PLANNING AN INDUSTRIAL SYMBIOSIS FOR PORT DICKSON, NEGERI SEMBILAN.

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ABSTRACT:

Despite a growing interest in and awareness of applications of Industrial Ecology (IE), such as Eco-Industrial parks (EIPs) and Industrial Symbiosis, little information is available about the potential economic and environmental benefits of EIPs, the process for successful EIP development, the important regulatory issues surrounding EIPs, or the technologies needed to support them. IE is an interdisciplinary framework for designing and operating industrial systems as living systems interdependent with natural systems. It seeks to balance environmental and economic performance within emerging understanding of local and global ecological constraints. Some of its developers have called it "the science of sustainability". IE supports coordination of design over the life cycle of products and processes. It enables creation of short-term innovations with awareness of their long-term impacts. IE helps companies become more competitive by improving their environmental performance and strategic planning. IE helps communities develop and maintain a sound industrial base and infrastructure without sacrificing the quality of their environment. It also helps government agencies design policies and regulations that improve environmental protection while building business competitiveness. IE principles and methods can be used by service as well as manufacturing companies. Application of IE will improve the planning and performance of government operations, including local, regional, and national levels of infrastructure. The Industrial Symbiosis at Kalundborg, Denmark can be described as one of the favorite cases presented by industrial ecologists showing the story of the spontaneous but slow evolution of the "industrial symbiosis" at Kalundborg, Denmark. Originally, the motivation behind most of the exchanges was to reduce costs by seeking income-producing uses for "waste" products. Gradually, the managers and town residents realized they were generating environmental benefits as well, through their transactions. It is hoped that this practical model can be modified and adopted by the Malaysian planners who are currently aware of the imbalance between the rapid industrial development and environmental conservation. With the right spirits of all the participating parties this model can be realized and made to happened, and putting the Malaysian Industrial Development on the right track towards achieving a better future for our generations to come. This paper wish to highlight the planning and implementation concept of Eco-Industrial Parks with special reference to the Industrial Symbiosis Model in Kalundborg Industrial Park, Denmark and try to build the same model for Port Dickson. It is hoped that the concept can be promoted and applied in designing and planning the ecological friendly industrial parks in Malaysia.

KEY WORDS: Industrial Ecology, Eco-Industrial Park, Industrial Symbiosis, waste products, sustainable development, pollution prevention, regulatory processes, environmental technologies, Design Principles, zero emissions , sustainable communities, material exchange.

ABSTRAK

Disebalik keghairahan masyarakat terhadap penggunaan konsep Ekologi Perindustrian (EP), seperti pembangunan Taman Perindstrian Ekologi (TPE) dan Simbiosis Industri (SI), masih terdapat terlalu sedikit maklumat berhubung dengan faedah ekonomi serta alam sekitar, proses pembangunan TPE, kerangka undang-undang berhubung dengan TPE dan juga keperluan teknologi yang dapat membantu pembangunan TPE. EP merupakan satu konsep perancangan multi-disiplin bertujuan untuk mencorak dan melaksanakan sistem perindustrian sama seperti sistem hayat yang saling bergantungan dengan sistem alam semulajadi. Ia cuba mengimbangkan perlakuan persekitaran dan pencapaian perekonomian sambil menghayati kewujudaan kekangan persekitaran tempatan dan juga global. Setengah pihak mengtakrifkannya sebagai 'sains pembangunan mapan'. EP menyokong penyelarasan corak kitar hidup produk dan proses-prosesnya. Ia membolehkan penciptaan innovasi jangka pendek dengan kesedaran impak jangka panjang. Melalui pembaharuan pelaksanaan dan perancangan strategi, EP membantu syarikat-syarikat menjadi lebih kompetitif dan berdaya saing. Ia juga membantu komuniti membentuk dan mengekalkan asas perindustrian serta infrastruktur yang baik tanpa mengurangkan kualiti alam sekitar. EP juga membantu agensi kerajaan mencorak polisi dan peraturan untuk melindungi alam sekitar sambil meningkatkan persaingan perniagaan. Pada hakikatnya, kaedah pelaksanaan dan prinsip EP boleh dimanfaatkan samaada untuk sektor perkhidmatan ataupun sektor pembuatan. Pelaksanaan EP membolehkan pihak kerajaan mempertingkatkan tahap perancangan dan pelaksanaan diperingkat tempatan, kebangsaan dan juga serantau. Pelaksanaan Simbiosis Industri di Kalundborg, Denmark adalah merupakan satu contoh popular yang menggambarkan satu keadaan evolusi simbiosis industri yang spontan tetapi mengambil masa yang lama untuk direalisasikan. Ianya bermula dengan kesedaran terhadap aspek pengurangan kos melalui program perolehan pendapatan dengan penjualan bahan buangan. Selanjutnya ia memperlihatkan keupayaannya menghasilkan keadaan persekitaran yang baik. Adalah menjadi sesuatu idaman, jika Model Kalundborg yang praktikal ini dapat dikaji, diubahsuai dan seterusnya dilaksanakan di Malaysia oleh pihak tertentu yang rata-rata begitu prihatin terhadap keseimbangan diantara pembangunan perindustrian dan pemeliharaan persekitaran. Kertas ini ingin menonjolkan konsep perancangan dan pelaksanaan Taman Perindustrian Ekologi secara am dan Model Simbiosis Industri yang dipraktikkan di Kawasan Perindustrian Kalundborg, Denmark, dan cuba menyesuaikan pelaksanaannya di Port Dickson. Diharapkan agar model ini dapat diselaras dan dipromosi untuk tujuan pelaksanaan taman perindustrian yang mesra alam di Malaysia.

