requirements of eco-industrial policies to prevent accidents and injuries in the workplace. This study was conducted to determine the level of OH&S awareness and participation in OH&S of factories in the selected IP. Before proceeding, it is important to define what we mean by the key terms “awareness” and “participation”. Awareness is the ability to know and perceive or to be conscious of something such as a situation, condition, or problem. In an industrial park, awareness is important when organising environmental practices in the park because if employers or employees are not aware of the need for OH&S, they will undermine or ignore the safety rules [275]. Participation in an eco-industrial project indicates that every firm participates voluntarily in all aspects including OH&S. There is no legal compulsion for the firms to follow ecological principles or health and safety principles beyond what the law enforces. The project works only by persuasion. Thus voluntary participation is the key to successful implementation of OH&S.

This chapter shows the results relevant to the 3rd and 4th focus question of this thesis. The chapter starts by analysing the survey results to determine to what extent the firms were aware of the implications for OH&S of entering an eco-industrial project, and how well they participated in this aspect of the project. It then examines the level of agreement about OH&S management in industrial ecology schemes. Following that, it considers the barriers and challenges to implementation of OH&S in the workplace, and discusses the factors that limit the implementation, including policy and regulatory frameworks, funding, organisational set ups, technical factors, information sharing and participation by firms in the IP.

7.2 The Awareness and Participation of Firms in the Industrial Park on OH&S in Accordance to the Requirements of EIP Regulations

Questionnaires assessing information such as the opinions on OH&S management through industrial ecology schemes were used as the main instrument to obtain data for this study. The quantitative data come from a self-check questionnaire completed by the safety officer or the person in charge of the OH&S section of the businesses in the Saha Group Industrial Park. The gathered data related to their awareness of their company’s
OH&S program, particularly what they need to do to participate in the EIP, and how their program actually operates. The questions related to this chapter are contained in parts 3 to 5 of the questionnaire presented in Appendix A.

Further data were also collected from a mix of formal one-to-one conversations (not interviews), informal conversations, the views of the management team support staff expressed at the meetings and the researcher’s own observations. In addition, project documentation such as project plans, progress reports, financial reports and lessons learned reports complemented the spoken data in the case analysed.

According to the survey, only 24 respondents (54.5 percent) had ever heard about the eco-industrial project which was supported by the DIW. Fifteen of them had only found out through an email/invitation letter from the head office (Sahapatana Inter - Holding, SPI) to take part in this research. Eighteen participants (40.9 percent) responded that they had never heard about this project before and 2 participants did not respond (See Figure 7.1).

![Figure 7.1 Recognition that the Eco-Industrial project is supported by DIW.](image)

For the awareness of the participation of Saha Group Industrial Park in the DIW pilot project, 29 participants (65.9 percent) were aware that their firm was participating. All of those who gave the source of information (8 respondents) said that they first knew about it from the email/invitation letter from SPI too. Thirteen participants (29.5 percent) did not know of the participation, and 2 participants did not respond (See Figure 7.2).
Figure 7.2 Recognition that the Saha Group Industrial Park is part of the Eco-Industrial project

According to the information they have heard, their understanding about the purpose of this project can be summarised from the open-ended questions.

“When participating to this project, it will help improve many aspects of the industry and community together to make it sustainable.”

“Industrial development is a way to develop by balancing the three pillars of economy, environment and society by making factories coexist with communities peacefully and sustainably.”

“The project encourages the firm to manage resources and energy with high efficiency. It also encourages the participation of all sectors in environmental management, such as government agencies and communities etc.”

“All companies located in the industrial park must follow the related laws to balance peacefully among all sectors upon the principle of the good environmental governance.”

Ideally, the firms co-located in the Industrial Park and the Park’s owner (SPI) should work together as partners. However, in several cases they have worked in different ways. The management systems of the Park are very well set up but so not work not well in practice. For example, problems related to OH&S were outstanding:

- The data about awareness of firms co-located in Industrial Park on EIP project showed that workers did not have enough knowledge and information about EIP participation project in the Park. One respondent from FGD said:
“We (the company) don’t know what this project (EIP) is. So, when we received
the invitation letter to attend this workshop meeting, we first thought that it’s not our
business and it didn’t relate to us at all.” (FGD-1)

- The comments from the employees about the information that firms received
suggested that they got almost no information about the EIP from any source (employer,
IP owner etc). The owners and management officers had never considered the possibility
of sustainable development in their workplace. The facility manager of the IP said

“We normally notify our members (companies in the Park) of the IP activities by
various communication channels such as circulating documents in the Park, email, social
networking etc. The problem is — sometimes we get small responses from the members
especially in the non-benefit business like EIP project. So, on the one hand we have to
continue the project as it is assigned by the Park’s director board. On the other hand, we
realise that to succeed in EIP project, we need the full participation of our firm
members.” (SPI-1)

- There is other conflict issue between the owner of firm and the workers. Most of
shareholders in Saha Group Industrial Park (about 80 percent of the corporate
establishment) are Japanese. One respondent from FGD confirmed

“As a key person in charge with the OH&S activity in the company, I found that
there was a problem sometimes to get funding in the budget from the foreign owners in
requesting a new OH&S project. This came from the lack of an overall understanding of
OH&S risk and the Thai law. So, I can only do my best with such a limit of the company
owner’s endorsement.” (FGD-2)

7.3 Level of Agreement about OH&S Management through Industrial
Ecology Schemes

The firms in Saha Group Industrial Park do not have a lot of agreement about the OH&S
management in the industrial ecology scheme of EIP. The results in Table 7.1 indicate
that 47.7 percent of the participants in firms co-located in the IP agreed (mean score value
of 4.39) that their companies give top priority to OH&S policies in the workplace. Further
responses agreed that the companies will gain benefits from joining the Eco-industrial
Project (59.1 percent) and this project will enhance the development of OH&S in their
factory (61.4 percent) with mean scores value of 4.05 and 4.07 respectively. Findings also
showed that 50 percent of the respondents agreed (with the statement that all employees
should be involved in the implementation of OH&S in line with the requirements of eco-industrial policies. In addition, 52.3 percent of participants agreed that the requirements of eco-industrial policies and the relevant legislation are appropriate for an industrial park. Finally, 59.1 percent of participants replied that they were satisfied with the implementation of OH&S in their agency with a mean score value of 3.86 (See Figure 7.3).

Table 7.1 Level of agreements on OH&S management through EIP policies in Saha Group Industrial Park.

<table>
<thead>
<tr>
<th>Question</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>% of Agreed</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does your company give top priority to OH&amp;S policies in the workplace?</td>
<td>44</td>
<td>3</td>
<td>5</td>
<td>47.7</td>
<td>4.39</td>
<td>0.618</td>
</tr>
<tr>
<td>2. Do you think that the Industrial Park will gain benefits from joining the eco-industrial project?</td>
<td>44</td>
<td>2</td>
<td>5</td>
<td>59.1</td>
<td>4.05</td>
<td>0.746</td>
</tr>
<tr>
<td>3. Do you think that joining the eco-industrial project will enhance the development of OH&amp;S in your factory?</td>
<td>44</td>
<td>1</td>
<td>5</td>
<td>61.4</td>
<td>4.07</td>
<td>0.759</td>
</tr>
<tr>
<td>4. Do you think that all employees should be involved in the implementation of OH&amp;S in line with the requirements of eco-industrial policies?</td>
<td>44</td>
<td>2</td>
<td>5</td>
<td>50.0</td>
<td>4.16</td>
<td>0.834</td>
</tr>
<tr>
<td>5. Do you think that the requirements of eco-industrial policies are appropriate for the Industrial Park?</td>
<td>44</td>
<td>2</td>
<td>5</td>
<td>52.3</td>
<td>3.93</td>
<td>0.789</td>
</tr>
<tr>
<td>6. Do you think that the requirements of eco-industrial policies comply with the</td>
<td>44</td>
<td>2</td>
<td>5</td>
<td>52.3</td>
<td>4.18</td>
<td>0.724</td>
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</table>
Table 5.2 Level of Agreement on OH&S management through EIP policies

<table>
<thead>
<tr>
<th>Question</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>% of Agreed</th>
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<tbody>
<tr>
<td>The company gives top priority to OH&amp;S policies</td>
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<tr>
<td>The requirements of EIP policies comply with the relevant legislation</td>
<td></td>
<td></td>
<td></td>
<td>59.1</td>
<td>3.86</td>
<td>0.734</td>
</tr>
<tr>
<td>All employees should be involved in OH&amp;S in line with the requirements of EIP</td>
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<tr>
<td>Joining the EIP will enhance the development of OH&amp;S</td>
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<tr>
<td>IP will gain benefits from joining the EIP</td>
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<td></td>
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<tr>
<td>The requirements of EIP policies are appropriate for IP</td>
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<tr>
<td>Satisfaction with OH&amp;S in your firm</td>
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</table>

Figure 7.3 Level of Agreement on OH&S management through EIP policies

Although the government agencies I-EA-T and DIW have carried out their important missions to develop EIPs since 2000, they attempted to apply eco-criteria only in environmental dimensions such as waste exchange and water/wastewater management. Indeed, at present there are no EIPs in Thailand following all the principles of industrial ecology. This work proposes that OH&S management can become an important criterion for evaluating industrial parks that wish to be eco-industrial parks, such as Saha Group Industrial Park, Sriracha. It seems likely that enhancing their OH&S performance will provide them with the opportunity to gain significant benefits. This work should therefore encourage industrial parks to implement an effective OH&S system and adopt a responsible behavior in this area. Consequently, they should bear in mind that other aspects need further attention, such as the awareness and participation of firms co-located...
in the industrial park that favor the implementation of such a management system, and the integration of the system into the management of the firm. From the results, it can be clearly seen that more than half of participants are aware of the implementation of the project. However, to succeed in this project, the industrial park must be fully supported by all firms, and they must clearly understand that they need to move forward together.

In this study, it should be borne in mind that the relations have been evaluated from the viewpoint of the firms’ safety officers only. In a similar way, it has been shown that the data is based from the safety officers’ willingness to respond. This fact could create biases, with the firms with the best safety culture being more predisposed to participate in the study. But this is a common problem in studies that use this methodology based on questionnaires.

### 7.4 Barriers and Challenges for Implementation of EIP in the Industrial Park

The data concerning the barriers to and the challenges for implementation of EIP in the industrial park are derived from the in-depth interviews. These interviews were gathered from informants from different organisational backgrounds. From the responses, the following main themes and sub-themes of challenges for implementing EIPs project were extracted in Table 7.2.

<table>
<thead>
<tr>
<th>Main factors</th>
<th>Sub-factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy and political challenges</td>
<td>• Unclear criteria/measures to guide.</td>
</tr>
<tr>
<td></td>
<td>• Shortage of specialists in understanding EIPs.</td>
</tr>
<tr>
<td></td>
<td>• Lack of funding support.</td>
</tr>
<tr>
<td></td>
<td>• Previous narrow focus on waste management.</td>
</tr>
<tr>
<td>Industrial Parks and personal challenges</td>
<td>• Weak cooperation between firms and the IP management.</td>
</tr>
<tr>
<td></td>
<td>• Need for guidance from governments (policy) and experts (advice).</td>
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<td>• Lack of funding support.</td>
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| Community/Local Government agencies’ challenges | • Weak cooperation between community and EIP management.  
• Difficulty in determining leader in communities.  
• Weak sense of responsibility among local government for running projects. |
| Technical and Knowledge challenges | • Limited dissemination of knowledge.  
• Lack of technical services.  
• Lack of support for training /education. |

The key barriers to development of EIPs in the Thai context are classified under these main themes in the following paragraphs.

**Theme 1 Policy and political challenges**

• Unclear criteria/measures to guide.

The criteria/measures to guide the EIP scheme have been confirmed by the informants who expressed a common view regarding the government’s criteria. Currently, there are two main agencies which have launched specific criteria to achieve EIP. Unfortunately, after criteria were set up in 2012, there is still no clear direction to define EIP and no clear mechanism to enforce the regulations for an EIP. While DIW monitors industrial parks and single factories using 5 dimensions with 20 aspects, the I-EA-T monitors industrial estates using the same dimensions plus two extra aspects. Moreover, the government has not yet set up incentives such as tax reduction policy to reward the IPs for participating in the EIP project.

An informant from I-EA-T commented

"Since the EIP projects were launched in 2012, some IPs, IEs claimed to be “Eco” even though they are still in the initial stage of development. Unfortunately, they are not endorsed by DIW/I-EA-T. Although the government has set up specific criteria to guide, there are still no clear measures addressed and guided to achieve this status.” (I-EA-T -1)"
• Shortage of specialists in understanding EIPs.

Most experts consider EIPs as one of a number of strategies that could lead to sustainable industrial development [62]. In Thailand, there is a limited specialised knowledge in the related government about how to work with and conduct implementation of EIPs. Presently, DIW has assigned various expert teams from academic or professional agencies to act as mentors to guide IP with their specialised knowledge. Moreover, there is no specific course in the educational system that supports this discipline.

A specialist from the public university said

“It learnt and cultivated the theory of EIP by getting involved and being part of a research team from Japan for many years. It’s very hard to find specialists because there are a limited number of the experts who are interested to do the research on this topic. It’s still quite new and there is not enough funding to encourage the researchers to do the research on the sustainable topic in Thailand.” (EXP-1)

• Lack of Funding support

The Thai government provided funding and support to implement EIP projects in the year 2012 and 2014. However, the funding was limited and was discontinued in 2011 because of the reluctance of the government to support the EIPs due to political changes. So, no funding was provided in some fiscal years. As a result, the projects did not run in the years 2011 and 2013 (confirmed in Chapter 3). So, the DIW was unable to effectively implement projects to fulfill their missions. Thus the projects had to start from the beginning again in 2014.

An officer from DIW clearly expressed

“We got a small amount of funding – approximately 10 Million Baht (AU$ 380,000) funded by the government to run the EIP projects in 2012. However, this funding is too small and inflexible, so most of the budget was only spent on the Eco-Forum which was set up as an open-floor for all stakeholders (Industrial Parks, local government agency, Community) to plan and prepare the long-term project. Furthermore, we didn’t get the funding in the next following year (2013), so, the projects were not continued.” (DIW-1)

• Previous narrow focus on waste management
The operation of EIP in the year 2012 finished with 3 Eco forums that included Saha Group Industrial Park, local government officers and an officer of the Bureau of Public Participatory Promotion, and the surrounding community [131]. The result showed that they set up 11 projects for the following year, focusing on waste management and community network development projects. The barriers to these plans were

- No primary database of waste management in Thailand. There are two data sets of waste treatment and disposal from the factory. The first set is the document reporting the amount and type of industrial waste that the factory wishes to take out of the production site. The second set is the actual data of industrial waste that is transported from production site to industrial waste treatment plant. Unfortunately, there is no proper evaluation of the data from the reports.
- Not enough official agencies to dispose of industrial waste. Illegally dumped waste is a problem.
- High fees for waste disposal by the standard waste disposal agencies.

Teeravaraprug, J. and Podcharathitikull, T. (2016) suggested in their study that the government should pay attention in resources and find a method to make resources ready for industries in order to achieve EIP [141]. The Business Development Manager, Siam Cement Group (SCG) who is involved in the country’s waste management statistics stated that

“Presently, the national data in waste management is duplicated and disorganised including the data from the primary sources from the factories. As long as the statistics are still not managed properly, appropriate waste management will never happen. The illegal dumping arises because there are not enough standard waste treatment plants and it is too expensive. It’s rare to have an inspection -- “WHO” or “WHEN” or “WHERE” or “WHICH” -- sources that break the law.” (EXP-3)

The facility manager of the IP mentioned another issue

“We have tried to focus on waste exchange since a few years ago. The problems were — we had no success to match waste to raw material – it was not worth using recycled waste and not widely accepted because we trade in a high quality market, so we have to give more concern to selecting high grade raw material as well.” (SPI-4)
Theme 2 Industrial Parks and personal challenges

• Weak cooperation between firms and the IP management.

