CHAPTER 2

CONCEPTUALIZING INDUSTRIAL ENVIRONMENTAL REFORM

2.1 Development of Industrial Waste Management

Industry plays an important role in economic development and in enhancing the economic welfare of the population. Despite obvious benefits of industrial development, it frequently causes damage to the environment and human health.

Prior to the 1950s, the prevailing response of industries to environmental pollution was to ignore the problem. Industrialization was still confined to a relatively small number of nations. On a large scale industries in these countries dumped waste materials from manufacturing processes into the environment without any serious treatment. At that time the problems were relatively small, many industrialists were rather unaware of the consequences of their actions and the public writ large had little knowledge of the impacts of industrial waste on the environment. No serious legislative or policy framework on the environment was in place in the industrialized countries, except national nature protection regulations.

The rapid growth in industrial production greatly increased the demand for natural resources and contributed to severe environmental degradation, which impacted the quality of life of significant parts of the population in the industrialized world. Several publications (such as Rachel Carson's *Silent Spring*, the MIT report *Limits to Growth* and the *Blueprint for Survival*) not only gave evidence of increasing academic and popular concern for the deteriorating quality of life, but also further triggered awareness among large categories of the population. Public campaigns, emerging new social movements and regulatory actions by national states put pressure on industries to start treating their waste and remove pollutants before discharging their non-products to the environment. The second half of the 1960s and the early 1970s formed a period of innovative regulatory, technological and civil society innovations with respect to environmental pollution. This phase was formative for an approach that dominated industrial waste management for at least two decades, if not more. In the current industrial waste management approaches of most industrialized and industrializing countries the central elements of that period are still in place.

However, the ever-expanding use of virgin natural resources for manufacturing and the proliferation of end-of-pipe treatment and disposal of generated waste started to be discussed and criticized against ideas of resource sustainability and preventive environment management. As a result, new ideas were being developed and put into practice in the 1980s. Figure 2.1 shows the development of industrial waste management practices in four phases. Different industries in different countries are in different stages of phases of this industrial waste management model. But the key challenge at the moment in most of the Southeast Asian industrializing economies is to move – in terms of Figure 2.1 – from b) towards c) and d). Figure 2.1d represents ideal future industrial practices that meet the goal of zero waste discharge. All residue/by-product from production process can be reuse/recycle both in the same firm/industry and in other sectors of the economy.

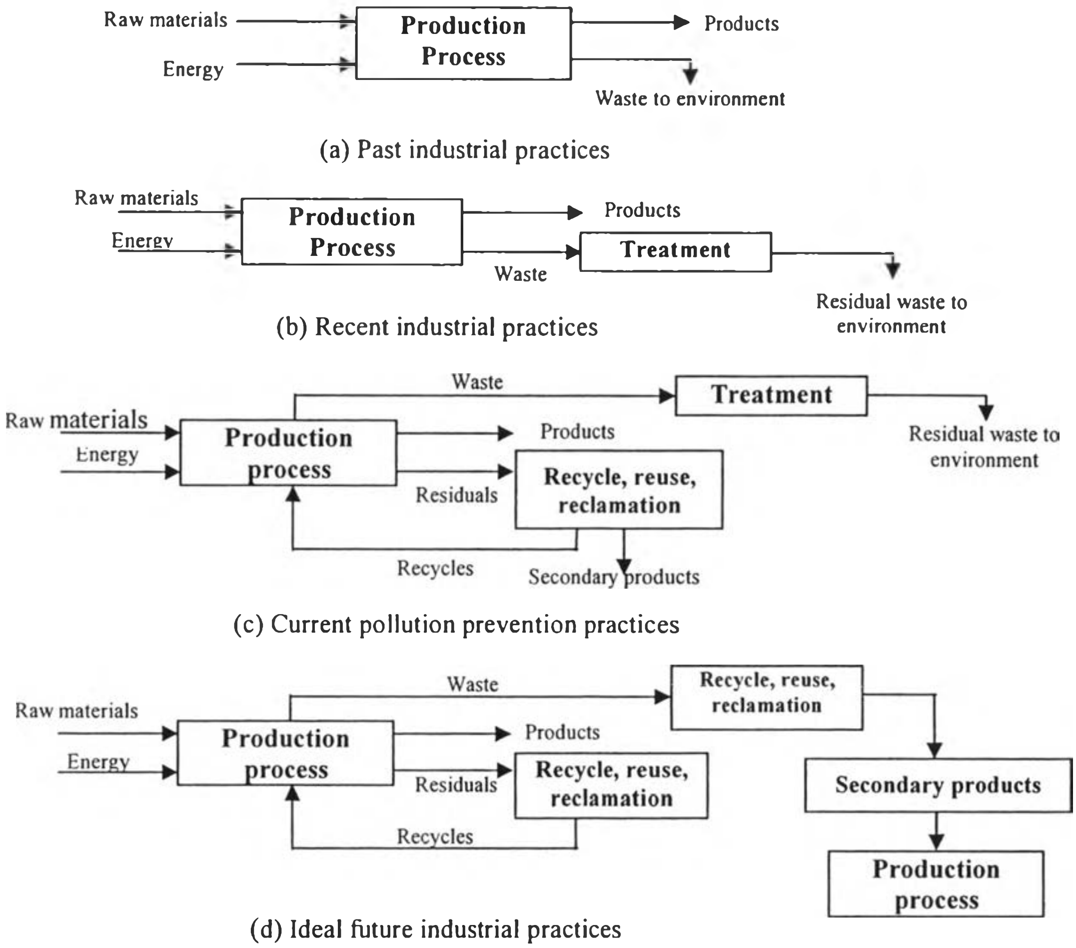

Figure 2.1 Development of industrial waste management practices (Adapted from Bishop, 2000).