KATA KUNCI: Ekologi Perindustrian, Taman Perindustrian Ekologi, Simbiosis Industri, Bahan Buangan, Pembangunan Mapan, Pencegahan Pencemaran, Proses Kawalatur, Teknologi Persekitaran, Prinsip Perancangan, Emisi Sifar, Masyarakat Mapan, Pertukaran Bahan.

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LIST OF ABBREVIATIONS

CFCs	Chloroflurocarbon
CM	Cubic Meter
CO2	Carbon Dioxide
DOE	Department of Environment
ECP	Electrochlorination Plant
EIPs	Eco- Industrial Parks
EQA	Environmental Quality Act
GDP	Gross Domestic Product
GJ	Giga Joules
IE	Industrial Ecology
JBA	Jabatan Bekalan Air
KG	Kilogram
KLIA	Kuala Lumpur International Airport
LPG	Liquid Petroleum Gas
m/Ton/year	Metric Ton per Year
NGO's	Non Governmental Organization
N.A	Not Available
P.D	Port Dickson
ROA	Return On Asset
SEDC	State Economic Development Corporation
STP	Sludge Treatment Plant

1.0 INTRODUCTION:

The release of the World Conservation Strategy in 1980, "Our Common Future", the report of the World Commission On Environment and Development in 1987, Agenda 21 in 1992 and the Montreal Protocol has resulted in gradual acceptance that sustainability must integrate ecological integrity, economic efficiency and social equity. Much of the effort of government and industry since 1987 has emphasized the linkage between economy and environment with much less attention being paid to the social or community dimension of sustainability. Since industry is a human creation and humans are social animals, we need an approach which brings industry and environment together with a social or community perspective.

Ecology is the study of the interrelationships of among species and between species and their physical-chemical environments. Key features of ecology are the habitats on which species depend, communities described as a grouping of species occurring in a particular area and ecosystems which are spatially defined assemblages of species, communities and physical and chemical components interacting to form a more or less stable system. What is significant about the three features of ecological systems is that they emphasize interaction and interdependence. The stability of an ecosystem depends to a large degree on the interconnectedness of the species within the system. These connections expand as the system matures. Humans are part of and interact with other species in ecosystems as well as influencing the physical and chemical character of the ecosystems.

In contrast, industrial systems have tended to emphasize the independence and competitiveness of enterprises. Yet companies are embedded in chains or webs of suppliers and customers, similar to those chains and webs which occur in indigenous or natural ecosystems. In addition, industries are dependent on resources available in the environment to ensure their productivity. These include the land on which the facility is constructed, the building materials, the hydrocarbons for their energy supply, the water which may be required for processing or cooling and air used by both workers and process equipment. In other words, individual companies and corporations are parts of systems. They are dependent on others and must cooperate with them to survive.

In this sense, we can discuss whether industrial ecosystems are simply analogies of natural ecosystems and investigated with that in mind or, the metabolism of industrial production and consumption systems are firmly embedded in the biosphere and industrial ecosystems are simply another form of ecosystem with humans as the dominant species. Industrial parks or estates, of which there are several types, have been suggested as one grouping of ecosystems.

Despite a growing interest in and awareness of applications of Industrial Ecology (IE), such as Eco-Industrial Parks (EIPs), little information is available about the potential economic and environmental benefits of EIPs, the process for successful EIP development, the important regulatory issues surrounding EIPs, or the technologies needed to support them. The dynamics of IE is in the system and implementing concepts whereby industrial development is perceived and viewed not in isolation from its surrounding system, but in concert with them (T.E.Graedel & B.R.Allenby, 1995). Generally, the IE takes it lead from our natural world, where we find a range of living systems which are in various stages of development in term of their efficiencies which can be summarized in **Figure 1**. EIPs can exist within defined boundaries and broader industrial ecosystems in a region. These communities consciously collaborate to enhance their economic performance through improved environmental performance. Their design is based, in part, on an understanding of the dynamics of natural systems and includes features such as conversion of wastes into valuable inputs, co-generation of energy, shared environmental infrastructure, and the minimization of material throughput.

As for Malaysia, development in industrial estates/parks continued to be an important activity in efforts to attract investment. This development was done by either Government, through its State Economic Development Corporation (SEDCs) or the private sectors headed by The Malaysian Industrial Estate Sdn. Bhd. In all the said developments, environmental factors were supposed to be observed fully whether in the development stage of the estates or the post implementation where factories were already in production. Legal frameworks and Laws have been introduced to curb any environmental degradation resulting from the activities in the estates. To our understanding, there is no specific area or industrial estates that have been either termed or pronounced as Eco-Industrial Park.