The Board of Directors in Saha Group Industrial Park, Sriracha was willing to get involved in EIP project voluntarily. They have worked on the pilot project with DIW since 2012 by setting a model plan to develop the EIP project in their IP. Unfortunately it’s difficult to develop a new project with the sustainable scheme because the firms do not cooperate fully. The facility manager of IP said

“The Board of Directors of the IP has fully attempted to develop the sustainable project in our area. We aim to live together with the community without any environmental issues. But, we still need whole-hearted collaboration from our members. One of the barriers to achieving this target is that we can’t force them by setting rules; we don’t have the right to do that because we have provided only land and facilities. So, we need to convince them to get involved with our project voluntarily and explain the benefits if they decide to be our partner.” (SPI-1)

Moreover, a specialist from the public university remarked

“EIP is a new phenomenon in Thailand. It is still running in a very early stage in the industrial sector of the country. From the project operation in Thailand since 2012, it was found that there has not been adequate cooperation from people in the community. The project also required a leader from the community and it is necessary to share knowledge from IP-related government agencies to create the idea and cooperate with each other.” (EXP-2)

• Need for guidance from governments (policy) and experts (advice).

Saha Group Industrial Park, Sriracha launched the pilot project of EIP voluntarily in 2012. Unfortunately, since there was no funding from the government in 2013, the project was discontinued because the IP couldn’t continue the project without the funding support and guidance from the government mentor group. The project re-started in 2014 with a new mentor group. So, the lack of a continuing tight conceptual focus contributed to its misconception by participants and confused practice in the IP. As a result, there was a big obstacle to continuing the project from the first stage because the IP needed to take time to restart from the beginning rather than go ahead to the next step. There was insufficient motivation in the IP to step forwards to reach the goal. The facility manager of IP stated
“We started the project and compiled the relevant data for running EIP project for a year. However, after a one-year gap in the government campaign, we had to re-start again in 2014. By changing the mentor to guide the project, it seemed like we had to jump back to the first stage just as we started in 2012. We can’t continue the project by ourselves without the funding support and guidance from the government mentor.” (SPI-1)

• Lack of Funding support

The funding from Thai government is provided to the EIP projects as a whole group. However, the funding was limited and was only used for centralised planning, not for the needs of individual projects. None of the EIPs had funding to take practical action on the criteria they had chosen. The result, from in-depth interviews, was that the participants agreed that it would be better if each IP could run its project independently or if the DIW could provide the funding to individual IPs and set the criteria to achieve EIP status case by case. An officer from Eastern Thai Consulting 1992 who had responsibility for Environmental management within the park and also was involved in EIP project said

“We got involved in the EIPs project in 2012. The first stage was to take part in the Eco-Forum to set the targets of the project and to discuss the issues or concerns. In the Environmental management of IP, we focused on waste water management, which was recommended by the mentors from the consultant agents hired by the government agency. After we finished the plan in 2012, we waited to take action to make the plans real in the following year. Nevertheless, the project was not funded in 2013 and ran again in 2014. The problem is the consultant team was changed by DIW. They stepped in and gathered data from us, so we had to start everything again. It would be better if we could run the project smoothly or if DIW provided the funding to each IP and set the conditions to achieve EIP status.” (SPI-3)

• Firms ignoring the intention of the EIP.

The main mission of the factories in the Saha Group Industrial Park is to manufacture products. The Park has provided facilities, land, and high quality facilities at a good price to the factories to enable them to develop a sustainable business. All these together ensure them maximum profit to stay in business after meeting their operating expenses and social and legal requirements. It is very important to keep in mind that
improved sustainability will fail if the increased profits of that improvement are not utilised for sustainability of factories. However, most of the factories mainly focus on manufacturing benefit rather than the environmental improvement. Hence, the owners were not interested in the environmental benefits, and regarded any environmental work as a burden on their business, not as a potential benefit. The officer in charge of OH&S of the Industrial Park noted

“The factory owners didn’t pay enough attention to responding our request about environmental issues. They always ask for the compensation or benefits if they decide to get involved with our project because they have to reassign their workforce and time on the project which might have an effect on the production plan.” (SPI-2)

**Theme 3 Community/Local Government agencies challenges**

- Weak cooperation between community and EIP management.

Cooperation among government, industries, and communities is important. The lack of cooperation among them may lead to failure of the EIP [141]. As the EIP project lacked a communication mechanism outside the IP, there were some conflicts between IP and residents in the surrounding community over effluents being released into the environment by some of the factories. Originally, there were no communities surrounding the site. However after the development of the IP, a number of dependent communities grew up near the site. These were the communities that complained. The EIP officer from Bureau of Public Participatory Promotion, DIW explained

“When we first launched this project in the target area, we found that there were some conflicts between IP and residents in the surrounding community. The problem occurred because of the lack of communication between them. On the one hand, the IP claimed that they had established and developed this area since it was a remote area and there were no communities surrounding the site. On the other hand, the community argued that the operation of some factories in the IP discharged their effluents directly into environment. So, it’s very important to make a compromise between them and seek for the cooperation to enhance the environmental together. (DIW-2)

Moreover, a local officer from Chonburi Industry Office said

“We are deeply concerned that the civil society participation in improving environmental program implementation is inadequate.” (LGO-1)
• Difficulty in determining leader in communities.

Coordination and working together with different sectors is a principle of the implementation of EIP. However, it is difficult to build effective coordination between IP and the communities. There are no leaders who can speak for their community. Many of the communities lacked a person to speak for them. This is a crucial problem in strengthening an effective partnership for an EIP project. As The EIP officer from Bureau of Public Participatory Promotion, DIW explained

“I have been actively involved in the implementation of EIP since it was introduced in Thailand. I found that it is very hard to deal with the communities. Many of them lacked a person to act as the leader of the community especially in the sensitive issue of negotiating with industries.” (DIW-2)

• Weak sense of responsibility among local government for running projects.

From the local government’s point of view, the EIP is a linking project between industry and the surrounding community. At the city level, there is no specific agency set up for this purpose. The EIP policies from DIW are passed through the local Industry Office in the area. The local government is responsible for undertaking, managing, supporting and regulating the policy which is issued by the DIW. Local government also has a key role to play in translating the national government policies into action for local communities and enterprises in the service area. It performs as a connector to carry out the government plan for the actual activities both in the IP and communities, then reports the results back to the DIW for the project performance record. However, the local government does not have any power to decide anything, just to carry out plans from the central government. It also does not have enough resources (money or manpower) to carry out its role. Thus local government officials feel little responsibility for the success of the EIP. These arrangements are not very effective. A local industrial officer from Chonburi Industry Office said

“We have our responsibility in the area as the coordinator between government and the private sector. The DIW indicates the criteria, they ask for our support when needed. We take action by talking with municipal government, public area, and creating activities as they request. Then give back the result to the central sector.” (LGO-1)

Theme 4 Technical and Knowledge challenges

• Limited dissemination of knowledge
Information about EIPs and industrial ecology is hard to find, both for researchers and for the public. Raw data from industrial firms is often unavailable or incomplete or inaccurate. Thus there is little understanding of what is really happening, or of what industrial ecology requires, and there is no training to provide experts. A specialist from the public university said

“There has been a limited research in EIP published from the country’s data in Thailand. Particularly, the published data from the industrial sector is hard to find. Additionally, no courses are designed for students to take these related subjects either in university or educational training course.” (EXP-4)

- Lack of technical services

In most development environments, some advisory and technical support services are needed during the development process. Accordingly, the creators and designers of EIP also have to provide technical support to each industry to continue their project. Unfortunately, there is little support available in Thailand. An active EIP officer from the Bureau of Public Participatory Promotion, DIW explained

“In our department, there are equally many barriers to innovation, including lack of resources — there is a small number of technical staff, lack of technical expertise, and also lack of technical assistance supporting the EIP.” (DIW-1)

- Lack of support for training /education.

The questionnaire revealed that the staff of Saha Group Industrial Park did not have an understanding about the environmental aspects of EIP including the criterion of OH&S, and they were not interested. So, they need a specific training or workshop to enhance the skills and knowledge of EIP before starting the project in an IP. However, the sharing of information and communication is also lacking. The government sector has not been effective in raising the awareness of the community and of the industrial partners nor in explaining the goals. One respondent from FGD said

“The company did not pay much attention in getting involved in the EIP activities. It wasted time and work time of staff (who had) to leave their regular job and attend the EIP meetings requested from SPI.” (FGD-2)

However, information and communication is also not being shared. The government sector has not been effective in raising the awareness of the community and
of the industrial partners and explaining the goals. An officer in charge of OH&S officer of Industrial Park indicated

“We have made an agreement by signing a memorandum of understanding (MoU) with the DIW to join in EIP project in Thailand since 2012. Nonetheless, we do not yet have a clear picture of the exact direction to reach the goal. We need someone to clarify and guide us about how to succeed and fully claim ourselves as Eco.” (SPI-1)

7.5 Discussion of Barriers and Challenges for Implementation of Health and Safety Programs in Eco-Industrial Parks

Although there have been many EIP developments, implementation of the concept is still emerging and there is not yet a fully realised operating EIP despite the fact that some pilot projects of waste management do exist in Thailand. In practice, the exact number of projects is not clear. In addition, some that have completed the first stage have not decided yet whether to go on to the second stage. Accordingly, the aim of developing an EIP with a comprehensive environmental management system at the park/estate level is a new challenge. Presently, although there is a lot of knowledge about EIP, there is not sufficient practical experience to provide practical solutions for all of the barriers facing EIPs. The identified EIP barriers and challenges factors based on experiences in Thailand can be categorised as:

(i) Policy and regulatory framework,
(ii) Funding support,
(iii) Institutional & organisational setups,
(iv) Technical factors,
(v) Awareness and information sharing,
(vi) Participation of IP members, and
(vii) Health and safety performance

7.5.1 Policy & regulatory framework

While economic benefits are or can be a main inspiration for businesses to engage in exchanges of raw materials, commonly there is not the commitment or capability to identify and take advantage of these opportunities. Consequently, government policy should provide political, representative, educational, and infrastructural support [99]. This is especially the case in the Far Eastern countries where IP and EIPs are initiated
because of national policy [276]. Thailand, like Korea and the Philippines, has developed national strategies for EIPs to help solve environmental degradation caused by failures of “end-of-pipe” pollution control approaches [277].

Chertow (2007) pointed out that the government should play three roles through policy making: (1) forming surveillance teams to identify industrial areas where there is a basis for waste exchanges and mapping the waste flows concurrently, (2) offering technical or financial support to increase the number of interaction sites, inspired by managers with a symbiotic mindset, and (3) seeking potential locations where normal symbiotic processes already exist, such as co-generation systems, landfill gas mining, and waste water reuse, to determine whether they may be sites for technical or financial assistance to open gates to more extensive symbiosis [278].

In Thailand, the government’s approach didn’t convince industries to participate since they considered “the project as a job creation initiative and not as an economic program designed to help the economic and environmental performance of the companies involved” [279]. Another important point to be addressed by government is to bring current environment legislation and standards into line with the principles of EIPs. There are regulatory barriers to the concept of waste exchange, the export of waste between firms. It is not possible for firms to exchange substances classified as “hazardous waste” under the Thai act. As Wasserman (2001) comments “while United States environmental regulations are strict, many times they prescribe technologies and limit exchanges of hazardous and solid wastes due to permitting requirements. This does not incentivise firms to seek by-product exchange as a solution to environmental control requirements” [280]. In addition, an option to start waste exchange brokerage approaches is also developed in an US EPA report [281].

Currently, the Thai experience in compliance and enforcement of environmental laws has been very weak; this is because the regulatory acts are not supported with adequate resources – money and people. Teeravaraprug and Podcharathitikull (2016) confirmed in their study that the main reason for problems in the environmental arena was the lack of the governmental monitoring and inefficient law enforcement [141]. Weak law enforcement; high costs of environmental monitoring and managing; lack of skilled and educated manpower in specific disciplines; unclear roles and responsibilities of regulatory controls; and inadequately flexible funding mean that environmental complaints are rarely investigated. Moreover, EIPs are not properly integrated into national development
planning processes to connect with the national plans, budgets, strategies, and local level implementation within the wider stakeholder community. If they were properly integrated, they would be one of the government’s devices to achieve economic growth and sustainable development. Thailand’s Industrial Development Strategy states that the development of Eco-Industrial Parks is currently on the top of the agenda of the Ministry of Industry where the private sector will be involved through a collaborative partnership approach. Under the framework of the current 11th National Economic and Social Development Plan, 2012-2016, Thailand plans to change into a "green society.” The plan attempts to develop eco-industrial towns and recover the environment in major industrial regions by creating awareness of the need for co-existence between industries and communities [282]. Although this indicates that Thailand is moving toward industrial ecology, the potential EIP conceptualisation focuses tightly on the economic factor leaving out the environmental and social factors. Moreover, no actual plan has followed this declaration to take the measures required to create EIPs in the country. Politicians and park managers just admire the concept, naming all and everything eco-industrial. Being “eco” seems to be the trend now in Thailand. However, merely talking about the concept or making a development plan does not transform a regular industrial park into an eco-industrial park, unless there is discernable change in the park or the tenants. Although it is good to have the interest in the EIP concept, the country has a long way to go to come up with real changes in how industrial parks are managed.

7.5.2 Funding support
At the early stages of EIP development, it was accepted that the government and industrial estates needed to provide funds and technical support to assist in awareness campaigns, establishing an information sharing infrastructure, and setting-up the EIP management system [276]. However, the lack of adequate funding for EIPs is a major problem. The implementation of industrial parks in EIPs relied heavily on full government funding, which was not reliable. The firms involved were not expected to provide any funding. As a result, industrial parks have been unable to effectively drive projects to achieve their goals. Funding is uncertain and subject to economic and political changes, and lacks long-term focus. This makes it difficult for the government agencies to support the sustainable development goals of the country. Local government bears the heavy cost of public activities, but it is constrained by limited central funding and weak financial controls, which sometimes impact on the flow of funds. In contrast, in the Dutch cases studied, the
financial participation of companies in the EIP development process was more developed [279]. In the Dutch cases, firms on the one hand, and government and other participants on the other hand, each seem to be responsible for 50 percent of the planning costs. Companies planned to contribute their 50 percent through the supply of personnel and equipment. Initial research indicates that the Dutch EIP projects are more successful than their counterparts. That is, the cost of the realisation of the planned EIP developments, beyond the part that is covered by subsidies, both in the Netherlands and the USA, was shared by the companies, who stand to gain from the implementation of the planned exchanges. This difference in financial participation can also be clarified through the record that American industries are more passive in the development of plans for the intended EIP. This means that the local/ regional government and other parties interested in the project bear the cost of the planning process in the USA [279]. Cooperation between companies cannot be addressed through policy intervention and laws but has to evolve over time through the motivation of the investors and directors. This difference in success can be accounted for by noting that the USA projects were initiated by local and regional governments that saw the project as a way to improve the local/regional economy with access to substantial national government funds. Because of this weighty government involvement, USA companies were in general not interested in the EIP projects. The more successful Dutch projects, on the other hand, were mostly initiated by the companies themselves with financial and advisory support from the local and regional government and from university faculty [276]. Besides companies’ support, successful EIP development requires broad community support and active participation of major stakeholders, such as educational & research institutions and multi-disciplinary experts and consultants. This sort of support will be examined in the next section.