Ecological modernization: from curative to preventive approaches

Before the idea of sustainable development became an integral part of every production system, environmental protection was carried out through end-of-pipe technologies (Visvanathan and Kumar, 1999; cf. Figure 2.1b). This end-of-pipe pollution control approach was traditionally connected to a command-and-control regulatory style, where the state established top-down environmental standards to regulate the discharge of pollutants. When emission and environmental quality standards became more stringent, the cost of such an end-of-pipe treatment of waste became more expensive and started to affect the production cost of industries. Besides the high costs, end-of-pipe treatment did not really eliminate pollutants, but merely transferred them from one medium to another. The limitations of end-of-pipe treatment made environmental decision-makers and researchers to search for other alternative methods of pollution control. During the last decade, the responses came in various forms, with a common denominator in the movement towards preventive approaches rather than curative ones. Environmental experts began focusing on cleaner production/waste minimization and even a new academic discipline, industrial ecology, was born with the mission to design zero-emission industrial processes (Aryes and Simonis, 1994; Graedel and Allenby, 1995; Allenby, 1999). These preventive approaches were found to be more cost-effective than add-on systems of treatment. Also, industrial wastes may still possess economic value (Tsai and Chou, 2004). Today, the relevance and important of the cleaner production issues has been well understood and documented through many case studies (UNEP/IEO, 1993). Despite all the advantages in theory, the application of the cleaner production concept in small and medium industry has often not been substantial (Visvanathan and Kumar, 1999). A number of barriers exist that limit the widespread implementation of cleaner production in a company. These barriers can be classified into economic, technical, attitudinal, and organizational barriers.

With the development of more preventive approaches in cleaning industrial production, state interventions also started to change. A pure command-and-control strategy started to shift to the inclusion of more cooperative or even voluntary approaches. In addition, the use of economic instruments and market dynamics in environmental regulation started to gain ground towards the end of the 1980s and throughout the 1990s. The diversification of policy instruments and the new policy strategies are tightly linked with a movement towards more preventive approaches, as the fine regulations of productions processes and the formation of waste linkages between different productive firms could not be handled by the state via a top-down command-and-control approach. The active involvement of market actors and polluters themselves became an essential element in the movement towards more preventive approaches. This development is further theorized and elaborated in the theory of ecological modernization (Spaargaren and Mol, 1992 ; Weale, 1992 ; Mol, 1995 ; Murphy and Goldson, 1995 ; Spaargaren, 1997 ; Gibbs, 2000). Within the idea of ecological modernization the change from the conventional regime of environmental reform, characterized by curative end-of-pipe technologies, command-and-control regulation and a dominant state, towards a new regime is analyzed. This new preventive regime sees different technologies, different regulatory approaches, and different actors. Table 2.1 summarizes the main transformations between the two regimes in four institutional categories.

Table 2.1 Technology, economy, state and civil society in environmental reform.

Institution	Indicator	Transformation
Technology	• Waste management	• End-of-pipe technology ⟶ Clean technology + industrial ecology
Economy	• Environment responsibility • Product	• State ⟶ also market and economic agents. • Cleaner products • Certification of product and process. (EMS, ISO 14000)
Political institution	• Role of state agencies • Environmental policy approach	• Top down dirigism ⟶ Negotiated rulemaking. • Commander ⟶ Facilitator • Curative and reactive ⟶ Preventive • Exclusive ⟶ Participatory policymaking. • Centralized ⟶ Decentralized • Command and control ⟶ economic and voluntary approach
Civil society	• Environmental NGOs' participation. • Responsibility for Environment	• Outside Commentators ⟶ Negotiator • The individual polluter ⟶ Community, government or society.

It should not surprise us that theoretical reflections and practical experiences of these transformations in industrial environmental reform have started in the industrialized countries. The core ideas of ecological modernization have been first coined against the background of developments in Europe (cf. Mol and Sonnenfeld, 2000). In the OECD countries the changes in regulatory styles and technological approaches to industrial environmental problems have been first experimented upon. But with the industrialization process in South-east Asia and the global spreading of ideas, concepts and experiences in environmental management we can also witness the emergence of these innovations in Thailand.

In this chapter, our focus will be primarily on the technological dimension of this regime shift in industrial environmental reform. We will subsequently introduce and analyze the concepts of end-of-pipe treatment, cleaner production/technology and industrial ecology, to be used in the following chapters to analyze actual and potential industrial environmental management strategies for Thai palm oil production.

2.2 End-of-Pipe Treatment

2.2.1 The concept of End-of-Pipe Treatment

Along with rapid industrialization, which has resulted in the rise of pollution, there is a growing concern about the quality of the environment. In 1970s, the government realized that pollutants had exceeded the assimilative capacity of the environment (Hwa, 2005). There were efforts to establish environmental standards to regulate the discharge of pollutant. The command and control regime is a regulatory approach mainly consisting of emission and ambient standards established by a governmental agency as national goals. This approach for minimizing industry's environmental impacts was originated in western countries and was adopted by many Asian nations during their industrialization phases. Factory is expected to comply with stated emission standard. Failure to comply can result in fines, imprisonment or closure. This approach reflects to curative or end-of-pipe approach or waste treatment strategies to pollution control. End-of-pipe treatment has been addressed for problems with emissions of pollutants from industrial sources. The companies have to treat their waste to meet standard emission to compliance with the regulation. This resulted in the installation of much end-of-pipe polluting control and waste clean up technologies. A great number of treatment plants applying biological, physio-chemical or chemical processes to treat different kinds of industrial wastewater, solid wastes and air pollutants are in use in most countries all over the world.

These approaches reduce the direct release of some pollutants to achieve regulatory compliance but do not really solve the environmental problems because they shift pollution from one environmental medium to another. Besides this, technology courses extra cost for investment and operation. However this approach is still one of the most used pollution treatment methods to handle unavoidable wastes and emission of pollutants from industrial production process. This is due to the generation of waste in a production process is still unavoidable. In current pollution prevention practices, total elimination through source reduction or recycling can not be possible. There always be some residues that cannot be prevented or reclaimed. The remaining pollution requiring treatment after source reduction and recycling should be greatly reduced in volume, however, thus making treatment easier and much less expensive. Wastes after treatment always directly discharge to the environment at levels that the environmental capacity can be support or to a secure landfill. Aside from waste minimization/ pollution prevention, industrial waste treatment technologies still need to be developed and regulatory emission standards for industrial regulatory are necessary where waste/ pollution could not be totally eliminated through source reduction, process modification and production management (Tsai and Chou, 2004).