2.0 BACKGROUND OF INDUSTRIAL POLLUTION

2.1 Environmental Impact from Industrial Activities

Industrial activities have been seen as a major source of environmental degradation and have posed numerous environmental hazards to the community surrounding the industrial premises. The environmental impacts derived from the industrial activities inside the industrial sites are usually

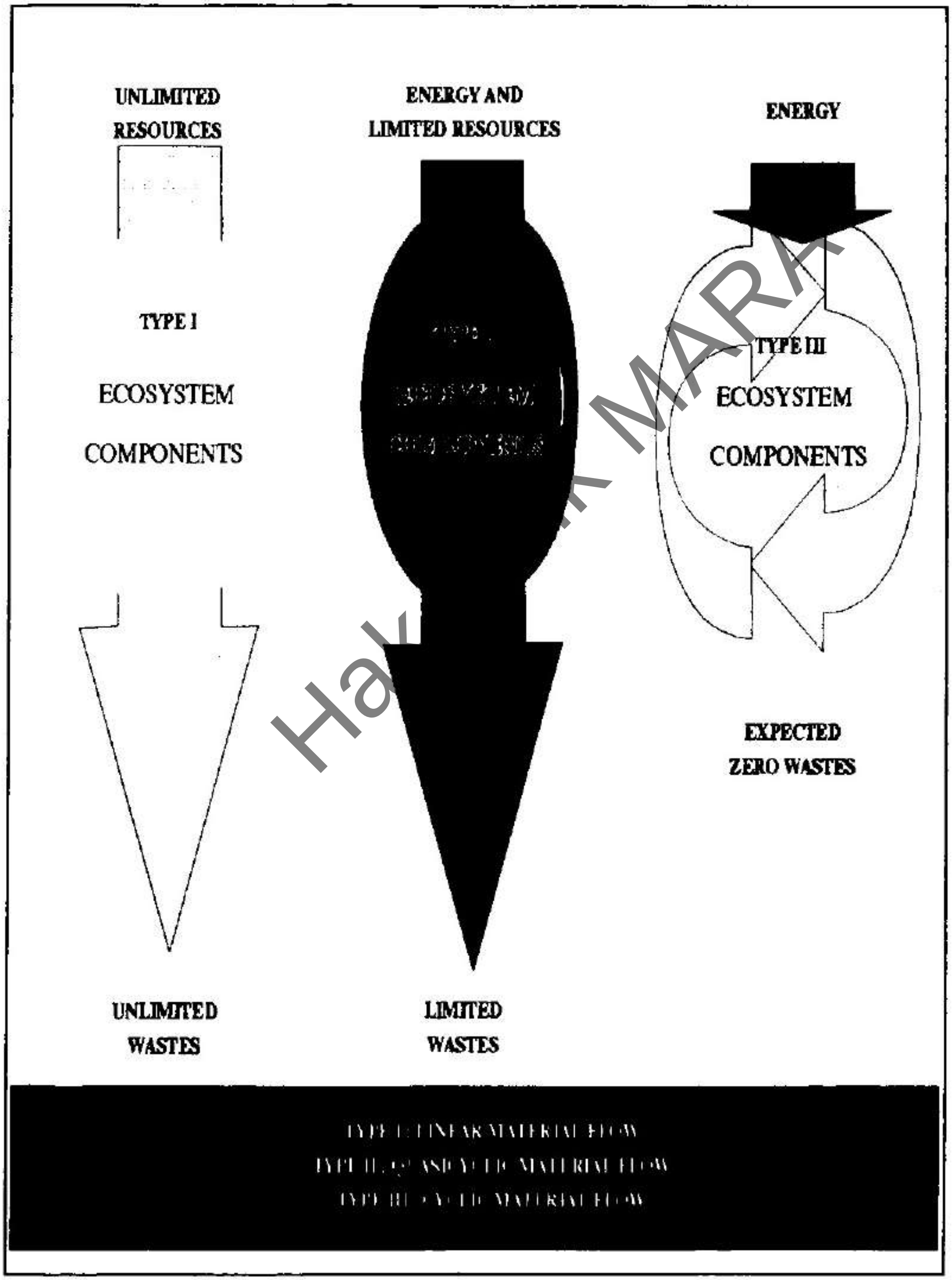


Figure 1: Industrial Ecology

inter-linked and require response actions that are also integrated. The most of the information gathered denounced that combustion of energy and affluent have much greater impact on the environment. **Figure 2** shows the industrial combustion flows and residuals.

2.1.1 Air pollution:

Industrial activities – in particular energy generation and use, and transport – release greenhouse gases closely associated with climate change into the atmosphere. Other air emissions such as heavy metals, dioxins, ground level ozone, dust and particulate, and other organic compounds also lead to a multitude of local and regional environmental and health impacts. However, the damage to ecosystems due to past emissions appears to be more long-lasting than originally believed. In industrializing countries, where acidifying gas emissions are increasing, acid rain is emerging as a serious environmental problem. Acid deposition levels are particularly high in industrial areas of Asia such as South-East China, North-East India, Thailand and South Korea. An estimated 38 million metric tones of sulfur dioxide were emitted in 22 Asian countries in 1990, over 50 percent more than in North America (UNEP 1998)

2.1.2 Water pollution and consumption:

Industrial activity consumes considerable quantities of water and generates polluted waste water. Globally, industrial water use is estimated to be at least twice domestic use. In addition, vast quantities of water are used by power stations as cooling water. Water used in industrial processes is often returned contaminated to its original source. This seriously degrades the water quality of many rivers, lakes and ground water sources, effectively decreasing the supply of fresh water.

Water supply is also increasingly constrained by land-use changes resulting, for example, from industrial expansion and forest clearance which tend to increase run-off and reduce water availability. It has been estimated that world-wide, water use cannot rise to match projected demand without a substantial increase in available supply and much more efficient use of the existing supply and major efforts to prevent pollution.