7.5.3 Institutional & organisational setups
A successful strategy to make an integrated EIP scheme is to integrate the planned exchanges of materials etc. between firms into the corporate organisational structure of each engaged firm and in the overall management system of the park [276]. Information sharing and basic infrastructure significantly encourages collaboration and knowledge exchange between firms. In the Industrial Eco-System project (INES) case in the Netherlands, one of the success factors is the presence of the Building Information Modelling (BIM) Network, which is a communications platform formed in the course of the EBB BIM project by a cluster of industries located in the Europoort–Botlek region.
The companies indicated in this network informed each other about their progress and problems in the implementation of pollution prevention and environmental management systems. This network was taken from a previous project of the Europoort Employers’ Association, concerning the implementation of environmental management systems in member companies, and functions as an important sharing platform among the firms.

In Thailand, the concept of sharing resources that is at the basis of the Industrial Eco-System case is unfamiliar. To encourage this sort of cooperation in the EIP at the national level, the government has founded a “Bureau of Public Participatory Promotion” to take responsibility in developing industrial sustainability in the country and mentor companies that are interested. They manage the projects by hiring professionals from outside to carry out the EIP projects. Notably, in the recent EIPs performance in 2012 and 2014, there were two different agencies that took charge as EIP mentors. In 2012, The Industrial Environment Institute under the Federation of Thai Industries carried out activities through 5 pilot projects. However, in the second stage in 2014, DIW assigned a new group of mentors from Kasetsart University to manage the previous 5 IP projects plus 4 more IPs. So, there was no continuity with the earlier projects, and the projects ended up starting all over again.

In the Industrial Park, although the company has set up an “Eco Centre” and a green area to foster eco-industrial management and support community activities, the Centre has no work to do on environmental management because the focus is only on waste water management, which was carried out by a separate company (Interview SPI-1). Thus the Eco Centre has no direct effect on the project but it serves as a part of corporate social responsibility (CSR) where industrial operators and community members can do activities collaboratively.

7.5.4 Technical factors

The most challenging technical issue facing an EIP is the lack of an internationally accepted standard to address the technical aspects of an EIP, to guide its planning and implementation, and to evaluate the performance in order to endorse the program [276]. In the global factors, this causes confusion and misleading claims of what it means to develop industrial sustainability. Peck (2002) introduced the development of a performance rating system, similar to the Leadership in Energy and Environmental Design (LEED) rating system, which would result in better acceptance of the concept and
help to encourage its integration into other internationally accepted standards like ISO 14001 for environmental management systems [283]. Another important point is the lack of efficient technical know-how for exploring and evaluating EIP opportunities, and implementing the technological measures needed to determine the EIP benefits. Several authors [26, 284-286] assume that industrial ecology is about enhanced pollution prevention, while others argue that IP may also affect firm-level environmental measures like cleaner production. Pollution prevention and cleaner production are connected with IP in many cases, where they clearly share a body of purpose and similar objectives [50]. The three concepts are designed to help company heads and their workers to reduce the polluting wastes, to avoid charges for treatment processes and disposal, to protect human health, and to minimise impacts on the environment and resources [287]. However, preventive approaches as mentioned above have their limits; they are engaged with reducing raw material consumption and reducing wastes at the factory level, and should be merged into industrial metabolism and industrial ecology [38, 101]. Cleaner production at the micro level of single companies can be interconnected to IP at the meso level of industrial parks, and further to sustainability through a systems approach labeled Cleaner Production Systems or Sustainable Consumption and Production Systems [288]. These also were intended in the EIP implementation in Thailand. However, although the government has set up the specific criteria to guide EIP development in the country, it still lacks efficient technical know-how and measuring and evaluating systems to achieve their goal.

7.5.5 Awareness and information sharing

It is important to raise the awareness of the public, of the managers of the industrial park and of each firm in the park. The initial EIP awareness should be raised through networking with key individuals and organisations; organising public events with media communication; conducting workshops or conferences; launching an informative website; and planning activities in institutions [50].

Information sharing is important since it encourages companies to find suitable business matches and allows sharing of all available tools and resources within the community [279]. The best person for information collection and exchange is the EIP manager. However these services are considered by them to be additional to the basic infrastructure services for tenants directed by law [277]. Veleva, et al. (2015) confirmed in their case study of Devens. They found that eco-industrial parks can be less about physical
exchanges of materials, energy, water and by-products, and more about infrastructure and knowledge sharing from weather and other business disruptions [109].

In Thailand, despite the relatively good awareness of the EIP concept among regulatory bodies, industries, local consultants and academics due to the effort of the government funded projects, there is little knowledge about IE/EIP at all levels. A study in the year 2016 also found the problem in information sharing and reporting among governmental agencies, industries, and neighboring communities which resulted from lack of participation by the surrounding communities [141]. Definitely, dissemination of information especially about successful existing EIPs worldwide and through the implementation of demonstration projects is imperative activities that could help to introduce the EIP concept to Thailand. The main gap is the scarcity of updated information about the environmental impacts of industrial parks and the resistance to the exchange of information between relevant entities. The key environmental data collectors are Pollution Control Department; Ministry of Natural Resources and Environment and Department of Industrial Works; Ministry of Industry. These collectors should collect a general description of the industrial facility, data on its inputs and outputs, a description of the production processes, data on the utilities within the facility, information concerning previous violations by the facility, information on sources, types and quantities of pollution within a facility, and changes in any of these data in the entire lifecycle. However these data are available only to the Inspection Unit staff and are not a representative sample of Thai industry because the Inspection Unit chooses to focus on specific sectors. These ‘hidden’ exchanges are frequently ‘uncovered’ by an intervenor such as an academic institution or business association, after they have implemented material and energy sharing activities and have attained environmental and economic benefits. In the industrial park itself, sometimes the companies involved are not aware of the information record and exchange in the park. If there is a system of information record and exchange, the system arose for economic and regulatory reasons and it was never labeled as part of the EIP. Thus, even when there is a working system for information exchange, it is underused.

7.5.6 Participation of IP members.

Eco-industrial parks are drawn to address the industrial system as a whole, where it examines technologies, economics, the inter-relationships of businesses, financing, government policy, and important issues in the management of organisations such as
environment protection and optimising the use of limited resources [289]. Active company participation in the EIP project is the most important element for success because, eventually, companies themselves need to implement the plans made. [279]. Kechichian and Jeong (2016) suggested in their report that although sustainable industrial areas focus on the management level of an industrial zone with the intent to guide the industrial area as a whole to become more sustainable, this approach does not deal with the individual companies. Hence, the sustainability framework at the park level is unlikely to initiate and encourage the change on the company level as well [30]. In Fairfield and Brownsville cases, the majority of companies located in the projects area did not want to invest in the establishment of the planned EIP exchange relationships with other companies’ located surroundings. They did not want to invest in such exchange relationships because they believed they would be financially risky and because of their distrust of the local government which helped to found the EIP plans [279]. In order to make a successful project, the developers and sponsors would have to promote more active involvement of the participating firms [279]. EIP needs cooperation, and teamwork encourages success. Trust among an industrial park’s members is an important prerequisite to changing their business models to become more sustainable. If organisations are willing to adopt alliance-like organisational structures, they will be less vulnerable to the fluctuations of the environment.

In Thailand, from the beginning stages of the 2012 and 2014 projects, another obstruction arose. Data collected from Saha Group Industrial Park, Sriracha showed that the board of directors of the business group was willing to participate in the project. Unfortunately, the greater number of the firms located in the area did not get involved in such projects. Most of them did not even know about the collaboration between the Park and the DIW as was confirmed from the survey questionnaire. They didn’t bother to participate in the project because of their concern about the business continuity rather than their attitude to sustainable development. Moreover, some companies indicated that they didn’t clearly understanding the purpose of becoming “eco” in this area. So, they set this voluntary task as lower priority, because it was not compulsory.

7.5.7 Health and safety performance
The integration of OH&S into environmental management systems can help enterprises to handle both environmental and safety risks as well as to prevent duplicated measures and find solutions in an optimal way [290]. However, the problems in life-cycle
assessments and in environmental technology databases are largely caused by the models of production processes that are applied in environmental engineering and economics [290]. In the scope of the systems, the human work force is left out or is only a passive object of destructive factors. From the OH&S point of view, this practice could be problematic when essential risk factors are neglected in the assessment. Industrial ecology aims to provide a production process that leads to sustainable development. However, O'Rouke et al. (1996) believe that industrial ecology does not take into account conflicting targets of various stakeholders and other socio-political factors. The OH&S issues have not been considered in any systematic way [291]. The legislation and administration of occupational health and safety and environmental protection have their own story. At least closer co-operation, if not new organisational structures, were needed between these authorities, when industrial firms began more and more to introduce management systems based on an integrated approach [290]. Amponsah-Tawiah (2013) stated that the best OH&S policies would lead a firm to reach the best economy in their operations both for the employee and employer. Moreover, OH&S policy is at the basis of environmental friendliness. Proper OH&S policy helps enclose effectual environmentally friendly programs to assure that the employee is safe in their working time.

In Thailand, national policy in OH&S issue has been developed for 40 years since the establishment of the Division of Occupational Health, Ministry of Public Health. However, with growing industrialisation, problems of OH&S have also surfaced in Thailand. Since then, OH&S issue has become more important in Thailand. High risk occupations still need attention in order to improve the diagnosis and reporting systems in those industrial sectors [166]. Although all relevant organisations in the country cooperate to accomplish their missions to solve or relieve the problems of working conditions problems, other proficient control measures, suitable measures at the enterprise level, are necessary. Ensuring occupational health, safety and environment is not only a technical question, but a political one as well, because it poses the question as to who determines and who instructs alternatives to the production process especially in an industrial park. In an industrial park, the park’s owner provides an up-to-date policy issued by the governor to co-located firms only. So, it is the responsibility of individual firms to send a report on its OH&S implementation directly to the local government annually. Hence the government should make provisions for compulsory disclosure of information regarding OH&S data by the owner. The risk of accidents during the work
process is to be disclosed to the workers employed in the factory, the factory inspector and to the general public in the vicinity of the factory. This information should not only include the workplace accidents but also OH&S policy for the workers, detailed emergency plans and disaster control and safety measures required to be taken in the event of an accident.

The Thai government initiatives have introduced criteria to help IPs’ evaluate their performance, though the current focus is sometimes limited to using the existing mechanisms to drive the process. The results from Saha Group Industrial Park, Sriracha show that OH&S management can become an important criterion for evaluation of eco-industrial development due to the Park management’s effective OH&S performance. However, the individual firms in the Park have not matched the performance of the Park management and need further attention before they are considered for eco-industrial status. To succeed in this project, the industrial park should be fully supported and all firms should clearly understand that they must move forward together. Nevertheless, despite the participation of some firms in the project, workers’ knowledge about OH&S is not satisfactory yet.

Seven factors of barriers and challenges based on experiences in Thailand were found as policy and regulatory framework, funding support, Institutional organisational setups, technical factors, awareness and information sharing, participation of IP members, and OH&S performance. Although there is a lot of knowledge about EIPs, there is not sufficient practical experience to provide practical solutions for all of the barriers facing EIPs.

**7.6 Conclusion**

This chapter has presented results from the case study of this research. A number of important findings from the fieldwork have been identified and analysed in this chapter. The results provide evidence to support the proposal. The findings of this work consequently represent an important source of motivation for firms to implement OH&S management in line with the requirements of EIP policies. In IP, OH&S policy has been driven solely by the need to comply with legislation. However, the owner of an IP has no power to force firms to comply; so many companies ignore the Park’s policy or even ignore the law. The employers’ understandings about OH&S are at a low level. They treat information about hazards to workers lightly. They also do not really understand the
OH&S laws that apply to their workplace. In summary, OH&S policy in the Saha Group Industrial Park has the potential to be effective and a useful criterion for determining the eco-industrial status of a firm, but the industrial park has insufficient power to enforce these policies. Some of these findings will be discussed in the next chapter.
Chapter Eight

Discussions and Recommendations

This chapter consists of one manuscript prepared for publication and one presentation at a conference. The bibliographic details, including all authors, are:


8.1 Introduction

The previous chapter presented key results and identified main findings from the implementation of the current EIP project in Saha Group Industrial Park. Although the project has not been completed yet, the current findings point out that there are both barriers and challenges to the industrial park response in Thailand. The experiences and lessons have great implications for the future of the Thai industrial sector.

This chapter shows the results relevant to the 5th focus question of this thesis. This chapter first highlights the main findings from the case study, and then discusses them by linking these to current Thai realities and to the literature. Some points of the discussion are confirmed by the literature, such as the development of EIPs worldwide; the development of EIPs in Thailand; the changes in the role of government in EIP development; and conflict issues in the EIP project management. The chapter lists the factors for EIP success and the utility of examining OH&S performance to guide EID in Thailand. Some recommendations for the future OH&S management based on the literature and the new findings are offered at the end of this chapter.

8.2 Factors Critical for Success of Eco-Industrial Park Projects in Thailand

Until recently, sustainable business practices were widely ignored or overlooked by most of the enterprises operating in industrial parks. In the next period of industrial zone development, sustainability and eco-industrial growth will play important roles in minimising environmental and social risks while generating profits for firms [30]. This combination will assist governments to scale-up and enforce sustainable infrastructure to fulfil their commitments to meet the sustainable development goals.

Mainstreaming EIP into the country’s national strategy is vital for its success and continuity similar to Thailand’s circular economy. EIPs should be integrated into national development planning processes to link them to national plans, budgets, sector strategies, and local level implementation within the wider stakeholder community. This would allow the government to use EIPs as one of the mechanisms to achieve economic growth and sustainable industrial development. Although there is a good indicator that Thailand is moving toward industrial ecology, the conceptualisation of an EIP still focuses strictly on a few factors only such as by-product exchange and waste management leaving out
the other factors. Unfortunately, no action plan has followed this declaration to set up the conditions required to create EIPs in the country.

Saha Group Industrial Park is focusing on all kinds of stakeholders which consist of internal and external participators, shareholders and employees and also the social and environmental responsibility by utilising management tools and methodology through company’s activities such as public forum, satisfaction or advice survey, complaint management system, company visit through Open-House activities and meetings. As a result, Saha Group Industrial Park could adopt some ideas for improving and developing the guidelines for business operation to meet the expectations of the community and of other stakeholders, which directly affects the sustainable growth of business and corporate governance of the company. The guidelines and strategies for stakeholders in Saha Group Industrial Park are suggested in Table 8.1.

Table 8.1 Guidelines and Strategies Applied to Stakeholders in Saha Group Industrial Park.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Guidelines and Strategies Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Partners</td>
<td>Create good mutual relationship pursuant to agreements and sharing information; perform in line with framework of government policy.</td>
</tr>
<tr>
<td>Employees</td>
<td>Develop potentiality for professional stability, concern for health and safety, and adhere to the principles of OH&amp;S.</td>
</tr>
<tr>
<td>Civil Society Sector</td>
<td>Open public forum; jointly build academic network for sustainable development of community and society.</td>
</tr>
<tr>
<td>Academics</td>
<td></td>
</tr>
<tr>
<td>Communities</td>
<td>Aware of health, safety and jointly create good quality of life with sustainability.</td>
</tr>
<tr>
<td>Government Entities</td>
<td>Carry out transactions with the government pursuant to intentions of law.</td>
</tr>
</tbody>
</table>

According to four challenges for implementing EIP projects which were presented in Chapter Seven (See Table 7.1), the critical success factors to succeed in EIP projects in Thailand can be described as follow:
Factor 1: Policy and political factors.