2.2.2 End-of-Pipe Treatment Approach

Advantage. The implementation of end-of-pipe treatment methods depends heavily on how serious pressure is from environmental authorities to control industrial pollution in firms. In environmental policy, command and control approaches have been adopted to provide incentives for polluters to introduce and operate pollution treatment facilities in most countries.). Through various instruments, such as market based instrument, polluter pay principle, of command and control approaches have been successful in dealing with environmental problems initially (Huber, 1991). Despite there is a change in intent, many policies are still based on pollution control in specific media. End-of-pipe abatement is still so widely used as there are many advantages such as: less capital investment; standard technology; easy implementation; easy to handle for regulation; profitable for environmental industry. Jackson (1993) stated that fast and less costly solutions make end-of-pipe treatment methods to be more attractive for a firm with a strict budget and limited funds. Most available expert advice from commercial consultant is based upon the use of add-on technology. Besides these reasons, firms especially SMEs have limitation of knowledge and awareness about the possibilities for a symbiosis of ecological and economic aspects in business innovations. They mostly adopt in end-of-pipe treatment to compliance the emission standard.

Disadvantage. Although end-of-pipe treatment control strategies have resulted in reducing negative environmental impact from industrial production, they focus on the symptoms and not the basic cause of environmental problem (Khan et al, 2001). The end-of-pipe strategy for treatment of pollution has proven to be useful in reduction of pollutant emission to the environment. But it is not adequate to make an efficient use of limited resource. Jackson (1993) concluded the significant problems associated with this approach as following :

- "end-of-pipe abatement in one medium risks transferring pollution from that medium to another, where it may either cause equally serious environmental problems or even end up as an indirect source of pollution to the same medium.
- Although not as expensive as remediation of environmental damages, end-of-pipe abatement contributes significantly to the costs of production products.
- End-of-pipe abatement of pollution requires regulation through control regislation which is often costly and cumbersome, leading to potentially inefficient regulatory structure and problems of noncompliance.
- End-of-pipe abatement technology represents a significant technological market with an associated economic inertia which encourages the continued generation of waste and works against any attempt to reduce pollution at the source."

Industry is accustomed to comply with this command and control regulatory standards on the measures and performances of industrial waste treatment, though these regulatory measures have been less effective in controlling the problems of gross pollution and deducting the future liability. It is increasingly recognized that these policy approaches face many drawbacks such as economic inefficiency, environmental ineffectiveness, no incentive for innovation and even democratic illegitimacy (Eckersky,1995). With all limitations, end –of-pipe approach is arguably proactive, has low performance and is more costly but less sustainable than other environmental protection approaches (Dieu, 2003).

2.3 Cleaner Production

2.3.1 Concept of Cleaner Production

Cleaner production is the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency and reduce problem and product risks to human and environment (UNEP, 2001a). Cleaner production can be applied to the processes used in any industry, to products themselves and to various services provided in society. Cleaner production is a preventive strategy to minimize the impact of production and products on the environment by applying clean technologies and organizational measures. It includes organizational changes, motivation and training for good housekeeping as well as changes in raw materials, process technology and internal recycling. Cleaner production also refers to a mentality of how goods and services are produced with the minimum environmental impact under present technological and economic limits. Cleaner production is a 'win-win' strategy. It protects the environment, the consumer and the worker while improving industrial efficiency, profitability, and competitiveness (UNEP, 2001). Cleaner production is an integrated approach in handling waste and pollutants in industries (UNEP/IEO, 1993). It is a broad term that encompasses what some countries/institutions call eco-efficiency, waste minimization, pollution prevention, or green productivity (UNEP, 2001a). The concept is especially important to developing countries, where energy natural resources are scarce, and the pace of environmental degradation is continuously increasing (Hamed and Mahgary, 2004).

Cleaner production differs from end-of-pipe treatment in that it increases production efficiency, while eliminates or minimizes wastes and emission at the sources. By introducing material and energy flow management into the companies in stead of end-of-pipe measures, cleaner production aims to avoid the generation of wastes and emissions and use materials and energy as efficiently as possible (Murphy and Gouldson, 2001). Table 2.2 shows the difference between pollution control (end-of-pipe treatment) and cleaner production.

In USA, the US congress passed the Pollution Prevention Act in 1990 that specifically required the evaluation of new opportunities and approaches to eliminate the generation of waste (USEPA, 1992). It established a hierarchy for determining how pollution should be managed. It is clear that source reduction is specified as the top hierarchy for determining how waste/ pollution should be managed, followed, by recycle/ reuse, treatment and disposal. Source reduction includes: material substitution; process substitution or elimination; good housekeeping and equipment maintenance; and water and energy conservation. Recycling is divided into two different alternatives: in-process recycling (material reuse or recycling) and end-of-pipe recycling (reuse and recycle either in production process within factory or reuse as raw material for other factory). Cleaner production covers the first two hierarchies such as: source reduction and recycling. Cleaner production/ clean technology and pollution prevention are not identical as pollution prevention includes management and production changes within production process and does not include end-of-pipe recycling that are covered by cleaner production such as reuse and recycle waste/ by-product (with/without treatment) as raw material for other factory).

Table 2.2 Difference between pollution control and cleaner production.

	Pollution control	**Cleaner production**
1.Timings	- React and treat approach	- Anticipate and prevent
2.Target of application	- Waste after generate from process	- Raw material, work practices and technology improvement, final product/by-product, production process and service
3.Outcome element	- Compliance state emission standard and reduce impact to the environment and human health	- Continuous production efficiency improvement and reduce risk to human and the environment
4.Innovative	- Technology only	- Technology integrated management change
5.Production process	- Concerning emission from the process	- Concerning raw material and energy, eliminate toxic raw materials, reducing the quantity of emissions and waste before they leave the process
6.Product Quality	- Not involve	- Reducing negative impacts along the life of a product, from raw materials to its ultimate disposal
7.Service	- Not involve	- Concerning designing and delivering services
8.Operating Cost	- Maintenance costs	- Return as saving cost
9.Employee involvement	- Only environmental section	- All employee from top manager to worker
10.Company's management	- Not involve	- Changing attitudes, applying know-how and improve technology

2.3.2 Cleaner Production Approach

Cleaner production is an operational approach to the development of the system of production and consumption, which in corporate a preventive approach to environmental protection (Jackson, 1993). In production process of a company, cleaner production can contribute to sustainable development, as endorsed by Agenda 21 "protect the environment, are less pollution, use all resources in a more sustainable manners, recycles more of their wastes and products, and handle residual wastes in a more acceptable manner (OECD, 1995). Cleaner production can reduce or eliminated the need to trade off environmental protection against economic growth, occupational safety against productivity, and consumer safety against competition in international markets. Stevenson (2004) stated that the present concepts of cleaner production go beyond the basic concepts of waste minimization and pollution prevention to address the total production process and its upstream and downstream consequences. This included substitution of raw material inputs with less toxic material, efficience use of raw material, life-cycle consequences of production. The management processes and continual improvement are needed to achieve a sustainable production process through greater efficiency and reduction of wastes. Eder and Fresner (2001) concluded that there are various types of cleaner production measures that typically identified and/or implemented in industries as shown in Figure 2.2. From this figure, the emission of pollution can be reduced or eliminated by reduce raw materials and energy consumption, reuse/recycle of waste/by-product in production process, and reduce waste disposal by recycle/ reclaim waste/by-product for other economic sector.