Industrial waste water varies considerably in the type of contaminant it contains and therefore can result in a multitude of environmental impacts. Some emissions to water such as heavy metals and

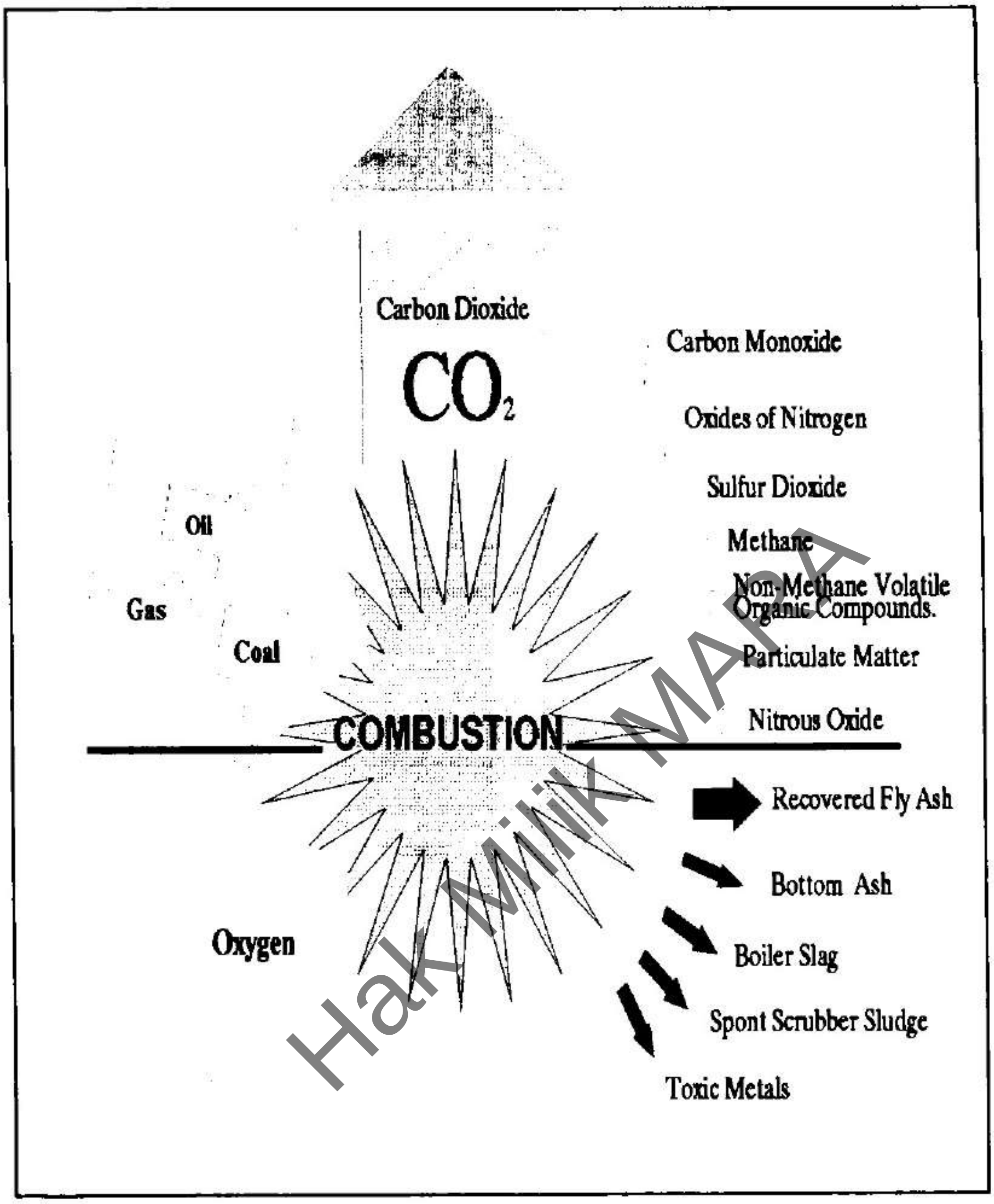


Figure 2: Industrial Combustion Flows and Residuals

(Source: Own Visualization)

near the source of discharge. Ground water and often coastal zones can also be highly contaminated with pesticides and fertilizers from agricultural run-off.

2.1.3 Soil contamination & land use :

Land use for industrial purposes can disrupt eco-sensitive environments thus contributing to land degradation, desertification and ultimately the global loss of bio diversity.

Industrial discharges of contaminants into soil/land from accidental spillage or leakage of chemicals at manufacturing or storage sites, and the disposal of wastes can result in site contamination. In many developing countries, household waste is disposed of along with industrial waste, exacerbating pollution problems. In many cities, only 30 to 50 per cent of solid waste is collected; the rest is either burned or dumped in unregulated landfills. Diffuse contamination from the indirect transfer of contaminants to soils, such as lead fall-out from car exhaust fumes, can contaminate large areas. Soil acidification is a larger scale example caused by the deposition of sulfur dioxide and other acidic chemicals emitted to the atmosphere.

Very few countries monitor soil contamination and land use as they do air or water pollution. Almost no international comparisons of land contamination exist. In the Netherlands, it is thought that 20 per cent of former and present industrial sites are seriously contaminated. The most important single category of contaminated land is waste dumps.

2.1.4 Waste:

Industrial wastes encompass a wide range of materials of varying environmental toxicity. The composition of industrial waste is complex and often changing which makes the collection of reliable data difficult.

The capacity of industrial waste treatment facilities in nearly all counties is insufficient to meet the need. Open dumping and uncontrolled land filling remain the main disposal methods for waste in many developing countries which can result in the contamination of ground water.