Structure and processes of the government agencies are most effective when their design and functions match their environment and the impact on their organisation’s strategies. Currently, various governmental agencies have some overlapping roles and responsibilities. Moreover, even with the Eco criteria set up since 2012, there is still no clear direction to define what an IP must do to become an EIP and there is no clear mechanism to enforce the regulations for an EIP. According to data from survey, the respondents agreed that the government contributed a group of mentor to guide and support the EIP project. Unfortunately, according to the limited of time and budget, they just provide concepts, guidelines, direction and support to IP that conducted by the owner company (SPI). However, the criteria and factors in the four stages of the project suggest that the IP has not yet achieved what is necessary for an EIP. These criteria and the recommendations to enable the IP to achieve EIP status which should provide by government sector are summarised in Table 8.2.

**Table 8.2 Criteria and Recommendations for Government sector to EIP Development Projects**

<table>
<thead>
<tr>
<th>Stages</th>
<th>Success Criteria</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptualising</td>
<td>• Addressing relevant needs of the target group of IP</td>
<td>• Provide clear understanding of project environment and provide sufficient funding to private sector</td>
</tr>
<tr>
<td></td>
<td>• Identifying the potential agency who capable and willing to get involved in EIP project</td>
<td>• Provide effective consultations with primary stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Matching policy priorities and raising the interests of key stakeholders</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>• Approval and commitment of the project by the key parties</td>
<td>• Compatibility of development priorities of the key parties</td>
</tr>
<tr>
<td></td>
<td>• Sufficient resources committed and ready to be disbursed</td>
<td>• Adequate resources and competencies available to support the project plan</td>
</tr>
<tr>
<td>Stages</td>
<td>Success Criteria</td>
<td>Recommendations</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Core organisational capacity established for project management</td>
<td>• Competencies of project planners</td>
</tr>
<tr>
<td></td>
<td>• Competencies of project planners</td>
<td>• Effective consultation with key stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Effective consultation with key stakeholders</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Resources mobilised and used as planned</td>
<td>• Continuing support of stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Activities carried out as scheduled</td>
<td>• Commitment to project goals and objectives</td>
</tr>
<tr>
<td></td>
<td>• Outputs produced meet the planned specifications and quality</td>
<td>• Competencies of project management team</td>
</tr>
<tr>
<td></td>
<td>• Key stakeholders informed of and satisfied with project progress</td>
<td>• Effective consultation with all stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Project financial settlements completed, and team disbanded to the satisfaction of key stakeholders</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Project end outputs are accepted and used by target beneficiaries</td>
<td>• Adequate provision for project closing in the project plan</td>
</tr>
<tr>
<td></td>
<td>• Project completion report accepted by the key stakeholders</td>
<td>• Competencies of project manager</td>
</tr>
<tr>
<td></td>
<td>• Adequate provision for project closing in the project plan</td>
<td>• Effective consultation with key stakeholders</td>
</tr>
<tr>
<td>Implementing</td>
<td>• Project has an obvious impact on the beneficiaries</td>
<td>• Government has clear policies to sustain project’s activities and results</td>
</tr>
<tr>
<td></td>
<td>• Project has built institutional capacity within the country</td>
<td>• Adequate local capacities are needed</td>
</tr>
<tr>
<td></td>
<td>• Project has good reputation.</td>
<td>• Create strong local ownership of the project</td>
</tr>
<tr>
<td>Completing</td>
<td>• Adequate provision for project closing in the project plan</td>
<td></td>
</tr>
<tr>
<td>Overall Project Success</td>
<td>• Adequate provision for project closing in the project plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Government has clear policies to sustain project’s activities and results</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adequate local capacities are needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Create strong local ownership of the project</td>
<td></td>
</tr>
<tr>
<td>Stages</td>
<td>Success Criteria</td>
<td>Recommendations</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>• Project has good chance of</td>
<td>• Fiscal incentives offered as</td>
</tr>
<tr>
<td></td>
<td>being extended as result of</td>
<td>part of governments’</td>
</tr>
<tr>
<td></td>
<td>success</td>
<td>national strategy for transit</td>
</tr>
<tr>
<td></td>
<td>• Project’s outcomes are likely</td>
<td>into EIP projects.</td>
</tr>
<tr>
<td></td>
<td>to be sustained</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Supportive tool</td>
<td></td>
</tr>
</tbody>
</table>

Importantly, two of the most valuable motivations to be considered are an incentives-based regulatory framework and encouragement by the government of continual improvement in environmental performance.

**Factor 2: Industrial Parks and personal factors**

Commitment and support from top management of IP plays an important role in influencing the success in almost any initiative within an organisation. The surveys show that respondents identified commitment and support from top management of IP as a significant factor in the future success of the EIP. Top-level management responds to business processes and sustainability of factories. The respondents indicated that five activities are required, which are as follows:

1. Top-level management support both from IP level and individual firms’ level
2. Integration of the entire EIP project management structure and processes
3. The participation of every firm involved
4. Knowledge and training support in EIP paradigm
5. Measurement of progress towards EID and rewards for committing to the EIP

A big project like EIP has to focus on working together with both the public and clients to forge durable decisions that can be implemented and sustained in the face of controversy and legal challenges. In order to operate as an EIP, the IP should over perform compared to a conventional industrial park on specific areas where the selected technical opportunities cover the way for industrial green growth. As a baseline, it can be presumed that the EIP has already accepted national and international industrial good practices and has implemented policies that are conducive to EID. These practices may be direct regulations on EID, with clear guidelines and indicators, or a proactive policy toward
EID, such as promotion of policies and actions on EIP efficiency, adoption of national sustainable targets, and incentives that promote sustainable practices within industries. At the time of this study, the IP was still in the beginning stages, so it is not possible to evaluate how well the participants are working together and how well they are progressing in the development of the appropriate policies, guidelines and indicators.

**Factor 3: Community/Local Government agencies factor**

Trust and acceptance of the industrial zone management in environment, safety and the impact they may have impact on the environment and public health is critical for the success of an EIP, because the public is increasingly aware of environmental and safety impacts of industrial processes. This has forced DIW (which controls, supervises and manages the environment and safety within industrial park) to change in order to secure trust and acceptance of the community. This will reduce possible conflict between industrial park’s operators and community while ensuring harmony between the industrial sector and society. However, the success depends on support from the government and local administration as well as the local community.

In Thailand, local governments have a restricted capacity to develop or place strong environmental conditions on approvals. Such planning decisions can be run by developers and, when this happens, local government planning decisions are remade by planning ministers from the central government. Local governments lack the legal power to ensure that their valid concerns are taken into account during the development processes. Because of this, local governments can sometimes best achieve their local environmental visions by negotiating conditions rather than refusing developments or imposing restrictive conditions that might bring on appeals. In the EIP project, there have been some problems such as lack of cooperation from people in the community because of some conflicts between the IP and residents in the surrounding community. The problem came from the lack of appropriate communication between them. In addition, the lack of community leaders actively involved in this EIP project is a crucial problem: acknowledged community leaders can strengthen an effective partnership for an EIP project. As a support agency, local government has a key role in passing the national government policies to local communities and enterprises in the service area and putting the policies into action, but it still has some difficulty to achieve the sustainable goals because of the limited manpower, funding and technical support.
Factor 4: Technical and knowledge factor

The most challenging technical issue facing EID is the lack of an internationally accepted standard to define it. Additionally, there is no clear standard to guide planning and implementation, nor to evaluate, or allow ranking & benchmarking among them. This causes misinterpretation and misleading concepts of what it means to develop an industrial ecosystem. Another important issue is the lack of endemic technical know-how capable of identifying and evaluating industrial symbiosis opportunities, and implementing the technologies and measures needed to realise the benefits. Actually, technical training in EIP is an integral part of good practice and should include training staff appropriately. The main reason for an education and training program is to ensure that the members are comfortable with the system and to increase the expertise and knowledge level of the members, which is suggested by DIW. The purpose of training is to improve knowledge, skills and attitudes that encourage the IP to increase their ability to reach the EIP target. It would also be advisable to give a more complete picture of the results in order to ensure employers’ and employees’ commitment. A number of project developments currently are being rolled out and others are in the planning stage. Further research and monitoring is needed in order to track the progress of these unfolding developments concerning the greening of industrial property in Thailand.

There is also need for a Centre for Eco-Industrial Development as a research and information centre. Some good examples of research centres in other countries are:

1. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China (found in 1975). The main purposes of RCEES are to carry out some national and international research projects in environmental sciences, environmental engineering, systems ecology and environmental biotechnology, to advance the science and technology nationally and worldwide, to provide fundamental data in ecological and environmental sciences for governments and to offer some applied high-level technology to enterprises [292].

2. The Center for Industrial Ecology at the University of Coimbra, Portugal is a research group in the multi-disciplinary field of Industrial Ecology. The Centre develops and applies tools to enhance the sustainability of products and systems supported by lifecycle thinking [293].
3. The National Center for Eco-Industrial Development, a joint project of the University of Southern California and Cornell University, is to facilitate job creation and sustainable industrial expansion in distressed communities around the nation by applying principles of industrial ecology, establishing eco-industrial parks, and expanding the use of environmentally benign manufacturing processes and techniques [294].

Thailand also needs a National Research and Development Centre for Eco-Industrial Development to act as a centre for both IPs and IEs to perform the implementation of EIP effectively. The country needs to establish more collaboration with other countries in South-East Asia as they already have established the ASEAN Economic Community (AEC) since 2015 which is a major milestone in the regional economic integration agenda in ASEAN. Thailand should use this opportunity to enhance the level of collaborative development by creating the Regional EIP Centre to share experiences among different countries.

8.3 The Utility of Examining OH&S Performance to Guide the Development of Eco-Industrial Parks

The progression of development and other adaptations of EIP concepts in individual countries shows a trend toward a comprehensive approach to green development [30]. This approach includes a wide range of stakeholders and aims to create social and environmental benefits as well as economic benefits. The multiple factors need to be considered when drafting policy. A large data base is required, and numerous, potential conflicts of interests need to be resolved. The approach in four steps to build an EID in Thailand is recommended in Table 8.3.

Table 8.3 A Recommended Approach to EID.

<table>
<thead>
<tr>
<th>Step 1 Planning</th>
<th>Step 2 Technique</th>
<th>Step 3 Activity</th>
<th>Step 4 Monitoring and reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Assess political economy of EIP development</td>
<td>• Conduct survey of Eco criteria production and assess resource value</td>
<td>• Design tool to monitor performance</td>
<td>• Design tool to monitor performance</td>
</tr>
<tr>
<td>• Collect information from firms</td>
<td>• Collect information from firms</td>
<td>• Collect information from firms</td>
<td>• Collect information from firms</td>
</tr>
<tr>
<td>Step 1</td>
<td>Step 2</td>
<td>Step 3</td>
<td>Step 4</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Planning</td>
<td>Technique</td>
<td>Activity</td>
<td>Monitoring and reporting</td>
</tr>
<tr>
<td>• Identify stakeholders and their needs</td>
<td>• Assess business case and prioritise projects</td>
<td>• Develop stakeholder reporting structure</td>
<td>enterprises and projects outcome</td>
</tr>
<tr>
<td>• Establish organisation and leadership, create a vision statement</td>
<td></td>
<td>• Publish / circulate report</td>
<td></td>
</tr>
<tr>
<td>• Establish Regional EIP Centre</td>
<td>• Assess business case and prioritise projects</td>
<td>• Develop detailed plan for project action</td>
<td>• Develop stakeholder reporting structure</td>
</tr>
<tr>
<td>• Establish Research and Development (R&amp;D) Centre</td>
<td></td>
<td>• Technology and vendor selection</td>
<td>• Develop detailed plan for project action</td>
</tr>
<tr>
<td></td>
<td>• Assess business case and prioritise projects</td>
<td>• Financing needs</td>
<td>• Publish / circulate report</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Training and manpower needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Identify financing mechanisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Identify institutional and organisational needs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Strengthen institutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Roll out projects</td>
<td></td>
</tr>
</tbody>
</table>

**1st Step: Planning**

It aims to set up political agreement and support from the central government and from international development partners. Existing national strategies or goals and the broader political agenda of the government need to be evaluated in order to determine whether there is an institutional framework supportive of EIPs already addressed. This stage must also be considered to identify the key challenges in committing political economy and stakeholders’ need in the different sectors such as public sector, private sector, and community sector. It is also need to establish organisation and leadership to create a clear
vision statement. In addition, key leaders or associations from industry should be identified to work together as a private sector part. Roles and responsibilities of these participating stakeholders need to be clearly addressed, with the first task being to set a vision statement for the IP. The vision statement should define a clear objective, such as resource efficiency maximisation, linked to the overall economic objectives in IP. The leader from IP owner will need to work with other stakeholders to ensure there is broad support within in the park from firms, actual benefits, and the community. During this step, the plan must also identify how much and where funding are necessary and available to meet these needs.

2nd Step: Technical Audit

This step aims to conduct survey of Eco criteria production and assess resource value. Audits to develop a resource-use inventory and forecast future uses as well as waste audits and surveys will identify the areas that need improvement. During these audits, an inventory of the waste streams needs to be built, and assessment should be made of which waste or production by products may have worthiness as material inputs for other firms in the IP. An analysis of material flow, energy, resources, and waste will need to be divided into demand side and supply side measures to identify possible areas for industrial symbiosis. However, other indicators such as return-on-investment, technical requirements, potential benefits, and potential barriers must be analysed in order to prioritise interventions. Moreover, data collection and analysis for second step may require technical assistance from development partners and consultants. During step three, the plan must first identify how much funding is necessary and what funds are available to meet these needs.

3rd Step: Activity

This step can be activated to develop the implementation, listing the technological, financing, and manpower needs. The project implementation must be aligned with the IP’s goals for highest efficiency and must be based on a design tool to monitor performance and feasibility study to cover the technical aspects of the project. Identifying and gathering information such as financing needs from enterprises is crucial for project implementation. Other activity needed in this step is the development of stakeholder reporting structure and circulate the report to public. Then, develop detailed plan for project action including its content and scheduling has to be announced. Various
mechanisms should be discussed in this report such as public-private partnerships, technology and vendor selection, financing needs, training and manpower needs, depending on Industrial Park conditions. In line with identification of financial needs and available resources, the EIP implementation plan must consider institutional and organisational needs as well as strengthen institutions and roll out the whole projects. As from the third step, the clear role of stakeholders to implementing EIP projects is shown in Figure 8.1.

![Figure 8.1 The role of stakeholders to implementing EIP projects.](image-url)
4\textsuperscript{th} Step: Monitoring and reporting

In the last step of the EIP implementation approach, a system to monitor performance after project rollout needs to be organised. It can be set up a computer databases system that stores and analyses data provided by various participating firms in IP. The data can also be used as a tool to monitor performance from enterprises and projects outcome. Key findings can be circulated amongst stakeholders to promote further discussion and awareness for EIPs as stakeholder report. In addition, it is necessary to inform firms in IP that performance reports can benefit individual firms in their competing in the global market as part of the corporate sustainability efforts.