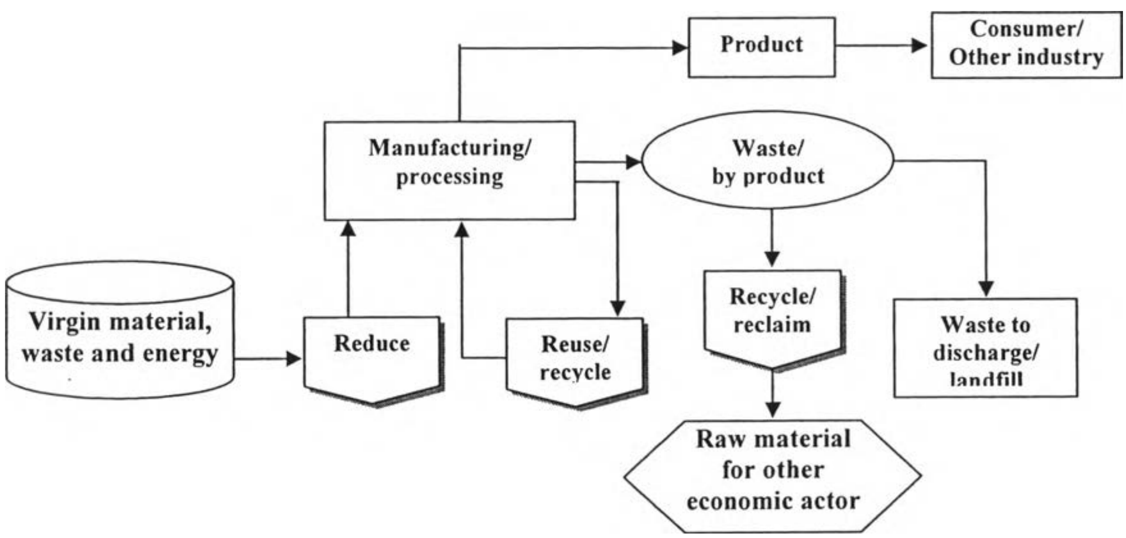

Figure 2.2 Hierarchy for cleaner production (Eder and Fresner, 2001).

Tsai and Chou (2004) concluded that cleaner production and waste treatment operationally interact with each other to achieve an integrated waste management system, and they must be coordinated both in practice and in regulation. It would be profitable from both an environmental and a economic point of view if they interact or work complementary.

According to UNEP (1994), cleaner production options are divided into 5 types such as :

- Good housekeeping: Improvements to work practices and proper maintenance can reduce the usage of materials and energy and produce benefit.
- Substitution of raw and auxiliary materials: Replacing hazardous materials with more environmentally benign materials in order to avoid environmental problem. These options may require changes to process equipment.
- Modifications of products: Changing product design can result in benefits throughout the life cycle of the product, including reduced consumption of raw material and energy, reduce use of hazardous substances, eliminate production steps with major environmental impact.
- Process modifications: minimize waste generation through improved operating efficiencies including internal reuse/recycling or Introduction of waste into external recycling networks.
- New technology: Adopting new technologies can reduce resource consumption and reduce waste generation.

The cleaner production methods use are following :

- Via an auditing process, a systematic balance of all the inputs and outputs of a company is conducted. Then waste and emissions are traced back to their respective source.
- The weak points and inefficiencies of material and energy used are identified and technological, behavioral, organizational options for both economic and ecological improvements are defined.
- Consequently, modifications to production processes and product lead to a situation with less waste and emissions.

It is by now a well-established fact that cleaner production can not function in a vacuum, devoid of other supporting environmental tools. There are various tools and strategies that effect to cleaner production implement by an industry. UNEP(2001) report on new tool that related to cleaner production such as: ISO14000 certification system; eco-labeling, cleaner production awards; economic incentives; financial sector and environmental accounting. To introduce cleaner production methods successfully, the small and medium sized sectors often need support, for instance on technology and finances, from policy organisations and non-governmental organisations, R&D companies and environmental consultances (Frijns and Vliet, 1999).

2.3.3 Barriers and Constraints of Cleaner Production

In response to Agenda 21, several bilateral and multilateral institutions established programs to promote the use of environmentally sustainable technologies and the adoption of concepts and practices of CP in developing countries (Luken et al., 2004) As becomes clear from a review of the extensive literature many clean technology options have been developed and are available in industry (Unapumnuk, 1999). Although there are obvious environmental and economic benefits in implementing clean technology strategies such as optimum use of resources, reduced wastage and waste generation, reduced production and waste management costs, the application of the clean technology in SMEs has not been substantial (Visvanathan and Kumar, 1999). The barriers to industrial pollution prevention in developing countries are related to the following subjects such as: environmental legislation and enforcement; political structures; institutional weaknesses; environmental pricing system; labor markets and education; structural weaknesses in industry; negative attitude towards consultants and other experts; and cost of environmental protection (Wilderer, 2004). Tsai and Chou (2004) conclude some barriers for adopting pollution prevention in Taiwan and state that industrial pollution prevention and waste treatment operationally interact with each other to achieve an integrated waste management system, and they must be coordinated both in practice and in regulation. Various authors have analyzed barriers and constraints which persist and slow the progress towards CP implementation. (Visvanathan and Kumar, 1999; Frijns and Vliet, 1999; UNEP,2001b, Hamed and Mahgary, 2004; Stevenson, 2004; Luken et al., 2004). These barriers fall mainly into four categories including technical, economic, attitudinal, legislative and organizational barriers (Table 2.3)

Table 2.3 Barrier of cleaner production implementation in industry.