For example in Latin America, the quantity of heavy metals, synthetic chemical and other hazardous wastes seeping into ground water from waste dumps appears to be doubling every 15 years according to World Bank figures. Where waste treatment and disposal facilities do exist, they may lead to other forms of pollution. Incineration of waste, when inadequately controlled, can cause atmospheric pollution. Improperly managed landfill operations can lead to leachate leaking and produce emissions of methane and CO2 (UNEP, 1998) In Malaysia as reported in the Environmental Quality Report 1997, a total of 5290 enforcement visits relating to industrial effluent discharges of non-prescribed premises were carried out, of which 4402 (83.2%) were found to have complied with the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979. Industrial compliance with the Environmental Quality (Clean Air) Regulations, 1978 was generally satisfactory, except for the non-metallic mineral and rubber-based industries as well as quarries; of the total 7660 sources investigated, 6813 (89%) were found to have complied 90 applications were received for contravention license under Section 22(1) and 25(1) of the Act to emit air pollutants and discharging effluents exceeding stipulated standards. The applications for contravening Section 22(1) decreased from 14 in 1996 to 12 in 1997 and for Section 25(1) increased from 40 in 1996 to 78 in 1997.

2.1.5 Bio diversity:

Large industrial developments can damage habitat and species diversity by changing the surrounding ecosystem. Such changes include soil erosion, changes in vegetation cover, and disturbances by noise and extraneous light. The combined loss of area (quantity) and of ecosystem quality can lead to considerable declines in the distribution or population numbers of many plant and animal species.

Bio diversity and species diversity are of value to industry as they provide a host of wild and domestic plant, fish, and animal products for use in the manufacture of medicines, cosmetics, industrial products, fuel and building materials, and food. However, many of the World's species are gravely threatened in large part due to industrial activities in particular mining, oil exploration and exploitation, tourism, and forest practices.

2.1.6 Environmental contaminants:

The number of chemicals in circulation has multiplied dramatically with technological progress and rising consumer demand for new products and services. The risks associated with the ever growing number of synthetic chemicals used in industry are difficult to assess because only about 20 percent have ever been tested for their carcinogenic, neuron- toxic, immune-toxic or other toxic potential.

Most chemicals that are produced eventually escape into the environment and may pose serious long term risks to human health and animal reproductive systems. A few notable examples include persistent organic compounds, organochlorine pesticides, heavy metals (eg. from tetra ethyl lead) and ozone depleting substances (CFC's, Halons etc).

2.2 Background of Industrial Pollution In Malaysia

2.2.1 General Observation

Although Malaysia has its share of environmental problems from mining and timbering, industrial pollution receives increasing attention. Rapid industrial growth has contributed in the rising levels of air pollution from increases in total suspended particulate are one problem; overall deterioration of river water quality is another (Malaysia DOE, 1997). Sewage and animal wastes are the largest contributors of organic water pollution, the Government of Malaysia estimates the following breakdown of industrial polluters: food processing (40 percent), rubber and palm oil industries (35 percent), industrial chemicals and electronics (12 percent), and textiles (9 percent).

The major industrial sources of water pollution are concentrated on the west coast of Peninsular Malaysia, with nearly 50 percent of the major sources found in the states of Selangor, Johor, and Penang. Trends in manufacturing in Malaysia strongly suggest that hazardous waste will become the principal industrial pollution problem in coming years(Malaysia DOE, 1997).

Very good examples of the industrial zones that are currently facing pollution problem are Shah Alam Industrial Area in the state of Selangor , Bayan Lepas Free Trade Zone and Prai Industrial Estate in Penang Pasir Gudang Industrial Estate and Senai Industrial Estate , Johore .

Industrialization has also lead to pollute the rivers of Malaysia . Many of her rivers have become polluted due to the many wastes that have been poured out into her rivers. Such as the paper making industry, it requires chemicals, often poisonous in its production. The rivers are used as an outlet for the chemicals to drain away, in turn harming the waters and the lives that revolve around them. The most talk about rivers that have been severely affected by pollution from industrial activities are:

i. **Sungai Juru in Penang**
ii. **Sungai Pinang in Penang**
iii. **Sungai Prai , Penang**
iv. **Sungai Pasir Gudang , Johore**

v. Sungai Gombak in Selangor

vi. Sungai Sepang in Selangor

According to the Environment Quality Report 1997, the number of clean rivers decreased from 42 in 1996 to 24 rivers in 1997 and the number of polluted rivers increased from 13 in 1996 to 25 in 1997, in terms of water quality index classification based on biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, ammoniacal nitrogen, suspended solids and pH.(Malaysia DOE , 1997)

2.2.2 Environmental Policies and Laws

Malaysia's environmental regime was established under the Environmental Quality Act (EQA) of 1974, which contains enabling provisions for air, noise, and water pollution; degradation of land; and oil pollution. Fifteen regulations have been enacted under EQA, the latest intended to address growing environmental threats from hazardous waste. Several amendments proposed for EQA were implemented in 1995 to empower enforcement activities, including an increase in prison terms and fines, stricter emission standards, auditing requirements, and power to close down polluting factories. The government also recently completed guidelines for the management and disposal of petroleum wastes, zoning and site regulations, and burning of timber. DOE continues to seek ways to improve its monitoring of compliance with its ambient air and water quality and effluent and emissions control standards.