The four development steps are offering to improve or adjust an existing IP into and EIP. Potential industries that tend to promote green growth should precede the four steps while being in line with the regional development’s core competencies. Then, rather than only focusing on the existing eco-criterion used in firms’ performance as ‘waste management’ and ‘by-product exchange in environmental dimension. It will be necessary to pay more attention to the other potential Eco criterion of the firms that wish to enter the EIP. Some key innovations and practices from current EIP efforts are needed to identify and used as a lesson learned to develop the EIP performance in Thailand. However, the steps taken in the cases presented can provide an alternative eco-criterion which it is already addressed as a tool to assess into EIP in the country.

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 [279, 295].

2. The preliminary should conduct from the firms rather than government [295].

3. Active cooperation from a range of stakeholders including public sector, representatives from companies, workman, community and environmental organisations and industry, as well as specialists in various disciplines such as architecture, engineering, ecology and environmental management [279].

4. The organisations should not involve in direct competition with each other [296].

5. A level of trust would rather keep between participants [297].
6. Strategies should endorse full integration of environmental, ecological and spatial concepts [297].

7. An association of the firms and a extensive support process should be created [297].

8. Good public connections between firms located near to each other are essential [295].

9. A diversity of companies with supplementary materials needed should be engaged [295].

10. The existing management processes should be utilised as much as possible [295].

11. Data gathering on a number of issues, for example, background company information, resource flows, employees, future plans, and markets are required [279].

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 [279].

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 [57].

8.4 Recommendations for the Future OH&S Management Development in Eco-Industrial Parks

Occupational health and safety issue seems to be a leading problem and becomes more important in Thailand. Although all relevant agencies collaborate to solve or alleviate the problems, effective control measures, particularly suitable measures at the enterprise level, are still weak. At present, many traditional health hazards in workplaces, such as musculoskeletal disorder, or unsafe work practice, still exist. The rate of occupational accidents and injuries is 3.44 per 1,000 workers in 2014 [167]. Although all relevant organisations put a lot of effort to improve OH&S management system in Thailand, there is still a very long way to go. In addition, the academic institutions have an important duty to assist the system by improving research-based knowledge and capacity building.
Although many studies are done each year, very few have an impact on the national policy and lead to an improvement of OH&S management in workplaces.

In 2014, the DIW integrated health and safety as a criterion in the environmental dimension of the requirements of the EIP paradigm. This aims to enhance the coverage of occupational health service provision a. At present, this criterion has never been considered as an evaluation tool for firms that wish to be recognised as eco-industries in Thailand. However, there are some barriers to using OH&S as a criterion for accessing EIP. They include shortage of staff in this field and poor co-operation among governmental agencies, employers and employees. Therefore, it is imperative that all relevant organisations including academies should get together to discuss and plan for these new challenges. In the near future, non-governmental agencies and the private sector need to play a major role in provision of OH&S services. Provision of these services depends on seven major activities as follows:
Table 8.4 Major Focus, Barriers, and Recommendations for effective OH&S management

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<th>Major Focus</th>
<th>Barriers</th>
<th>Recommendations</th>
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<td>National Level</td>
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<tr>
<td>1. Enforcement of Labour Regulations</td>
<td>- Enforcement of OH&amp;S laws is ineffective.</td>
<td>- Development of more systemic inspection procedures and provision of sufficient training to safety inspectors.</td>
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<td>- Inadequacy of inspection by government agencies.</td>
<td>- Development of a safety inspection system and provision of OH&amp;S knowledge.</td>
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<td></td>
<td>- Lack of safety inspection system. Some enterprises had never been inspected.</td>
<td>- Development of effective occupational injury and disease reporting system.</td>
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<td>- Establishment of an OH&amp;S certifying system, which will enhance the enforcement of OH&amp;S regulations on establishments.</td>
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<td>- Development of a supervision system for safety inspection.</td>
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<td>2. OH&amp;S Administrative Structure</td>
<td>- Overlapping responsibilities of government agencies</td>
<td>- Restructure of a department-level agency responsible for national OH&amp;S affairs.</td>
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<td>- Restructure of an independent organisation responsible for OH&amp;S services.</td>
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<td>- The reformation of OH&amp;S supervisory structures is required to resolve overlapping roles and responsibilities of the related governmental agencies and ministries. In</td>
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<td>Major Focus</td>
<td>Barriers</td>
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<td>the long term, some government agencies should be combined for better performance and efficiency. It is critical to rearrange and improve OH&amp;S regulations and enforce their usage. The revised regulations should reflect technological developments and have an effective inspection system.</td>
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<td>3. OH&amp;S Research and Development</td>
<td>- Lack of research to prevent occupational accidents and diseases as well as to promote better working environment and workers’ health.</td>
<td>- Research into industrial safety, critical employee groups comprising different workers, workers in IP, OH&amp;S standards and 5 analytical methods, legislation, development of safety inspections, OH&amp;S information systems, and small firms.</td>
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<td>4. Control and Protection of Occupational Injury and Diseases</td>
<td>- No continuous surveillance programs both on environmental monitoring and health examinations undertaken for physical hazards in workplaces.</td>
<td>- Collection of accident data and analysis for priorities at three levels: establishment, local/provincial and national to prevent occupational injury&lt;br&gt;- Study of problems of occupational diseases and dissemination of knowledge and encouragement of workers to protect themselves.</td>
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**Industrial Parks and factory Level**
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<th><strong>Major Focus</strong></th>
<th><strong>Barriers</strong></th>
<th><strong>Recommendations</strong></th>
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| 5. Personnel Skill Development | - Both employers and employees have insignificant knowledge about OH&S.  
- Most employers and most employees are failing to acknowledge the risks in their workplaces.  
- Hazard information from external sources as labour unions, government agencies and other enterprises is not disseminated. | - Develop personnel for labour inspectors, technical inspectors, assessment officers with good skills and technical experience.  
- Develop personnel for the OH&S information system  
- Develop skilled personnel in private sector such as safety officers in all level who must be trained in standardised curricula as required by law.  
- Formulation of systemic measures to continuously educate safety officers and OH&S committees in the establishments  
- Development of OH&S personnel network among ministries and academic institutes leading to a highly efficient and unified OH&S administration. |
| 6. Development of OH&S Information Sharing | - Lack of information or publication on OH&S management for the specific needs of industry. | - Establishment of an OH&S information system network comprising information sources from various ministries and departments, universities, and other relevant organisations.  
- Establishment of an OH&S centre to manage OH&S data such as industry profiles, business performances, OH&S records etc. |
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<th>Major Focus</th>
<th>Barriers</th>
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<td>7. OH&amp;S Campaign</td>
<td>- Low awareness among workers about their safety and health because of the lack of knowledge about preventing occupational diseases and accidents.</td>
<td>- Continuous dissemination of important information to stimulate public awareness and protection of occupational injury and diseases.</td>
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<td>- Holding national safety week, exhibition of new knowledge and technology in OH&amp;S</td>
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<td>- Promotion of OH&amp;S in general labour, new graduates and new entrants to prevent accidents and occupational diseases</td>
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<td>- Development of OH&amp;S standards an encouragement of establishments to implement them</td>
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Other barriers are sometimes the most numerous and include inexistent measurement culture in most small enterprises - so that there are a lot of accidents, poor record keeping, little or no benchmarking against successful cases, mindsets that resist change, limited training among workers, lack of technology development strategy or technology forecasting, poor teamwork and excluding employees from decision-making processes. Lastly, as the safety and health of workers is a significant issue for the workplace overall both in socio-economic and sustainable development, OH&S needs to be became more intense. Proper collaboration among relevance agencies is essential for synchronising and developing of OH&S standards and EIP paradigm.

To sum up, Saha Group Industrial Park could adopt some ideas for improving and developing the guidelines for business operation to meet the expectation of the stakeholders. Such practices will directly affect the sustainable growth of business and corporate governance of the company. The recommended shift in industrial zone management will be driven by a number of factors in emerging projects:

- There is already a template plan of five stages for development of the overall project: conceptualising, planning, implementing, completing and overall project success;
- Industrial Park is expected to over perform compared to a conventional industrial park on specific areas, which will be attractive to investors;
- A requirement for developers and operators to provide additional information/services to tenants and differentiate themselves from other types of industrial land;
- Individual firms will have encouragement from external stakeholders such as the government, regulators, nongovernmental organisations, and civil society organisations to press the IP to implement the project in an environmentally responsible way;
- Voluntary action by industry to self-regulate and increase their focus on practical corporate social responsibility efforts.

These, with other factors, have produced a demand for more knowledge and information on the EIP approach. Moreover, there is a need for an EID framework. The EIP approach allows developers and managers to offer value-added services to their tenants and a sustainable infrastructure so that investors can build, reduces their initial investment and operational costs. There is a large financing gap, and thus an opportunity, for the financial sector to support the infrastructure and investment needs of an EIP agenda. While these
drivers have contributed to a shift in IP management trends, profitability and financial viability remain IP operators’ main targets.

8.5 Conclusion

The chapter has first outlined the main findings from the previous chapter and then developed a discussion about the strategies needed for improving EID in Thailand. The stakeholders are business partners, employees, civil society sector, academics, communities, and government entities. However, the success of EIPs depends heavily on support from the government and local administration as well as the local community. Then an approach in four steps to building an EID is recommended as: planning, technique, activity, and monitoring and reporting. Finally, barriers and strategies to develop OH&S management for the future were recommended the national level and industrial park and factory level. This discussion allows for the research conclusions to be accurately documented in the next chapter.
Chapter Nine

Conclusions
9.1 Introduction

In view of the importance of EIP for Thailand as it moves towards sustainable industrial development, and the difficulties of accessing data on waste and hazards to evaluate EIP performance, this thesis investigates the utility of occupational health and safety (OH&S) performance, an eco-criterion from the environmental dimension, as an alternate means to evaluate the EIP performance in Thailand. The study first reviews the conception and good practices of EIPs around the world, then looks at the progress of EIP development in Thailand, followed by an analysis of the current system and development of OH&S in Thailand particularly within an industrial park. After that, the main findings from the case study both in qualitative and quantitative approaches are identified. Lastly, a discussion of the findings and a number of recommendations are provided in the previous chapter. These have significant implications for the future direction of EIP projects in Thailand.

This final chapter summarises the purpose and overall findings of the research, and offers a chapter by chapter summary of the thesis. It also draws attention to the major contribution and significance of the research. Finally limitations of the research and suggestions about possible directions of further research on EIPs project in Thailand are outlined.

9.2 Summary of Research Findings

9.2.1. Overall purpose and main findings of the research

The overall purpose of this research is to examine the feasibility and utility of applying the eco-criterion of health and safety to assess enterprises performance towards developing into an EIP based on the EIP regulations which were launched by the DIW. Thailand, as a developing country with a large population and with rapid growing economy, has been in a transitional period of seriously tackling pollution problems in the last decade. However, EIPs are new and still at a very early stage in Thailand. The study also aims to identify strategies to improve OH&S systems in enterprises and workplaces. Survey research was carried out using a questionnaire, in-depth interviews and focus group discussions in the Saha Group Industrial Park, Sriracha. The specific objectives were to identify the level of awareness and participation of IP participating firms in OH&S and EIP implementation, and to identify the problems, barriers and challenges to meet the criteria for EIP status as well as to identify what enterprises need in order to
contribute to the good operation and more effective OH&S management of EIPs in Thailand. The main findings and discussion of this research are summarised as follows:

- The current successful development of the various EIP pilot projects initiated all over the world demonstrates that there is no academic or standardised definition to define an EIP. However EIP development could be useful to establish an international standard in industry development;

- Industrial symbiosis, as exemplified in EIPs, is a fairly new concept in Thailand. There are hence no successful case studies yet to demonstrate to interested investors. Examples from other countries can clarify the eco-criteria and define what eco-industrial parks are, how they are designed and operated, and finally how they contribute to environmental, social and economic sustainability;

- The I-EA-T and DIW have played an increasingly important role in EID since the first projects were launched in 2000. However, they are currently facing the multiple challenges of registration difficulties, insufficient funding and weak organisational development;

- The operation of EIP in the years 2012 and 2014 finished with Eco forums that included Saha Group Industrial Park, Sriracha. The projects focused on waste management and by-product exchange plans. Nevertheless, there are a lot of waste management problems in Thailand such as the inapplicable of a primary database of waste disposal, a lack of proper evaluation of the data from the reports, a lack of official agencies to dispose of industrial waste, high fees for waste disposal by the standard waste disposal agencies, and the consequent illegal dumping of waste;

- Participation of firms in IP has been identified as very important in EIP projects. Participants agreed that sharing challenges, strategies and successes is critical to further progress;

- There has been little awareness and understanding of the concept of EIP among all level of stakeholders involved, from the relevant government officers to the leaders, management personnel and workers in the industries within the IP. Workers do not have enough knowledge or information about EIP participation project in the Park. It will need a communication strategy to promote awareness and commitment to EIP to stakeholders for future development in Thailand;
• The research into EIP or into the discipline of sustainability in Thailand is also needed. The problems include the lack of technical services to enhance the performance of EIP in the country, and the lack of resources — there is a shortage of technical staff, a lack of technical expertise, and also a lack of technical assistance supporting the EIP;

• The sharing of information and communication also needs more promoting. The government sector has not been effective in raising the awareness of the community and of the industrial partners and explaining the goals;

• The OH&S sector in Thailand has played an important role to improve health and safety working conditions in the workplaces. However, there remain problems needing to be addressed; and

• The OH&S performance in Saha Group IP is all related to the level of development, education, qualified safety officers, relative strength of infrastructure, and attention to OH&S issues.

9.2.2 Summary of each chapter of the thesis

Focusing on the research topic, this thesis starts with Introduction in Chapter One. Then, it is developed in two parts: first, a literature review; then the research methodology and findings and discussion, and the conclusion chapter at the end of this thesis.

Chapter One: This chapter provides the fundamentals of this research. It focuses on the research background and rationale and gives the details about the development of EIPs project as well as a brief history of OH&S in Thailand. This chapter also sketches the background of the Thai economy and gives a brief demographical description. Then, the statements of the problem which relate to this research study are addressed. The significance of this study is described as an important and timely contribution to the field of EID and OH&S in Thailand. The last section of this chapter describes the structure of the whole thesis.

Part I, the Literature Review, includes Chapters Two to Four, and summarises the literature of the contextual fields of this research, global trends in EIP and Thailand, OH&S, and the linkage between industrial ecology and OH&S.
Chapter Two: This chapter describes the concept and current situation of EID in the world. This chapter also provides the concept of industrial ecology and industrial symbiosis which emerge from the integration of concepts of sustainability into environmental and economic systems. It presents the strategies used for designing an EIP, the potential stakeholders, and the benefits and risks of development. The result shows that several topics need to be noted to visualise a potential EIP. However, the current successful development of the various EIP pilot projects initiated all over the world are proving to be promising steps towards a more sustainable society. The successful EIP cases can be used as valuable exemplars and can help motivate other companies to follow their operations.

Chapter Three: This chapter analyses the history and experiences of EIP implementation in Thailand. Strategies used in Thailand for handling and managing Eco-industrial are described as well. Currently, EIP in Thailand is driven by two main government agencies -- the Department of Industrial Works (DIW) and the Industrial Estate Authority of Thailand (I-EA-T). The experiences of EID in Thailand are identified and assessed according to the concepts and ideas as well as the established criteria in the Thai context. However, there is inadequate clarity when it comes to measuring the sustainability level of a company or the sustainable development. Lastly, issues of eco-industrial implementation are presented at the end of this chapter.