Barrier	Details	Reference
Technical barrier	• Lack of educated and skilled manpower. • Lack technical know-how. • Lack of access to CP technology. • Weak national innovation system.	Visvanathan and Kumar, 1999. Chiu & Peters,1994 Hamed and Mahgary, 2004 Intarakumnerd et al., 2002
Legislative and organizational barrier	• Absence of incentive law and regulation to encourage the adoption of CP such as market-based instrument. • Weak emission standard. • Ineffective enforced regulatory regime. • Weak monitor and enforcement by state officer. • Lack of transparency and accountability in decision making.	Stevenson, 2004. Hilson,2000 Dieu,2003 Stevenson, 2004 Martin et al., 2004
Economic barrier	• Lack of capital investment. • Lack of access to finance.	Visvanathan and Kumar, 1999 Hamed and Mahgary, 2004
Attitude barrier	• Negative attitude about changing production process or operation. • Lack of transparency in the industry. • Lack of environmental awareness.	Visvanathan and Kumar, 1999 Hamed and Mahgary, 2004 UNEP, 2001b

After a 5-year exposure to pollution prevention activities, the Federation of Thai Industries, through its Industrial Environment Management Program, summarized the constraints of cleaner production implementation in Thailand (UNEP, 2001b) :

- "Lack of environmental awareness among Thai industrialists. The majority still perceives environmental protection as generating unnecessary costs, which they are not willing to bear.

- The small and medium sized industries lack the resources to start prevention programs and lack the initiative to seek external assistance. Moreover, financial obstacles are crucial.
- Many industrialists in Thailand lack effective management. They lack the basic knowledge of good (environmental) management and adequate evaluation tools such as environmental audits and impact assessments.
- Lack of information on pollution prevention techniques and methodologies among industrialist, and governmental agencies.
- Lack of clear and consistent government policy on waste minimization.
- Lack of government mechanisms for pollution reduction and control"

Luken et al. (2004) reviews the seven programs promoting CP in developing country by international organizations and stated that.

"Future CP projects should consider how to more effectively involve the owners and production managers of the demonstration companies as advocates for CP. Also, more efforts should be made to involve governmental policy makers, academics and NGO's in helping to mainstream the CP concepts, approaches and technologies so that more real progress can be made in helping each country help itself on it journey toward to becoming a sustainable society."

2.4 Industrial Ecology

2.4.1 Concept of Industrial Ecology

Although cleaner production is already a more integrated approach than end of pipe solutions, it still is restricted to only one production process or one factory. In industrial ecology (IE), an industry -with its relations to other industries and actors- is considered as an industrial ecosystem. The major advance of industrial ecology is that it overcomes the shortcoming of end of pipe treatment and cleaner production in that it deals not only with individual firms; it strives to environmentally optimize material flows and use from the respective of a whole industrial (eco)system. Where as cleaner production is process-oriented, industrial ecology is system-oriented and it covers both a long time frame and the whole array of manufacturing.

Frosch and Gallopoulos (1989) first introduced a simple definition of an industrial ecology. This concept focuses on the relations among companies in a direct waste/ by-product exchange. The idea of industrial ecology is based upon a straightforward analogy with natural ecological system (Deanna, 1994). In nature, there is little or no waste. An ecological system operates through a web of connections in which organisms live and consume each other's product and waste. Every industrial activity is linked to many other transactions and activities and to their environmental impact. One factory will have many stakeholders or actors, such as raw material suppliers, customers, consumers, contractors, recyclers, etc. Roberts (2004) stated that the various actors in an industrial system can be interpreted in a way that is analogue to biological organisms. If production and consumption methods in human-controlled systems could be made to mimic the efficiencies of natural and biological systems, then greater sustainability would ensure and means would emerge to address the growing amount of waste produced by industry and a consumption-driven society. To this end, we need to identify new uses and innovative techniques for using waste materials. This view provides the basis for thinking about ways to connect different waste generating from factories into an operating web which can reduce the total amount of waste that goes to disposal. The focus changes from a particular process or facility, commonly known as "cleaner production or pollution prevention" to minimizing waste produced by larger system as a whole (Deanna, 1994).

The industrial ecology concept suggests several environmentally desirable changes in industrial production and practices. These changes include improving the efficiency and productivity of industrial systems, minimizing waste by reduce raw materials consumption, reducing the use of such resource (hazardous material) by substitution of benign materials, developing useful application for waste products, and reusing manufactured products at the end of their first life (Graedel and Allenby, 1995 ; Erkman and Ramaswamy, 2001). Industrial ecology is used as a level beyond a company's internal cleaner production optimum (including product eco-design, extended producer stewardship). Cleaner production and environmental management as process-oriented, while industrial ecology is systems oriented and covers a longer time frame and the whole array of manufacturing. Industrial ecology concept can be applied to all economic activity, including agriculture, mining, forestry, industries and consumers. However most of industrial ecology studies limit the discussion to manufacturing activities. Table 2.4 shows difference among end-of-pipe treatment, cleaner production and industrial ecology approach.

Table 2.4 The difference among end-of-pipe treatment, cleaner production and industrial ecology approach.

	end-of-pipe treatment	**cleaner production**	**industrial ecology**
1.Target of application	- Waste after generate from process	- Raw material, work practices and technology improvement, final product/by-product, production process and service	- Close loop system (zero waste discharge)
2. Objective	- Reduce emission of pollutant to the environment	- Reduce resource consumption and waste generation	- Optimize the industrial metabolism, Reduce environmental impact,
3.Innovative	- Technology only	- Technology integrated management change	- Technology integrated management change
4. Production process	- Concerning emission from the process	- Concerning raw material and energy, eliminate toxic raw materials, reducing the quantity of emissions and waste before they leave the process	- Concerning utilization of waste/ by-product for other industry, Waste exchange
5. Application Level	- single company	- single company	- Community of business
6. Co-operative approach	- Industries	- Industries and commercial	- Industries, commercial and residence