Besides the EQA, there are other legislative framework pertaining to the development of industrial estates/parks in Malaysia. They are:

i. Legal Framework related to Planning and Land Use

National Land Code 1965 (Act No. 56)
Land Ordinance 1956 (Sabah)
Land Code 1957 (Sarawak)
Local Government Act 1976 (Act No. 171)
Land Acquisition Act 1960 (Act No. 486), revised 1992
Land Development Act 1956 (Act No. 474), revised 1991
Land Conservation Act 1960 (Act No. 385), revised 1989
Town and Country Planning Act 1976 (Act No. 172), amended
Municipal and Town Boards (Amendment Act 1975 (Act No. A289)
Housing Developers (Control and Licensing) Act 1966 (Act No. 118), revised 1973
Federal Territory (Planning) Act 1982 (Act No. 267)
City of Kuala Lumpur (Planning) Act 1973 (Act No. 107)

Geological Survey Act 1974 (Act No. 129)
Land (Group Settlement Areas) Act 1960 (Act No. 530), revised 1994
Sewerage Services Act 1993 (Act No. 508)
Street, Drainage and Building Act 1974 (Act No. 133)
Waters Act 1920 (Act No. 418), revised 1970, 1989
Drainage Works Act 1954 (Act No. 354), revised 1988

ii. **Legal Framework Related to Industrial Development**

Promotion of Investment Act 1986 (Act No. 327)
Malaysian Industrial Development Authority (Incorporation) Act 1965 (Act No. 397), revised 1989
Occupational Safety and Health Act 1994 (Act No. 514)
Factories and Machinery Act 1967 (Act No. 139), revised 1974
Poisons Act 1952 (Act No. 366), revised 1989
Atomic Energy Licensing Act 1984 (Act No. 304)
Industrial Coordination Act 1975 (Act No. 156)

3.0 LITERERATURE REVIEW

3.1 New Paradigm In Planning of an Industrial Park

Industrial activity releases wastes into local, regional, and eventually global ecosystems. Since the industrial revolution, myriad laws and regulations have been promulgated to limit emissions to air and water, and to regulate solid and hazardous waste disposal. Further, industrial activity results in non-point source pollution caused by general runoff, spills, or illegal dumping. Business and the environment have traditionally been consider natural enemies. The assumption has long been "more environmental protection corresponds to higher costs for business;" however, new developments in research and business operations are challenging this assumption.

The next century will give rise to a new kind of industrial development that uses resources dramatically more effectively and refines the manufacturing economy. Current trends in sustainable development and business management are converging on a new model of industrial operation exemplified by the discussion of eco-industrial parks (EIPs)

At its core, an EIP is very simple. It strives simultaneously to increase business success while reducing pollution and waste. Rooted in the emerging discipline of industrial ecology, an EIP mirrors natural systems. As single organisms can be viewed alone or in a larger ecology, single enterprises can organize themselves in more complex business ecology. While referring to EIPs it is far more than a share plot of land. By moving to higher levels of interdependent organization quantum level improvements can be realized in resiliency, flexibility and resource conservation. This pays off for the business and the environment.

Why is the concept so appealing? Inherently the challenge of reconciling the demands for business and environmental excellence is a strong attraction. There are many elements of EIP activity that have already proven themselves. It is common for two companies and even more to develop mutually advantageous relationships where the waste products of one company forms a valued input product for another.

3.2 Definition of Eco-Industrial Park

An industrial park is generally defined as large tract of land, sub-divided and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and close proximity of firms . Types and synonyms of industrial parks include industrial estates, industrial districts, export processing zones, industrial clusters, business parks, office parks, science and research parks, and biotechnology parks. Eco-Industrial Parks have now been added to this list. As in the case of industrial ecology itself, there are several definitions of the term Eco-Industrial Park.

In 1995, Cote and Hall proposed this definition:

> *"An Eco-Industrial Park is an industrial system which conserves natural and economic resources; reduces production, material, energy, insurance and treatments costs and liabilities; improves operating efficiency, quality, worker health and public image; and provides opportunities for income generation from use and sale of wasted materials."*

Yet another definition was put forward by Lowe, Moran and Holmes, (Lowe, Moran, & Holmes 1997)

> *" An Eco-Industrial Park is community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resources 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 realized if it optimized its individual interests."*

At an October 1996 workshop hosted by the United States President's Council on Sustainable Development 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, minimize waste, and build sustainable economic, ecological and social relationships."*

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impact. Components of this approach include new or retrofitted design of park infrastructure and plants; pollution prevention; energy efficiency; and inter-company partnering. (Lowe, Moran, & Holmes 1997)

An EIP is not only an efficient collaboration among co-located industries; it is also an excellent urban neighbor. The emphasis on material, energy and water use efficiency reduces demands on the environment for resources and cuts pollution when compared to a traditional industrial park. While the goals of an EIP include efficient use of resources, the full concept seeks improvement in all aspects of environmental performance.

Some developers and communities have used the term EIP in a relatively loose fashion. Actually most EIP Planners encourage applying this term to developments that are more than

- a single byproduct exchange pattern or network of exchanges;
- a recycling business cluster (e.g., resource recovery, recycling companies);
- a collection of environmental technology companies;
- a collection of companies making "green" products;
- an industrial park designed around a single environmental theme (i.e., a solar energy-driven park);
- a park with environmentally friendly infrastructure or construction; and

- a mixed use development (i.e., industrial, commercial, and residential).

An EIP may include any of those features. But the critical element in defining an EIP is the interactions among its member businesses and between them and their natural environment. EIPs may provide benefits to the companies that participate, to the to the local community, and to the wider community. EIPs also pose some formidable challenges and significant risks.