Chapter Four: This chapter addresses the current situation of OH&S in terms of national policy framework and gives a brief history of OH&S implementation in Thailand. The Thai government has acknowledged the seriousness of OH&S issues as various policies and relevant initiatives have been launched since 1966. Then, issues of OH&S practice in Thailand are highlighted. The literature suggests that there is an imperative for Thailand to further strengthen its national policy for enterprises to improve OH&S. Next, the roles of H&S in EIP in Thailand are investigated in terms of benefits, and basic requirements used as criteria. This is the main focus of this study.

Part II, Research Methodology, Results and Key Findings has four chapters: Chapters Five to Eight.
Chapter Five: Based on the literature reviewed in Part I, this chapter describes the research design, presents the research question, the conceptual framework and the methodological approach (including the combination of qualitative and quantitative methods applied in this research), and provides details of the field work processes, the data collection, and the analysis. To examine the implementation of EIP in Thailand, this study focuses on a potential industrial park which plans to transform itself into an EIP -- Saha Group Industrial Park, Sriracha, focusing on OH&S issues which relate to the EIP regulations. The researcher started by exploring the key influencing factors and challenges in EIPs worldwide and in Thailand using a qualitative approach with a document review and in-depth interviews. Then, quantitative data were collected from the factories’ safety officers or person in charge of OH&S in the park. Both qualitative and quantitative data were collected and analysed concurrently and then merged to present a more complete understanding of research aims, or to compare the different results.

Chapter Six: This chapter reviews the results from the quantitative findings, using the questionnaire survey from the case study. The review starts from an overview of general data about the Park. Then, a data set of OH&S performance in the Park from the survey questionnaire is explored and described. The Saha Group encourages all of the firms located in the Park to follow the regulations and policies on occupational safety consistent with the laws. However, the Saha Group has no right to force all the firms by setting rules because the Park has provided only land and facilities. Lastly, the implementation of health and safety criteria in the Park is presented at the end of this chapter.

Chapter Seven: This chapter reviews the qualitative findings, which include the level of awareness and participation of firms in Saha Group Industrial Park. Level of agreement about OH&S management, and the barriers and challenges for implementation of OH&S programs in EIPs are also discussed. The findings show a possible trend for firms to implement OH&S management in line with the requirements of EIP policies. However, the employers’ understandings about OH&S are at a low level, and they do not really understand the OH&S laws that apply to their workplace. So, many companies ignore the policy.

Chapter Eight: This chapter recommends strategies needed for improving EID in Thailand based on the key results and main findings identified in Chapters Six and Seven.
At present, OH&S criteria have never been considered as a tool to help an IP become an EIP in Thailand. However, there are some barriers to using OH&S for obtaining EIP status. These include shortage of staff in this field and weak co-operation among governmental agencies, employers and employees. Therefore, it is critical that all relevant organisations including academic organisations should get together to discuss and plan for these new challenges. The discussion covers the compatibility of OH&S in EIP concepts and recommendations are provided for each area discussed.

Chapter Nine: This chapter concludes the whole thesis and indicates the conclusions, develops a summary of research findings based on the major findings about EIP projects, and ends with suggestions and recommendations of the thesis.

9.2.3 Significance of this Study

This study is an important and timely contribution to the field of EID and occupational health and safety in Thailand. Since the concept of the EIP was introduced in Thailand in the year 2000, various factors have impeded its development. Many projects in Thailand launched by the government agencies have tried to apply eco-criteria in the environmental dimension to develop industrial production that is ecologically sustainable through waste exchange and water or waste water management. However, no fully successful EIPs exist yet in Thailand. Although there are many laws and government agencies regulating pollution, enforcement of these laws is superficial. Thus, new eco-criteria such as “health and safety” were suggested in 2012. In the attempt to meet the requirements of the government regulations, the barriers and challenges in OH&S issues are a very important concern for industry. The investigation from this study not only confirms key findings in literature, but also provides an illustrative example from Thailand. The research findings identify the areas for further discussion and research in this discipline. The survey results show that there are OH&S policies in most enterprises. Its findings and recommendations are useful and should be used by decision makers, and other officials and scholars from government, academia, and the private sector to further improve the effectiveness of eco-industrial development cooperation. The lessons learned from the case study presented in this research are useful advance understandings of OH&S management and EIPs by defining the concepts and fundamental relationships effective in EIPs. This research can
serve as a model to support and help develop an OH&S management for the site selection process and help set up guidelines or a model to meet the requirements of EIP regulations in Thailand.

9.3 Major Conclusions

Since the concept of the EIP was introduced in Thailand in the year 2000, various factors have impeded its development. Many EIP projects launched by the government agencies have tried to address only a small number of eco-criteria such as waste exchange and water or waste water management in the environmental dimension to develop the EIP. However, there are some barriers to using these eco-criteria. They include as the lack of a primary database of waste management in Thailand, or lack of capacity of official agencies to dispose of industrial waste, and high fees for waste disposal by the standard waste disposal agencies. In this situation, the integration of OH&S into EIP can be considered as an alternative way to enhance the industrial development in Thailand. By law, the government has already put OH&S criteria in the EIP regulations. So, this study is an important and timely contribution to the field of EID and OH&S in Thailand.

The current global framework for EIP has been defined in various ways. However this study has found that there are nearly identical academic or standardised definitions of the industries’ environmental performance in terms of managing materials, energy and waste. It is then recommended that a common framework should be developed which provides developers, operators, and the community with an assured level of confidence in the concept of an EIP. The main conclusions from this study are:

- The review of EIPs globally has shown that while many projects have failed to meet expectations, many other successful EIPs have been developed. The current development of the various EIP pilot projects worldwide demonstrates that the lessons learnt from successful EIP cases can be used to help motivate other enterprises to follow their success. An ongoing international comparison of EIP projects could further help stimulate governments and companies to initiate EID projects. This is particularly useful for governments of developing countries such as Thailand;

- There has been limited research into EIPs based on Thai data, especially data from the industrial sector, which is hard to access. Lots of information and knowledge are needed to implement a successful EIP. The sharing of information and communication among government sector and industry sector is lacking. The government sector has not
been effective in raising the awareness of the community and of the industrial partners and explaining the EIP target goals. There is a lack of technical services to enhance the performance of EIP in Thailand. There is also a shortage of technical staff, a lack of technical expertise, and a lack of technical assistance supporting the EIP concept. Additionally, there are no courses for students to take these related subjects either at university or educational training institutes;

- Most industrial parks in Thailand are at a very early stage of development of a sustainable approach. The Ministry of Industry through the Department of Industrial Works (DIW) developed indicators for an eco-industrial development, covering the 5 dimensions of an effective industrial part, namely physical, economic, environmental, social and managerial. Although the development of EIPs is a good sign that Thailand is moving toward industrial ecology, the EIP concept mentioned above focuses strictly on a few factors only such as by-product exchange or waste management, leaving out the other factors in the environmental pillars. Unfortunately, there has been no action plan to achieve progress in developing sustainability in an EIP in Thailand;

- The performance of OH&S in Thailand has played its important role to ensure safe and healthy working conditions in the workplace. However, certain problems still persist. The problems from the employers’ point of view are the confusion in the enterprises regarding OH&S regulations and the inadequacy of inspection by government agencies. In the workplace, workers are poorly protected from harm due to the inadequate provision of personal protective equipment and the employer’s inadequate knowledge about OH&S. From the employees’ point of view, the employees of firms within the park do not really understand the concept of EIP, nor do they understand the OH&S laws that apply to their workplace. Thus, government agencies and industrial parks have to formulate and manage the OH&S data properly both at the national level and at factory level;

- It is feasible to use OH&S to evaluate its progress into an EIP in Thailand. However, the target values (criteria) and indicators for outcome evaluation should be carefully set up by the policy makers and make them clearer in order to motivate and guide enterprises to actively improve their performance in the EIP;

- There are four barriers and challenges to success in EIP projects. First, policy and political factors: incentives-based regulatory framework and continual improvement in environmental performance are two of the most valuable motivations to be considered.
Second, personal factors: commitment and support from top management of IP plays an important role in influencing the success in almost any initiative within an organisation. Third, community/local government agencies factor: as a support agency, local government has a key role to realise the national government policies in local communities and enterprises in the service area but it still has some difficulty to achieve the goal of sustainability because of the limitations of manpower, funding and technical support. Fourth, Technical and knowledge factor: technical training in EIP is a part of good practice and should include training staff appropriately. The purpose of training is to improve knowledge, skills and attitudes that encourage the IP to increase their ability to reach the EIP target; and

- There are a number of recommendations to assist to stakeholders -- the Thai government agencies as national policymakers, Industrial Parks as private sector and local government and communities.

  - Thai government agencies should make clearer directions to define an IP as an EIP and set up clearer mechanisms, provide appropriate incentives, provide specific support for an EIP to meet the requirements to enhance the EID in Thailand.
  - Industrial parks should encourage firms to commit to participating in EIP projects, and should promote the information sharing and communication among stakeholders.
  - Local government and communities should promote sustainable livelihoods and sustainable development opportunities for local people.

9.4 Suggestions and Recommendations

Based on the results above, this research formulated the following key requirements for fully meeting the criteria for OH&S in Industrial Ecology in the prototype EIP. These requirements may increase the impact of factors for success:

Management and Organisational requirements

1. Commonly, the significant initiative to transform traditional industrial parks into EIPs and develop new parks requires participation of all relevant agencies responsible for economic development, environmental protection, transportation, and
non-governmental organisations. Cooperation among the national agencies with responsibility for development of EIPs or standard IPs is important. The Ministry of Industry, Ministry of Labour, Ministry of Public Health, and the Federation of Thai Industries need to be working together in support of the EIP initiative with coordination by the DIW. Within every EIP project, there should be at least one full time officer with primary responsibility for managing the EIP process.

2. Each IP that wishes to move to EIP status requires an adequate management structure for coordination and cooperation supporting the transition to an EIP. The management should include at least one officer responsible for coordinating standard management functions with the EIP development process. This requires collaboration among IP owners, associations or companies in the park, local government officers, and representatives from community interests. The management of each park needs to design communication channels with the surrounding communities and individual residents as well as public authorities.

3. Public management authorities and business associations require capacity development and education so they can participate effectively in the EIP initiative. Special workshops focused on specific pilot projects are required. An example might be a distance learning program that links international and local experts with project planners, and university or educational training courses and short-courses.

4. Businesses in the park need to participate from the beginning in the planning process. They are one of the most important parts in the project. This is a crucial success factor for the EIP development process. Participation of private companies ensures that the project is guided by their knowledge of issues, needs, resources, and opportunities. An individual company in a park which is willing to become an EIP should arrange one main staff person with EIP duty in his job description. Moreover, industrial park staff should provide educational training that indicates the business advantages of participation to the businesses in the park.

_Technological requirements_

5. An EIP is not only an exchange of by-products among companies. By-product exchange among companies is only one strategy in the whole system of the EIP. It needs to be connected to a trustworthy industrial waste management system and other strategies
for the development of the EIP. Achieving exchanges relies on business factors, not just technical potential. There are regulatory barriers to the concept of by-products exchange, the export of waste between firms. Thus, alternative criteria such as OH&S criteria are needed.

6. Strong support for the growth of the environmental technology and services cluster will provide Thai industrial parks with many of the solutions required. The EIP project has incorporated promotion of the environment as a component of EIP planning. In this way a business cluster should support environmental excellence among EIP firms by transferring advanced environmental technologies and services. This strength helps the central government to achieve its environmental goals of enhancing the sustainability paradigm in the industrial sector.

Policy context requirements

7. National policy should support excellent management of the EIP initiative and individual industrial parks. Without appropriate organisational management, the most promising technological solutions have tended to be unsuccessful throughout the history of EID. Therefore, policy should support adequate staffing, capacity development, management systems, and other measures important to the agencies involved and in the industrial parks themselves.

Based on the discussion above, this research formulated the following key recommendations:

Thai government agencies as a national policymakers should:

- Develop a sustainable realistic plan including revising/reconsidering the criteria used in EIP implementation and the commitment of funds to bridge the funding gap;
- Make clearer directions to define an IP as an EIP and set up clearer mechanisms to enforce the regulations for an EIP;
- Help and guide effective consultations with primary stakeholder agencies to choose potential IPs in appropriate areas and with reasonable project activities, and to continue to develop the long-term project in the same IP to reach the target goals;
• Develop communication mechanisms to ensure that all stakeholders are well coordinated to avoid duplication and confusion among key active groups;

• Offer appropriate incentives as part of the national strategy for transition to EIPs such as tax reduction policy to reward the IPs for participating in the EIP project;

• Explore other innovative oversight mechanisms appropriate for Thailand;

• Enlarge the scope of the EIP concept to cover the environmental planning strategy for sustainable development;

• Encourage and support educational & research institutions and multidisciplinary experts and consultants to do more research into EIP or into the discipline of sustainability in Thailand; and

• The policymakers should reconsider the eco-criteria in the long-term of sustainable development rather than only focusing on short-term outcomes.

**Industrial Parks as private sector stakeholders should:**

• Work with the participating firms towards joint missions and joint sector reviews as a critical opportunity to review shared objectives, agree on processes and policy conditions and encourage further alignment with national plans, under national leadership;

• Enhance collaboration with firms by explaining the benefits gained if they decide to be a partner to move towards EIP project-based approaches under the leadership of the IP holder;

• Enhance knowledge about the concept of EIP and potential strategies to make full use of existing mechanisms and flexibilities to provide a greater performance in EIP development;

• Industrial parks, private firms inside the park, local residents and the community should be encouraged to carry their part of the environment responsibility at each area;

• As a form of corporate social responsibility, Industrial Parks should also seek to provide more activities in the area, contribute to education, engage the community in emergency preparedness and integrate services like recreation, transport including emergency plans, with the community;

• Continuous training course should be enhanced to increase knowledge within organisations. Information sharing can be improved by institutionalising cooperation; and
• Industrial should offer appropriate incentives to firms, such as giving tax reductions to reward them for participating in the EIP project.

**Local government and communities should:**

• Promote sustainable livelihoods and sustainable development opportunities for local people; and

• In a locality, residents need a community leader to make connections, identify common interests and work toward a community in which all the necessary underpinnings of health are available to everyone. So, the key person can express the community’s points of view or act as a representative for their people. Citizens of a locality may feel that they have very little in common with one another, or even that their interests conflict.

### 9.5 Advantages and Limitations of the Research

The adoption of environmental policies and regulations can give an enterprise a global competitive advantage; however, at this moment, the eco-industries are under high pressure from global competitors. Many countries including Thailand have adopted EIP strategies to provide opportunities to coordinate a policy dialogue on this complex and developing issue in a whole-of-government approach. However, more clarity is needed about policy measures that would make the assessment and comparisons even more useful. In addition, it would be useful for the nation to reconsider the strategy and criteria that were successful in other particular projects. This study is the first study that focuses on OH&S in the EIP framework in Thailand.

However, there are a number of limitations of the research. Firstly, this research used a single case study. Much of the data focused on the implementation of one project in Thailand, which was the core of this research. Caution is needed when generalising about the applicability of this research to existing EIP projects in Thailand or other international projects. Secondly, the fieldwork of the research was conducted in a limited period. Data collection for the research was for a short period (around five months), and was only conducted in the implementation period. The observations focused on the project implementation rather than the project preparation and evaluation. Thirdly, the information abstracted for study purposes was based on a review of written officer reports and IP records, which has well-recognised limitations. Complete records may be kept only in the individual firm and these firms may be less than fully cooperative and
forthcoming. Some workers may have sustained injuries that were self-assessed as mild or trivial or complaints may have been rejected on investigative screening, so the incidence of minor injuries may have been underestimated.