2.4.2 Material and energy flow in industrial ecology

The basis of industrial ecology is provided by the phenomenon of industrial metabolism, which stands for the whole integrated collection of physical process that convert raw materials and energy, plus labor, into finished products and wastes in a (more or less) steady-state condition (Ayres and Simonis, 1994). Material flow and energy flow are two key aspects of industrial metabolism (Manahan, 1999). The material flow in the industrial production begins with virgin materials, which flow through cycles of manufacturing/ process, transportation/ distribution, reuse /recycling and final disposal. (Erkman, 1997). Material flow analysis is an important tool to identify and quantify the material and energy input and output in industrial ecosystems. These data can be used to assess the impact of those material and energy uses and releases to the environment, and then optimizing options for improving the environmental performance of the industry. It is clear that to prevent pollution from manufacturing processes is no longer enough for sustainable concept. Dillon (1994) argue that now we are beginning to see instead a shift in industry and government toward a broader concept of pollution prevention- beyond the manufacturing process- to encompass environmental concerns and pollution prevention through the life cycle of a product, from acquisition of raw material to ultimate disposal. Hoffman et al. (2004) state that industrial ecology attempts to mimic natural cycles, which mostly keep materials moving in a way that does not disrupt the biosphere, and to modify industrial wastes so that they are more amenable to cycling in natural system. The concept of IE with natural systems is to model industrial system after the cycles characteristic of natural systems. According to Manahan (1999), based on as complete knowledge as possible of a system of industrial metabolism, it is possible to optimize the industrial system for maximum efficient production, minimum waste and minimum environmental pollution by internalization of the material cycle (closing). This means that the material cycle is closed as far as possible in a way that materials need not be shipped over long distance to be used. Local markets have to be developed for potential waste materials or such materials need to be locally upgraded to higher value products (Dieu, 2003).

2.4.3 Industrial Ecology Approach

Industrial Ecosystem

Industrial ecosystem is a model to study the applications of industrial ecology to industry development. The system boundary of an industrial ecology is set up before analysis. Industrial ecosystem is an emerging framework for evaluating industrial activities in terms of their environmental aspects (Chiu and Yong, 2004). Industrial ecosystem are the environmental friendly systems for industrial waste recycling, resembling the food chains, food webs and the nutrient recycles in natural environment (liu and Shyng, 1999). Industrial ecosystems are generally considered to be much more environment friendly compared to other end of pipe treatments such as incineration, solidification and landfill.

There are three stages in the evolution of an industrial ecosystem. Type I industrial ecosystem, are characterized by linear, one-way flows of materials and energy where the production, use and disposal of products occur without reuse, or recovery, of energy or material (Figure 2.3). This type can refer as end-of-pipe approach. In Type II industrial ecosystem, some internal reuse/recycle of waste/by-product or energy occurs, but there is still a need for virgin material input, and wastes continue to be generated and disposed outside the economic system. Type II is refer as current pollution prevention that waste/by-product from production process can be reuse/recycle within production step and result in reduction of resource consumption. Hypothetical Type III industrial ecosystem would be characterized by completes internal cycling of materials. A mix of Type I and Type II material flows can characterize current industrial ecosystem. The Type III industrial ecosystem model, material is highly conserved, no waste material is released, and heat escapes It is keeping with the limiting goal of the "zero discharge" adopted by several major companies (Allenby and Richards, 1994).

Major Components of Industrial Ecosystem

The four major components of an industrial ecosystem are primary materials and energy producers, materials processing and manufacturing sector, waste processing sector and consumer sector (Figure 2.4). The primary material and energy producers may consist of one or several enterprises providing the basic materials that sustain the industrial ecosystem. Manufacturers and processors acquire raw materials and energy from the primary producers/suppliers. Throughout the various steps of extraction, refining, processing, separation and finishing, virgin materials are converted into finished materials and energy and wastes may be generated. This sector shows several opportunities for recycling such as process recycled steams or external recycled steams. Products can be used by other industries or sold to consumers. Industry and consumers return wastes and by-products to the production system through recycling, thus closing the loop on the product life cycle. At all stages of the cycle, energy and materials are lost to the system, due to inefficiencies in resource/ product conversion processes (Roberts, 2004).

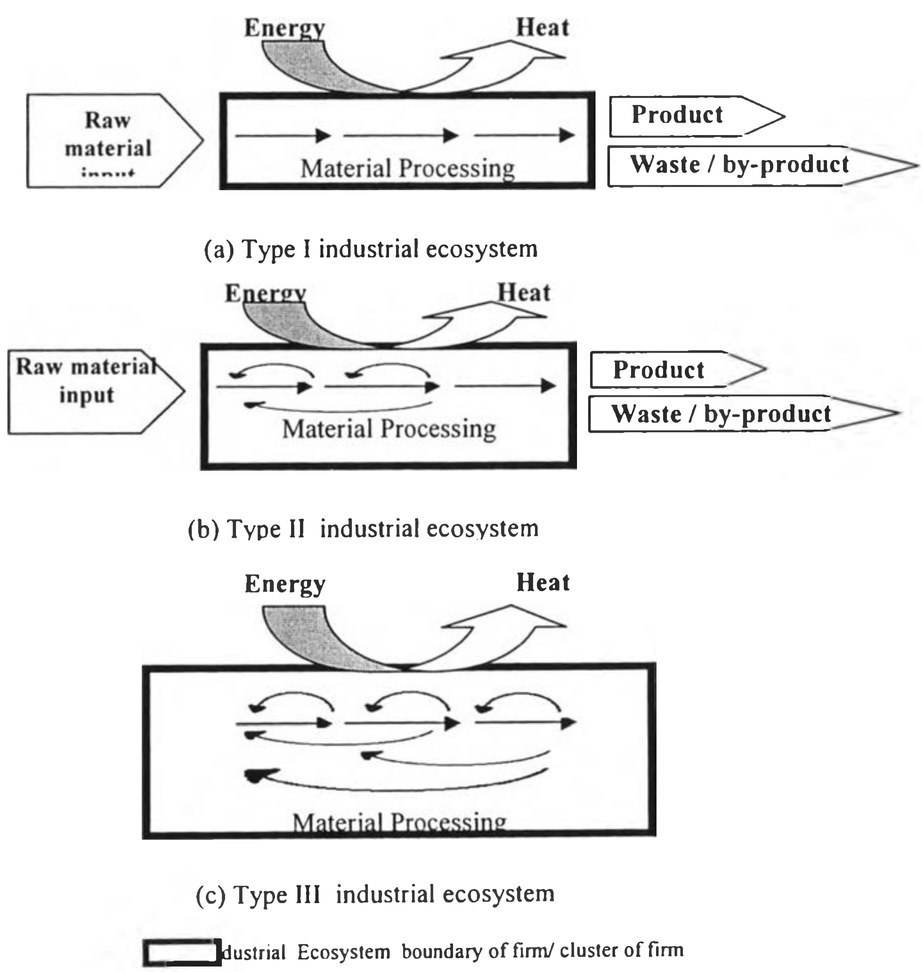

Figure 2.3 Type of industrial ecosystem (Adapted from Allenby and Richards,1994).