3.3 Defination of Industrial Symbiosis

In the EIP model of industrial symbiosis, the eco-industrial park is the staging area for inter-firm linkages, and park management is entrusted with playing an organizing and catalyzing role. The analyst / planner function is hard-wired into the EIP; park management is clearly identified as meta to the industrial subsystem of the park. The auto catalytic or evolutionary model of industrial symbiosis development is at the other end of the spectrum. Here participating businesses individually feel evolutionary pressure toward the formation of an industrial ecosystem and enter into bilateral arrangements. The system is self-organizing, but such self-organization relies on a institutional connections among firms.

The system concept is of key importance because industrial symbiosis represents an effort to optimize (or at least increase) the systemic efficiency of material and energy use. This is in contrast to the more limited focus of previous approaches to environmental management on individual firms and processes. Industrial symbiosis is an implicit acknowledgment that larger efficiencies can be realized by also considering potential interactions among disparate industrial units. The notion that expanding the scope of concern to a larger set of industries can yield results that treating them separately cannot is at the core of industrial ecology.

According to Valdemar Christensen [Valdemar Christensen is production manager of Asnæs Power Station in Kalundborg, Denmark] , one of the main architects of the symbiosis at Kalundborg and originator of the phrase, industrial symbiosis is "a cooperation between different industries by which the presence of each...increases the viability of the other(s), and by which the demands [of] society for resource savings and environmental protection are considered (e.i.o.) [Quoted in Holger Engberg, "Industrial Symbiosis in Denmark" Stern School of Business, New York University, 1993.] . The linkages among the local firms (as well as some more distant ones) through which materials and energy are transferred are the sort of loop-closing measures that are called for by an industrial ecology paradigm.

Each of these linkages bears an economic advantage for the participating firms, while reducing the pressure on the environment and on resource stocks. While the participating companies herald the environmental benefits of the symbiosis, it is economics which drives or thwarts its development. From the perspective of public policy, however, the environmental and resource benefits should provide the motivation to create incentives which encourage such cooperation. It is such a systematic increase in the efficiency of materials and energy use which is called for by industrial ecology [The Greening of Industrial Ecosystems Braden Allenby and Deanna Richards, editors. National Academy Press, Washington D.C. 1994]. And while the general public benefits from the symbiosis in the form of reduced environmental loading and better use of resource stock, this public benefit does not have a direct advocate among those managers responsible for bringing it about. Several of the symbiotic linkages developed, however, in response to environmental regulation.

All documented examples of industrial symbiosis to date have evolved in such an auto-catalytic way, but this may simply be due to the fact that until recently no public or private organizations actively encouraged the development of symbiotic linkages among industries.

3.4 Planning Principles of Eco-Industrial Park / Industrial Symbiosis

Eco-industrial parks have been primarily described in the industrial ecology literature as a means of managing material and energy flows with attention to the possibility of particular chemical linkages. Further, environmentalists have been intrigued with the fit as a means for waste minimization. By creating specific connections, solid waste disposal can be reduced while input and transport costs can be lowered both in dollar value and environmental damage. There are possibilities of shared steam systems, beneficial use of toxic wastes and aggregated collection of materials to produce sufficient quantities for use elsewhere. There are difficult issues associated with this approach about timeliness, volume, quality, transport and reliability that need to be worked out. Further, direct pipe to pipe connections are a possible but improbable outcome. In most cases intermediary processes are required that would expand the possible interface between outputs and inputs to meet the issues previously mentioned. Regardless of one's perspective, research is needed on improving the usable connect ability of resources from one source to another. Yet there is an alternative approach to the same set of concerns that looks primarily on the set of organizations as a business relationship.

A second approach appears to believe that organic growth of connections among companies which is facilitated leads to a larger range of connections, greater ownership over the process and higher results over a broader range of measures. Structures and specific material and energy connections emerge from the network of companies becoming an organism and developing its own character. Trusting in a theory of emergent systems optimization, its proponents seem to substitute vision and process for uncertain outcome targets. Other approaches seem to straddle some of these beliefs such as Cornell's approach to seeing maximum probable connection within upstream and downstream materials domain such as organic, metals, energy cascades, etc. Lowe and Warren use the concept of an anchor tenant as a means to help to create a more definable set of possible connections.

Eco-industrial parks also exist within an economic and socio-organizational framework which has a considerable literature and experience of its own. What is often described in chemical metabolism of a healthy organism has its organizational analogue in the business world of resource efficiency. Examples of business process re-engineering are ways to assure that internal processes are aligned in ways that lead to maximum output. In accounting terms, this is expressed as Return on Assets (ROA). ROA is an appropriate measure of EIP performance for several reasons. The primary effect of an EIP on a business has to be asset maximization—the highest possible yield for the least possible set of inputs. Those inputs can be technological, raw materials, capital, labor, energy, transaction, marketing, etc. The chemical/energy ecology is only one of the possible levels of efficiency and should be vigorously pursued especially when it leads to higher productivity or less pollution and toxicity. A complete approach also devises strategies for the other components of business success.

There is a dimension of eco-industrial parks that the fascination with internal efficiencies tends to ignore. The success of an eco-industrial park will not be simply a function of its environmental record but its ability to compete in the marketplace.

3.5 Goals of Eco-Industrial Park

3.5.1 Zero Emission

An overarching goal of IE is the establishment of an industrial system that cycles virtually all of the materials it uses and releases a minimal amount of waste to the environment. Theoretically, the developmental path to such an end state follows an orderly progression from what Allenby and Graedel call Type I, II, and III systems. Type I systems require a high throughput of energy and materials to function and exhibit little or no resource recovery. Type II systems represent a transitional stage where resource recovery becomes more integral to the workings of the system but do not satisfy its requirements for resources. The final stage, the Type III system, cycles all of the material outputs of production, though still relying on external energy inputs (Allenby & Graedel , 1995).