Additionally the EIP projects were discontinued and terminated in the early implementation progress, causing changes in the plan. These changes may impact on the project’s implementation progress in Thailand. This research used a questionnaire survey specifically formulated by the researcher. During the process of the fieldwork, respondents completed an official self-monitoring questionnaire survey which had some ambiguous content so that respondents required the clarification from the research team about the questionnaire. In order to avoid doubt, the researcher prepared some important components of this research by forming a research team to work together to achieve the aim of this research. The data collected from the official survey may be less specific and lack validity and may not truly reflect the project’s operation. It is believed that an expert review, along with clear guidelines developed for EIP and OH&S implementation progress in Thailand, could minimise this limitation.

9.6 Implications of this Research and the Future Research Directions

Acknowledging the limitations of the research above, the researcher recommends the following solutions to address research limitations. Firstly, future research should increase the number of case studies by grouping and comparing two or more IPs which have similar characteristics. Secondly, future research should follow the whole EIP project from the initial stage until the ending stage, so it will obtain the complete data from the preparation to the evaluation processes. Thirdly, future research should encourage the IP to use a database to collect the information such as number of accident cases, number of training courses, etc. from firms and transfer the data to the main-board computer. In this way, complete records may be kept both in the individual firm and by the IP owner as the back-up record and the data can easily be used to develop the whole park.
Further studies on the current topic are recommended because there are still several knowledge gaps remaining as rapid changes bring about unknown future developments in sustainable projects in Thailand. Follow-up research should focus on future development of EIP projects which would be especially valuable in helping policy makers to better understand the roles and responsibilities of this concept in Thailand. Further studies can go hand in hand with learning by doing as strategic options that exist in continuing EIPs project.

Finally researchers in Thailand also need to build their capacity to communicate the lessons from their experience to counterparts in other countries. What is needed is a cross-national study involving other emerging countries, for example by setting up a Regional EIP Centre among Southeast Asian countries. This cross-national study will contribute to international debates on effective strategies for development and industrial issues reduction.

Given the importance to the individuals of healthy and safe workplaces, good regulatory systems and effective legal and other mechanisms that promote effective OH&S management are paramount. This is a rational approach that is justified by the control of the employer over the business enterprise and how it conducts its OH&S activities should keep up with changing times. Many traditional safety activities may not be effective any longer. If workers experience a program as inappropriate or out-of-date, they may not be willing to participate in other safety activities. So, the implementations of a safety program often prove to be a disappointment. Preventive treatments and cultures in workplaces should be adopted in work places to reduce the economic cost of work accidents. Then, the integration between OH&S and EIP is an alternative way to enhance the industrial development in Thailand. However, there are some issues that have to be borne in mind if the Park desires to follow the “Health & Safety” aspect.
However, in May of 2014, a military coup ousted the government of Prime Minister Yingluck Shinawatra replacing it with a military-run “National Council for Peace and Order.” In August 2014, General Prayuth Chan-ocha, the chief of the National Council for Peace and Order, took control as Prime Minister of the country, and democratic elections are not planned until May 2017 at the earliest. This political uncertainty and the resulting economic uncertainty within Thailand make substantial policy changes unlikely in the near future.
References


32. Antonopoulos, I., et al., *Sustainable development and industrial ecology: methods and steps applied in industrial areas*. The Italian Association of Chemical Engineering, 2013. 35.


64. Trillium Planning and Development INC., *Eco-industrial development feasibility study: City of Fairborn, Bath and Mad river townships*, 2003: Wright State University, B-W Greenway Community Land Trust.


77. Bailey, C., et al., *Approaches for Developing an Eco-Industrial Park in the City of Rosemount*, 2015: Resilient Communities Project (RCP), University of Minnesota.


131. The Federation of Thai Industries, *Executive Summary: Eco-industrial development under the cost to develop green industry (In Thai)*. 2013.


201. World Health Organization (WHO), in *The World Summit on Sustainable Development* 2002: Johannesburg, South Africa.


288. Baas, L. *Cleaner production systems in the context of needed partners and policies at the micro, meso and macro level*. in UNIDO Cleaner Production Expert Group Meeting, Baden, Austria, pp. 29e31 October. 2006.


294. The National Center for Eco-Industrial Development: http://www.usc.edu/schools/price/research/NCEID/.


Appendices

Appendix A

Questionnaire Surveying (For Factory)

---

Questionnaire Surveying (For Factory)

Survey data

No. of paper

The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development: A Case Study of Saha Group Industrial Park Sriracha, Thailand QUESTIONNAIRE EXPLANATIONS

1. This questionnaire is part of the curriculum in Doctor of Philosophy, School of Engineering (Environmental Engineering), Griffith University, Australia. The objective of the study is to investigate the current situation of Occupational Health and Safety (OH&S) of organization, and the development of through the requirements of Eco-Industrial regulations.

2. The researcher will focus on the development of OH&S of the organization. All of the data obtained from the questionnaires will kept confidential without reference to any person or entity.

3. This questionnaire consists of five parts in five pages in total, details as follow:

   Part 1  General Data

   Part 2  Occupational Health and Safety Data

   Part 3  Questionnaire on the acknowledgement of organization on OH&S through the requirements of Eco-Industrial regulations.

   Part 4  Questionnaire on the opinions of OH&S management through the requirements of Eco-Industrial regulations.

   Part 5  Questionnaire on the problems, obstacles, and suggestions on OH&S management through the requirements of Eco-Industrial regulations.
### Place of the Survey
Name of the factory
Date of survey Time
Address
Contact Number
Informant Position

---

### Part 1 General Data

#### Factory Data
Business Type
Products Type
Establishment period years (Or Establish since year )
The latest time from factory adjustment
Cause of factory adjustment
Details of adjustment

#### Personnel Data
Number of employee (Male Female)
- Employees in the office
  - Office Hour Overtime
    - Number of workdays Days per week (From To )
- Employees in the manufacturing
  - Number of shifts to be operated
    - Shift operates Days per week (From To )

---

### Part 2 Occupational Health and Safety Data

#### Number of Safety officer
- Safety officer Safety officer at executive level
- Safety officer at supervisor level Safety officer in technical level
- Safety officer in advanced technical level
- Occupational health Safety and working environment committee

#### Management Systems (Several answer are possible)
- ISO 9000 ISO 14000 TQM
- GMP / HACCP OHSAS 18000
- Others
## Accident Record

The most serious accident ______________________________________________________

Occurred ___________________________ __________________________________________

Cause of accident ____________________________________________________________

 Improvement __________________________________________________________________

### Personal Protective Equipment, PPE

- Ear plugs
- Ear muffs
- Goggles
- Gloves
- Safety shoes

- Particulate-filter respirators
- Vapor-filter respirators
- Masks
- Aprons
- Others (Please specify) ____________

### Occupational Health Care

- Health care
  - Health care room
  - Bed recuperating____
  - Ambulance____

- Occupational Medicine physician
  - Full- time Consultant physician____
  - Part - time Consultant physician____

Number of workdays ________________Days per week (From ______To_________)

- Occupational Health Nursing
  - Technical Nurse _____
  - Part - time Nurse____

Number of workdays _____________Days per week (From _______To________)

- Training of nurses __________________________________________________________________

Details __________________________________________________________________________

### Workplace health check

- Annual health check
- Pre-placement medical examinations

- Pre - assignment medical examination
- Medical check after an injury

- Health risk factors check (Specify) __________________________

- Others __________________________________________________________________________

### Analysis of health data

- Systematically analysis
- No systematic analysis

Details __________________________________________________________________________
The threat level indicates
- ☐ Illuminance
- ☐ Noise
- ☐ Heat
- ☐ Chemicals (details)
- ☐ Others

Emergency plan
- ☐ Fire
- ☐ Chemical leak
- ☐ Flooding
- ☐ Others

Health Promotion
- ☐ Hearing Conservation Programs
- ☐ White Factory
- ☐ Physical activity
- ☐ Quality control of cafeteria
- ☐ Smoking cessation program
- ☐ Others

Part 3 The acknowledgement of organization on occupational health and safety through the requirements of Eco-Industrial regulations.

Please mark ✓ in ☐ according to the most appropriated

1. Have you ever heard about the Eco-Industrial project supported by Department of Industrial Works?
   - ☐ No
   - ☐ Yes, Please specify source of data

2. Have you ever heard about the Saha Group Industrial Park Sriracha is part of this project?
   - ☐ No (Please go to item 4)
   - ☐ Yes, Please specify source of data

3. According to the information you have heard, what do you understand about this project mean in your own word?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Part 4 Opinions on occupational health and safety management through Industrial Ecology schemes.
Please mark √ in the appropriated level of your opinions

<table>
<thead>
<tr>
<th>Mean</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Moderate/Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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<table>
<thead>
<tr>
<th>Question</th>
<th>Level of Opinions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does your company give top priority to Occupational Health and Safety policies in the workplace?</td>
<td></td>
</tr>
<tr>
<td>2. Do you think that the Industrial Park will gain benefits from joining the Eco-industrial project?</td>
<td></td>
</tr>
<tr>
<td>3. Do you think that joining the Eco-industrial project will enhance the development of Occupational Health and Safety in your factory?</td>
<td></td>
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<tr>
<td>4. Do you think that all employees should be involved in the implementation of Occupational Health and Safety in line with the requirements of Eco-industrial policies?</td>
<td></td>
</tr>
<tr>
<td>5. Do you think that the requirements of Eco-industrial policies are appropriate for Industrial Park?</td>
<td></td>
</tr>
<tr>
<td>6. Do you think that the requirements of Eco-industrial policies comply with the requirements of the relevant legislation?</td>
<td></td>
</tr>
<tr>
<td>7. Are you satisfied with the implementation of Occupational Health and Safety in your agency?</td>
<td></td>
</tr>
</tbody>
</table>
Part 5 Problems, obstacles, and suggestions

1. Do you have any problems and obstacles in the implementation of Occupational Health and Safety in your agency? What are they?

2. Do you have any suggestions for the implementation of Saha Group Industrial Park Sriracha in line with the requirements of Eco-industrial policies?

Thank you very much for your timely help
Appendix B

INFORMATION SHEET (Questionnaire Surveying)

The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development: A Case Study of Saha Group Industrial Park Sriracha, Thailand

Research Team:
Chief investigator: Prof. Cordia Chu (Principal supervisor)
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Contact email: c.chu@griffith.edu.au
Student investigator: Kultida Bunjongsiiri (PhD student)
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Griffith School of Engineering, Centre for Environment and Population Health, Griffith University, Australia
Associate supervisors (In Thailand): Assoc.Prof.Dr. Jakkris Sivadechathep, Vice President for Academic Affairs, School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact Phone: +66 2 504 7111
Contact Email: jaksiv@yahoo.com

Questionnaire Surveying is undertaken to investigate the current situation of Occupational Health and Safety (OH&S) of organization, and the development through the requirements of Eco-Industrial regulations.

Why is the research being conducted?
This research is a component of a student’s PhD program at Griffith School of Engineering and Centre for Environment and Population Health, Griffith University, Australia. Generally, the study seeks to analyse the factors influencing on the management of health and safety in the Industrial Park factories and Industrial Park attendant base on Eco-Industrial handling and management aspect which launched by Industrial Estate Authority of Thailand, as well as to identify the needs for fully applying health and safety to meet the requirement of EIP regulations in Thailand.

The objectives of this study are
• To examine the implementation of Health and Safety in a selected Industrial Park which related to the Eco-Industrial Parks regulations;
• To point out the barriers and challenges for using Health and Safety criteria in the Eco - Industrial Parks context in Thailand;
• To investigate awareness and participation of Industrial Park members in Health and Safety issues relating to the protection of Industrial Park factories in the selected Industrial Parks operation project; and
• To propose the factors needed to develop Health and Safety management and it is contribute to the good operation and more effective management along with EIP regulation in Thailand.

What you will be asked to do?
The questionnaire consists of five parts in five pages in total, details as follow:

- Part 1: General Data
- Part 2: Occupational Health and Safety Data
- Part 3: Questionnaire on the acknowledgement of organization on OH&S through the requirements of Eco-Industrial regulations.
- Part 4: Questionnaire on the opinions of OH&S management through the requirements of Eco-Industrial regulations.
- Part 5: Questionnaire on the problems, obstacles, and suggestions on OH&S management through the requirements of Eco-Industrial regulations.

You will be provided an information sheet and interview guideline in Thailand to help you understand the study.

The basis by which participants are selected or screened
The potential participants will be addressed by position of OSH officer or the personnel in charge in Health and Safety section of the businesses in manufacturing factories. The researcher will use face-to-face contact by making an appointment before conduct data.

The expected benefits of the research
The benefit to you is that this research will make recommendations to enhance understanding on the current situation of Health and Safety in industrial park in Thailand as well as it barriers and challenges; to provide useful information for policy makers and industrial park owner to overcome the evaluation on the acceptability and capability of industrial park members in Health and Safety. Based on the “search of knowledge” Griffith University will also obtain benefit from this research such as developing adaptation strategy for the implementation of health and safety and the development of eco-industrial park projects.

Risk to you
There are no risks caused by this research to the participants or the research team; no risks to the environment and no risks that could impact on your job.

Your participation is voluntary. If you choose not to participate, it will not affect your current or future relationship with the university or your job. There are no penalty or loss benefits for not participating or for discontinuing your participation.

Your confidentiality
The records of this study will be kept private. All audio and audio visual records will be erased after transcription. All you responses will be coded for analysis to remove individual identification. None of the specific records will be used for wider purposes other than students’ academic program. In any report to be published, no information will be provided that could identify you. Data collected will be kept in a locked file and be accessible only to the researcher. The researcher will facilitate the focus group discussion and prior to discussion starting the researcher will explain the purpose of this study; so, participants can decide whether they wish to participate or not.

Questions/further information
If you have any additional queries, concerns or complaint about this research, you may contact:
Prof. Cordia Chu (Principal supervisor)
Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
Contact email: c.chu@griffith.edu.au
Centre for Environment and Population Health
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Local contact:
Assoc.Prof.Dr.Jakkris Sivadechathep
Vice President for Academic Affairs, School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact Phone: +66 2 504 7111
Contact Email: jaksiv@yahoo.com

The ethical conduct of this research
Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on (617) 3735 5585 (or research-ethics@griffith.edu.au).

Feed back to you
Because this research is a component of a student’s PhD program at Griffith School of Engineering and Centre for Environment and Population Health, Griffith University, Australia, the report will be published as a thesis by Griffith University. Participants will receive a transcript as feedback of the summarised results.

Privacy Statement
All participant responses will be coded for analysis to remove individual identification. In any report to be published, no information will be provided that could identify participants. Data collected will be kept in a locked file and be accessible only to the researcher. The university review board is responsible for protecting human participants and regulatory agencies. The manager Research Ethics will be notified promptly of any concerns received with regards to the ethical conduct of the research. The conduct of this research involves the collection, access and /or use of your identified personal information. The information collected is confidential and not will be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguard. For further information consult the University’s Privacy Plan at www.gu.edu.au/ua/aa/vc/pp or telephone 61 7 3735 5585.
Appendix C

INFORMED CONSENT FORM (Questionnaire Surveying)

INFORMED CONSENT FORM
(Questionnaire Surveying)
The Utility of Health and Safety Performance to Examine the Eco -
Industrial Parks Development: A Case Study of Saha Group Industrial
Park Sriracha, Thailand

Research Team:
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kultida73@gmail.com
Griffith School of Engineering, Centre for Environment and Population
Health, Griffith University, Australia
Associate supervisors (In Thailand): Assoc.Prof.Dr.Jakkris
Sivadechathep, Vice President for Academic Affairs, School of Health
Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact Phone: +66 2 504 7111     Contact Email: jaksiv@yahoo.com

Principal Investigator:  Signature
of PI:
SGI #:

Use of this Form: Use this form to request review if you propose to
obtain informed consent for the research activity without also obtaining
the subject’s signature on the consent form.