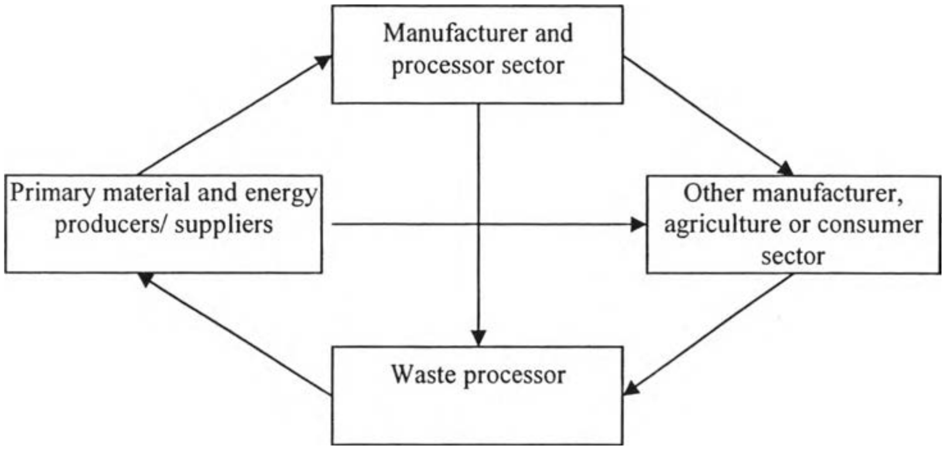

Figure 2.4 The major components of an industrial ecosystem (Adapted from Graedal and Allenby,1995).

Types of Industrial Ecosystem

To study the current state of an industrial ecosystem, we have to identify the scope of system boundary and industrial metabolism in order to achieve the goals for the optimized use of materials and energy in an industrial ecosystem. To analyze the environment burdens of an industrial ecosystem, the scope of evaluation has to be limited: What materials, processes, or products are to be considered. Also the resources that can be applied to the analysis should be scoped.

Chao (1999) reported that four types of industrial ecosystems are envisaged :

- "In- plant ecosystem: In-plant reuse, recycle, waste minimization.
- Ex- plant ecosystem: Joint recycling of wastes among different plants in the same type of industry.
- Cross-industry ecosystem: Joint recycling of waste s among different industry, Eco-industrial park.
- Cross-border ecosystem: Joint recycling of waste s among the industrial sector and other sectors such as agricultural and mining."

Baas and Boons (2004) argued that there are three such boundaries: the sector of industry, the product chain or in network, and the regional industrial system. Robert (2004) concludes that Industrial ecology can be applied to eco-industry development at three levels. The boundaries can be defined at micro-level (firms), meso level (eco-industrial parks), and macro-level (regional and wider global networks of manufacturing activity centers.

Firm level. Applying industrial ecology at factory level can achieve operational savings such as; supplement energy and raw material demand and reduce cost of waste disposal.

Eco-industrial parks. Industrial ecology works best where there is a strong agglomeration or clustering of firms that have the capacity to utilize waste as a resource in production (Roberts, 2004). The concept of "eco-industrial parks", that originated in the early 1990s, are areas where factories cooperate to make the most of resource use, namely through mutual recovery of the waste they generate or waste generated by one firm can be used as material by another (Erkman and Ramaswamy, 2001). Such firm in eco-industrial park can reduce operational costs for companies sharing common suppliers and services and at the same time reduce the collection and disposal cost. Firms can reprocess waste material or sell it to firms in an eco-industrial park who can use these waste as raw material or make use of recycled water or energy. In the Developing Countries in Asia, the application of industrial ecology is common in industrial estates. The terms applied have included eco-industrial development, eco-industrial Park or industrial symbiosis (Chiu and Yong, 2004). In principle, the eco-industrial park concept takes a systems approach, trying to optimize the industrial metabolism of a group of companies found in industrial estates, hence decreasing their environmental impact (Martin et al., 2004). The major difference between eco-industrial park and traditional industrial estates is the integration of an environmental and social agenda into the economic structure (Roberts, 2004).

Regional level. The third model, networked eco-industrial park system (NEIPS), emerges where industries seek opportunities for alliances and partnership to encourage the development of synergies though network as well as spatial association. NEIPS are not just a waste exchange system or market. They can be designed to encourage synergies between industries that deal in waste (Robert, 2004). . However the results of completed and ongoing research projects in Germany's Rhine-Neckar region indicate that larger regional areas may be more suitable for closing material loops and creating sustainable industrial ecosystem (Steerr and Ott, 2004). For regional industrial systems, Baas and Boons (2004) concluded that they often consist of actors that are not automatically dependent on one another for their activities (in contrast with a product chain, where, i.e. suppliers and producers have such a dependency relation). There is usually a geographical separation between the production system and the actors that consume the products. This makes it difficult to make a regional system more sustainable as compared to a product chain.

2.4.4 Industrial Waste Exchange

Similar to the food chain processes of natural ecosystems, networks of resource and waste use in industrial systems have to created so that almost all the residues become resources for other enterprises (through eco-industrial network) (Erkman and Ramaswamy, 2001). A major component of the industrial ecology concept is to design and develop efficient technologies and networks for recycling and reusing waste materials, in order to minimize or even eliminate the extraction of virgin materials. One opportunity for such improved performance is in industrial waste exchanges, where collections of companies achieve materials and energy efficiency through the reuse of by-product (Malaviya, 2002). The waste exchange process connects waste generators with waste reusers and recyclers. The benefits of waste exchanges include: reduce disposal costs, reduce demand of natural resources, and reduce disposal quantities and a potential increase in a value of waste (US EPA, 1994).