1. I agree to participate as in the study to investigate the current
situation of Occupational Health and Safety (OSH) of organization, and
the development of OSH through the requirements of Eco-Industrial
regulations.
2. I acknowledge that I have read the Information Sheet, which explains
in detail the reasons for my selection, the aims and method of the study
and any risk and benefit that are associated, and describes what my
participation in the study will require.
3. My decision to participate will not prejudice my relationship with
Griffith University.
4. I understand that I am free to withdraw from the study at any time.
5. I agree that research data collected from the results of the study
may be published, and that my involvement will remain confidential.
6. I understand that if I have any questions or and concern relating to
my participation in this research, I may contact the chief investigator
Assoc.Prof.Dr.Jakkris Sivadechathep at contact phone: +66 2 504 7111.
7. I acknowledge receipt of a copy of this Consent Form and the
Participant/Informant Information Statement.

NOTE: This study has been approved by the Griffith University Human
Research Ethics Committee. If I have any complaints or reservations
about the ethical conduct of this research, I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 0061 7 37354375 (or research-ethics@griffith.edu.au). Any issues I raise will be treated in confidence and investigated fully, and I will be informed of the outcome.

4) As previously advised, participants must be provided with feedback and a copy of the thesis is not an acceptable form of feedback.

**Response:**

Because this research is a component of a student’s PhD program at Griffith School of Engineering and Centre for Environment and Population Health, Griffith University, Australia, the report will be published as a thesis by Griffith University. Participants will receive a transcript as feedback of the discussion results.

After conducting interviews, the researcher will share research findings with research participants by sending a short, readable, jargon-free summary of interviews results and summaries to the respondents. They can conveniently get access to this information from research team both in Australia and Thailand at

**Australia:** Centre for Environment and Population Health
Contact Phone: +61 7 3735 7458
Contact Email: cepadmin@griffith.edu.au

**Thailand:** School of Health Science, Sukhothai Thammathirat Open University (STOU)
Contact Phone: +66 2 504 7111
Contact Email: Netchanok.Cha@stou.ac.th

Researcher: Kultida Bunjongsiri
Contact Phone: +61 406453559 (Australia), +66 8 46656050 (Thailand)
Contact Email: kultida.bunjongsiri@griffithuni.edu.au
Appendix D

In-Depth interview from Industrial Park

In-Depth interview from Industrial Park

Part 1 General Data
Informant_________________________ Position_________________
Contact Number__________________________

Part 2 Interview questions

1. How does Industrial Park assign the duties and responsibilities related to the implementation of the Occupational Health and Safety (OH&S) in line with the Eco-Industrial Park project requirements?
2. How does the administrator of Industrial Park support the implementation of OH&S in line with the Eco-Industrial Park project?
3. Has Industrial Park implemented the policies for OH&S management in terms of prevention complying with OH&S laws or relevant standards? How?
4. Has Industrial Park set up guidelines for Safety Audit? How? When some errors occur, how does it solve the problems?
5. Has Industrial Park built a chemical database connecting to health and safety? And how has it disseminated the information related to other agencies?
6. How has Industrial Park defined security plan for the fire incident?
7. Does Industrial Park has emergency response plans and does it conduct emergency exercises on a continual basis? Does it conduct a review and how?
8. Does Industrial Park have cooperation network which has mutual aid agreement with community? How?
9. Does Industrial Park have a community emergency plan? And does the community participate in the planning process? How?
10. Does Industrial Park have cooperation or information exchange with other agencies in community health surveillance, such as nursing homes and community centres, in carrying out the health surveillance? How?
11. Has Industrial Park set up community health surveillance system? Does the community participate in the planning process? How?
12. Do you have any suggestions on how to set guidelines for the management of occupational health and safety in line with the Eco-Industrial Park project?
Appendix E

INFORMATION SHEET (In-Depth Interview)

INFORMATION SHEET
(In-Depth Interview)

The Utility of Health and Safety Performance to Examine the Eco - Industrial Parks Development:
A Case Study of Saha Group Industrial Park Sriracha, Thailand

Research Team:
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Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
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Contact email: Kultida.bunjongsiri@griffithuni.edu.au,
kultida73@gmail.com
Griffith School of Engineering, Centre for Environment and Population
Health, Griffith University, Australia
Associate supervisors (In Thailand): Assoc.Prof.Dr.Jakkris
Sivadechathep, Vice President for Academic Affairs, School of Health
Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact Phone: +66 2 504 7111 Contact Email: jaksiv@yahoo.com

Why is the research being conducted?
This research is a component of a student’s PhD program at Griffith School of Engineering and Centre for Environment and Population Health, Griffith University, Australia. Generally, the study seeks to analyse the factors influencing on the management of health and safety in the Industrial Park factories and Industrial Park attendant base on Eco - Industrial handling and management aspect which launched by Industrial Estate Authority of Thailand, as well as to identify the needs for fully applying health and safety to meet the requirement of EIP regulations in Thailand.

The objectives of this study are
• To examine the implementation of Health and Safety in a selected Industrial Park which related to the Eco - Industrial Parks regulations;
• To point out the barriers and challenges for using Health and Safety criteria in the Eco - Industrial Parks context in Thailand;
• To investigate awareness and participation of Industrial Park members in Health and Safety issues relating to the protection of Industrial Park factories in the selected Industrial Parks operation project; and
• To propose the factors needed to develop Health and Safety management and it is contribute to the good operation and more effective management along with EIP regulation in Thailand.

What you will be asked to do?
In this research you will be asked to be involved in in-depth interviews to obtain information on the Eco - Industrial Parks practices and also potential adaptation needs considering from your viewpoint. You will be provided an information sheet and interview guideline in Thailand to help you understand the study.

**The basis by which participants are selected or screened**
The researcher will interview decision makers in relation to the Eco - Industrial Parks and Health and Safety management in selected Industrial Park. These interviewees will include The leaders and managers consist of the manager or the personnel in charge of Industrial Park in Sriracha, manager or the personnel in charge of Industrial Park in head office, safety officer of Industrial Park in Sriracha, specialists, local politician, The Industrial Estate Authority of Thailand (I-EA-T) and Department of Industrial Works (DIW) officers. They have been selected because they are key people in the Eco - Industrial Parks and Health and Safety management movement.

**The expected benefits of the research**
The benefit to you and decision makers is that this research will make recommendations to enhance understanding on the current situation of Health and Safety in industrial park in Thailand as well as it barriers and challenges; to provide useful information for policy makers and industrial park owner to overcome the evaluation on the acceptability and capability of industrial park members in Health and Safety. Based on the “search of knowledge” Griffith University will also obtain benefit from this research such as developing adaptation strategy for the implementation of health and safety and the development of eco-industrial park projects.

**Risk to you**
There are no risks caused by this research to the participants or the research team; no risks to the environment and no risks that could impact on your job.

Your participation is voluntary. If you choose not to participate, it will not affect your current or future relationship with the university or your job. There are no penalty or loss benefits for not participating or for discontinuing your participation.

**Your confidentiality**
The records of this study will be kept private. All audio and audiovisual records will be erased after transcription. All you responses will be coded for analysis to remove individual identification. None of the specific records will be used for wider purposes other than students’ academic program. In any report to be published, no information will be provided that could identify you. Data collected will be kept in a locked file and be accessible only to the researcher.

**Questions/further information**
If you have any additional queries, concerns or complaint about this research, you may contact:

Prof. Cordia Chu (Principal supervisor)
Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
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Vice President for Academic Affairs, School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand. Contact Phone: +66 2 504 7111
Contact Email: jaksiv@yahoo.com

The ethical conduct of this research
Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on (617) 3735 5585 (or research-ethics@griffith.edu.au).

Feed back to you
Because this research is a component of a student’s PhD program at Griffith School of Engineering and Centre for Environment and Population Health, Griffith University, Australia, the report will be published as a thesis by Griffith University. The copy of this thesis also will be given to Saha Group Industrial Park Sriracha, Thailand as feedback and report on the findings of the research.

Privacy Statement
The conduct of this research involves the collection, access and /or use of your identified personal information. The information collected is confidential and not will be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguard. For further information consult the University's Privacy Plan at www.gu.edu.au/ua/aa/vc/pp or telephone 61 7 3735 5585.
Appendix F
INFORMED CONSENT FORM (Participants)

INFORMED CONSENT FORM (Participants)
The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development: A Case Study of Saha Group Industrial Park Sriracha, Thailand

Research Team:
Chief investigator: Prof. Cordia Chu (Principal supervisor)
Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
Contact email: c.chu@griffith.edu.au

Student investigator: Kultida Bunjongsiri (PhD student)
Contact Phone: +61 406453559 (Australia), +66 8 46656050 (Thailand)
Contact email: Kultida.bunjongsiri@griffithuni.edu.au, kultida73@gmail.com

Griffith School of Engineering, Centre for Environment and Population Health, Griffith University, Australia

Associate supervisors (In Thailand): Assoc.Prof.Dr.Jakkris Sivadechathep, Vice President for Academic Affairs, School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact Phone: +66 2 504 7111 Contact Email: jaksiv@yahoo.com

1. I of___________________________ agree to participate as in the study to investigate the current situation of Occupational Health and Safety (OSH) of organization, and the development of OSH through the requirements of Eco-Industrial regulations.
2. I acknowledge that I have read the Information Sheet, which explains in detail the reasons for my selection, the aims and method of the study and any risk and benefit that are associated, and describes what my participation in the study will require.
3. My decision to participate will not prejudice my relationship with Griffith University.
4. I understand that I am free to withdraw from the study at any time.
5. I agree that research data collected from the results of the study may be published, and that my involvement will remain confidential.
6. I understand that if I have any questions or/and concern relating to my participation in this research, I may contact the chief investigator Assoc.Prof.Dr.Jakkris Sivadechathep at contact phone: +66 2 504 7111.
7. I acknowledge receipt of a copy of this Consent Form and the Participant/Informant Information Statement.

NOTE: This study has been approved by the Griffith University Human Research Ethics Committee. If I have any complaints or reservations about the ethical conduct of this research, I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 0061 7 37354375 (or research-ethics@griffith.edu.au).
Any issues I raise will be treated in confidence and investigated fully, and I will be informed of the outcome.

Signature of Participant __________________________ Signature of Investigator __________________________
Print Name __________________________ Print Name __________________________
Date __________________________ Date __________________________
Appendix G

ETHICAL ISSUES IN FOCUS GROUP DISCUSSION

ETHICAL ISSUES IN FOCUS GROUP DISCUSSION

The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development:
A Case Study of Saha Group Industrial Park Sriracha, Thailand

Research Team:
Chief investigator: Prof. Cordia Chu (Principal supervisor)
Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
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Contact Phone: +66 2 504 7111 Contact Email: jaksiv@yahoo.com

This Focus Group Discussion (FGD) is undertaken to identify the potential adaptation responses require for the community people of urban settings to recommend for developing appropriate adaptation strategies for dengue fever due to climate change.

A Focus Group Discussion is required to provide an opportunity to discuss to identify the current problems and obstacles in the implementation of Occupational Health and Safety in the agency and the participation of Saha Group Industrial Park Sriracha in Eco-Industrial project. The focus group will include 6-12 participants.
The researcher will facilitate the focus group discussion and prior to discussion starting the researcher will explain the purpose of this study; so, participants can decide whether they wish to participate or not. Participants will be involved in discussion and required to share information and sign the relevant informed consent form. They also will receive a transcript as feedback of the discussion results.
To ensure that all participants feel able to participate honestly the researcher will ask all focus group participants to respect the privacy of other comments made by other participants.
The records of this study will be kept private. All audio records will be erased after transcription. All participant responses will be coded for analysis to remove individual identification. None of the specific records will be used for wider purposes other than students’ academic program. In any report to be published, no information will be provided that could identify participants. Data collected will be kept in a locked file and be accessible only to the researcher. The university review board is responsible for protecting human participants and regulatory agencies. The manager Research Ethics will be notified promptly of any concerns received with regards to the ethical conduct of the research.
Appendix H

INFORMED CONSENT FORM (Focus Group Discussion)

The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development: A Case Study of Saha Group Industrial Park Sriracha, Thailand

Research Team:
Chief investigator: Prof. Cordia Chu (Principal supervisor)
Contact phone: +61(07)3735-7458, Fax: +61(07)3735-5318
Contact email: c.chu@griffith.edu.au
Student investigator: Kultida Bunjongsiri (PhD student)
Contact phone: +61 406453559 (Australia), +66 8 46656050 (Thailand)
Contact email: Kultida.bunjongsiri@griffithuni.edu.au, kultida73@gmail.com

Griffith School of Engineering, Centre for Environment and Population Health, Griffith University, Australia

Associate supervisors (In Thailand): Assoc.Prof.Dr. Jakkris Sivadechathep, Vice President for Academic Affairs, School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand.
Contact phone: +66 2 504 7111 Contact Email: jaksiv@yahoo.com

By signing below, I confirm that I have read and understood the information sheet and the ethical issues document and in particular have noted that:
• I understand that my involvement in this research will include participation in a Focus Group Discussion (FGD) with other participants (between 6 and 12 people)
• I have had any questions answered to my satisfaction
• I understand the risks involved
• I understand that there will be no direct benefit to me from my participation in this research
• I understand that my participation in this research is voluntary
• I understand that my participation will be recorded on audio-tape
• I understand that only the research team will have access to this tape
• I understand that the audio-tape will be erased following transcription
• I understand that if I have any additional questions I can contact the research team
• I understand that I am free to withdraw at any time, without comment or penalty
• I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on 3735 5585 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project.
• I agree to respect the privacy of comments made by others during the FGD
• I agree to participate in the project

Name
Signature
Date

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Appendix I

Ethical Clearance

GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE

06-Jun-2014

Dear Mrs Bunjongsiri

I write further to the additional information provided in relation to the conditional approval granted to your application for ethical clearance for your project "The Utility of Health and Safety Performance to Examine the Eco-Industrial Parks Development: A Case Study of Saha Group Industrial Park Sriracha, Thailand" (GU Ref No: ENG/13/14/HREC).

This is to confirm receipt of the remaining required information, assurances or amendments to this protocol.

Consequently, I reconfirm my earlier advice that you are authorised to immediately commence this research on this basis.

The standard conditions of approval attached to our previous correspondence about this protocol continue to apply.

Regards

Dr Kristie Westerlaken
Policy Officer
Office for Research
Bray Centre, Nathan Campus
Griffith University
ph: +61 (0)7 373 58043
fax: +61 (07) 373 57994
email: k.westerlaken@griffith.edu.au
web:

Cc:

Researchers are reminded that the Griffith University Code for the Responsible Conduct of Research provides guidance to researchers in areas such as conflict of interest, authorship, storage of data, & the training of research students.

You can find further information, resources and a link to the University’s Code by visiting http://policies.griffith.edu.au/pdf/Code%20for%20Responsible%20Conduct%20pdf

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Appendix J

Publication Awards

### Appendix K

**Key Informants (KI)**

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<td>Facility Manager of Saha Group Industrial Park, Sriracha, Chonburi</td>
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<td>2</td>
<td>SPI-2</td>
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<td>Environmental Engineer in charge of OH&amp;S officer of Saha Group Industrial Park, Sriracha, Chonburi</td>
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<td>M</td>
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