Although closing material loops by reusing and recycling wastes is a major part of industrial ecology, formal waste exchange services have been established in order to conserve resources and equipment. The first waste exchange service was established in

Britain in 1942 (US EPA, 1994). Many North America and European nations' states and provinces have established formal waste exchange services. The numbers of waste exchange services appeared to be expanding rapidly in North America. In 1999, there are more than 70 formal waste exchange services operating in major urban centers in North America. However, its popularity is declining due to a lack of funding from governments, low levels of marketing by waste exchange facilitators, and already-established industrial networks that no longer require participation in a waste exchange.

Asian countries have been informally exchanging wastes for centuries. Three Southeast Asian countries: the Philippine, Taiwan and Indonesia, are currently operating the formalized waste exchanges. A major question is how the industrial ecology concept and waste exchanges can be successfully applied to Thailand. Which is the way and the conditions necessary for it.

2.4.5 Industrial Ecology Potential in Thailand.

In north America and Europe, there exit several eco-industrial development projects and many of their outputs are quite promising. The applications of industrial ecology in the industrial estates are evidence in Asia Pacific. Most of them were introduced and partnered with international organizations, such as the United Nations Development Programme (UNDP) PRIME project in the Philippines, UNEP project in China, Deutsche Gegellschaft fur Technische Zusammenarbeit (GTZ) involvement in Thailand. All these projects have comprehensive benefits, but there are still many barriers and difficulties. Chiu and Yong (2004) argue that unlike the usual way of applying industrial ecology as a technical tool, the Asian Developing Countries (ACDs) need to adopt industrial ecology as a strategic vision and a strategic approach to plan the economic, social and ecological development of their national economies. It can be possible for the ACDs to avoid the same problems that occur when the developed countries experienced industrialization and move toward more sustainable development.

In Thailand, the concept of eco-industrial park is new and is being considered by the national government as a way of achieving more sustainable industrial development. It has embraced industrial ecology as a potential approach to economic development. Industrial Estate Authority of Thailand (IEAT) with technical supported by GTZ, applies, the industrial ecology concept in some industrial estates such as; Estate Authority of Thailand at Map Tha Phut, Lampoon, Bang Poo, and Amata Nakorn. For firms level, industrial ecology is a concept that is misunderstood and treated with suspicion. This study is to investigate the application of clean technology and industrial ecology concept to ensure more sustainable industry development in Thailand and to find out how to apply industrial ecology at the factory level.

2.4.6. Strengths and Weaknesses of Industrial Ecology Approach

Strengths. The industrial ecology is a concept dealing with many linkage between production and consumption processes are grouped. Its concept certainly follows the principle goals of environmental protection; i.e. first to reduce/avoid, followed by recycling and if otherwise not possible, treatment and disposal of the waste in an environmental friendly manner (Wilderer and Huber, 2004). Olderburg and Geiser (1997) argue that industrial ecology achieve the optimize resource flows rather than just preventing pollution and to promote sustainability rather than only reduce risk. The eco-industrial park concept promises to overcome a number of barriers of industrial pollution prevention, especially for problems relating to human factors. It has the potential to improve the sustainability of manufacturing by minimizing waste and converting by-product into reusable products or resource. It even appears to help stimulate economic growth, making the idea of industrial estates attractive for economic development (Allenby,1999; Erkman,1997; Wilder,2002). The principles of industrial ecology application to improve total environmental quality, while satisfying the economic demands of industry, in a win-win situation are (Roberts, 2004) :

- "Promote opportunities to establish genuine partnerships and engagement with communities and government in developing a more responsive attitude to sustainable industry practices;
- Co-locate industries that will benefit economically from the trade or exchange of waste and by-products;
- Capture and create opportunities to add value by applying waste and energy recovery practices in industrial systems;
- Provide a catalyst to create synergies and an environment for fostering technological advancement in cleaner production, waste management and sustainable industry development;
- Support industry policies and incentives to encourage innovation, collabolation and commercialization of new and improved product developments using materials water and energy surplus to production.

Weakness. The planning of eco-industrial parks tends to be more specialized and have higher levels of capital investment in infrastructure designed to support cleaner production and reduce environmental waste (Roberts, 2004). Chiu and Yong (2004) overviews the industrial ecology potential in Asian Developing Countries and conclude that only a very few initiatives have done beyond material flows; for example, such question as the management and organizational arrangements for inter- organizational and network management platforms and systems or the planning of community and stakeholder participation have been given very little attention, because focus has mainly been on the physical flows of matter and energy. Bass(1998) state that the major weakness of these approaches are: (1) they do not address issues of co-ordination (mechanism) within and between organisms and (2) almost ignore the institution structures within which the organizations operate. According to Van Koppen and Mol(2001), 'If we want to bring IE perspectives from the design table more into practice, it seems essential to further develop an actor and socio-institutional perspective of these kind of industrial transformation'. This gap can be filled by EMT as discussed in the next section. Weakness of the preconditions of IE in Asian Developing Countries is classify to (Chiu and Yong, 2004) :

- "Lack of complete understanding of eco-industrial development.
- Lack of funding and subsidies to promote IE education and information dissertation.
- Lack of a mindset to promote proactive utilization of IE as a strategic capability-building tool for national development.
- Lack of good governance, capability and transparency in the implementation of rules and regulations in many developing economics.
- Lack of proper technology and know-how.

- Insufficient management systems and practices".

2.5 Conclusion

Through the years environmentalism developed from a protest movement to an institutionalized power. The first curative measures of end of pipe treatment are nowadays replaced by systematic methods of reducing the use of raw materials and the generation of waste at the source. Ecological modernization emphasizes environmental reform through new forms and styles of regulation, new partnerships of actors and agencies, innovative technological trajectories and the use of market dynamics. It is about minimizing both resources and waste generation via criteria of ecological rationality. By means of cleaner production it is tried to minimize these streams at the source. Industrial ecology on its turn tries to find an appropriate reuse for the streams and also wide partnerships that further induce non-state actors and institutions in environmental protection reform. The combination of ecological modernization and industrial ecology seems to be promissions approach in handling environmental crisis in Asian Developing Country such as Thailand. But it is legally still a theoretical construct without much practical. To improve the environmental performance of crude palm oil industry in Thailand by applying the ecological modernization and industrial ecology theory, the current situation in the adaptation and adoption of industrial ecology in Thai industry have to be analyzed.