3.5.2 Material Substitution

The goal of minimizing waste may be reached by the leap of using a wholly new material for a purpose rather than refining the processing of an old material. The new material should perform the function longer, be processed less wastefully, or be acquired with less waste. Widespread examples of materials substitution include metals for wood, aluminum for steel, and high carbon steel for other steels, and, more specifically, steel for rayon in tires and plastics for glass in beverage containers. Historically, many of the substitutions have been alloyed blessings, bringing new environmental problems as well as reducing old ones.

3.5.3 Dematerialization

Materials substitution is considered a principal factor in the theory of dematerialization. The theory asserts that as a nation becomes more affluent the mass of materials required to satisfy new or growing economic functions diminishes over time. The complementary concept of decarbonization, or the diminishing mass of carbon released per unit of energy production over time, is both more readily examined and has been amply demonstrated by researchers over the past two decades. For materials in general, several forms of innovation (more efficient recovery of minerals and metals from crude ores, imbuing materials with improved properties per unit mass; and better societal mechanisms for handling and reusing wastes) drive this purported phenomenon. Dematerialization is advantageous only if using less stuff accompanies or at least leaves unchanged lifetime, waste in processing, and waste in acquisition.

3.5.4 The Resource Recovery Industry

An EIP is not only an efficient collaboration among co-located industries, it is also an excellent urban neighbor. The emphasis on material, energy and water use efficiency reduces demands on the environment for resources and cuts pollution when compared to a traditional industrial park.

The resource recovery industry includes reuse, recycling, remanufacturing and composting, as well as the marketing and end-use of reclaimed discarded materials. As a vertical industry it involves a wide range of business activities including collection, sorting, and processing of industrial and biological materials; repair, refurbishing, or dismantling of equipment; and wholesale or retail sales. The unifying concept is that discarded materials, goods, and by-products are turned into salable materials and products.

3.6 Kalundborg Industrial Symbiosis Model

3.6.1 Introduction

The best place to see the principles of industrial ecology and industrial metabolism in practice is Coastal City of Kalundborg, Denmark (**Figure 3**). Here, waste products do not necessarily go to waste. Instead, a number of large industrial enterprises in the area have developed what they now call an ‚industrial symbiosis', a word coined by Valdemar Christensen, operations manager at the nearby Asnæs power station In nature, symbiosis is defined as ‚an association of dissimilar organisms in a mutually beneficial relationship', or simply ‚mutual exploitation'. This is exactly what is going on at Kalundborg. It all began early in the 1970s when the Asnæs power station started supplying steam to Novo Nordisk and the local refinery. Steam used in the production of electricity at the power station is reused by other companies, instead of being cooled to water and discharged into Kalundborg Fiord. It is one of a few spontaneous examples of a form of business interaction known as Industrial Symbiosis. According to Vlademar Christensen, one of the architects of the symbiosis at Kalundborg and originator of the phrase, industrial symbiosis is "a cooperation between different industries by which the presence of each... increases the viability of the other(s), and by which the demands [of] society for resource savings and environmental protection are considered".

The industrial relations at Kalundborg did not develop as a case study in industrial symbiosis, but rather as a business response to economic and environmental forces. The symbiosis developed gradually and without a grand design of the past 25 years, as firms sought to make economic use of their byproducts and to minimize the cost of compliance with new, ever-stricter environmental regulations. The Danish regulatory environment, which emphasizes performance standards rather then technology standards, seems to be a critical factor in the development of many of the linkages that have occurred. The particular interactions are both unique to the participants, and generalizable to numerous other situations. The parties have all benefited economically from the interactions, and overall environmental impacts have been lessened, compared to the same activities done separately. The development chronology can be summarized in **Table 1.**

3.6.2 Description of interactions

The interactions at Kalundborg mainly consist of interactions between five main participants: the Asn-BEs Power Station, a coal-fired power plant, Statoil refinery, Novo Nordisk, a maker of pharmaceuticals and enzymes, Gyproc, a plasterboard manufacturer, and the municipality of Kalundborg. These entities trade or sell various waste streams and energy resources, and turn waste products into industrial raw materials. Asn-BEs power plant significantly increases the overall efficiency of converting coal to energy by selling excess heat to the town for district heating and by heating its own fish farm. The plant also sells steam to Statoil and Novo Nordisk, gypsum from its SO_2 scrubber to Gyproc, and fly ash to construction firms. Statoil refinery sells its flare gas as fuel to Asn-BEs and to Gyproc instead of burning it off, and sends its cooling water to Asn-BEs, thereby reducing the power plant's fresh-water requirements, while selling pure sulfur from its desulfurization plant to a sulfuric acid maker. Novo Nordisk generates a great deal of organic sludge as a process byproduct, which it treats and distributes to local farmers as a fertilizer supplement. Gyproc makes plasterboard by using the power plant's scrubber byproduct and flue gas from the refinery. Graphically , the nature of the relationship between the participating companies and the by products involved can be viewed in **Figure 4**

3.6.3 Motivation for development

The symbiotic links in Kalundborg can be divided into two primary categories. The initial links tended to involve the sale of waste products without significant pretreatment. Asn-BEs' sale of fly ash, clinker, waste heat and process steam, as well as the use of cooling water to heat fish farm ponds fall into this category, as does the sale of Statoil's flue gas.

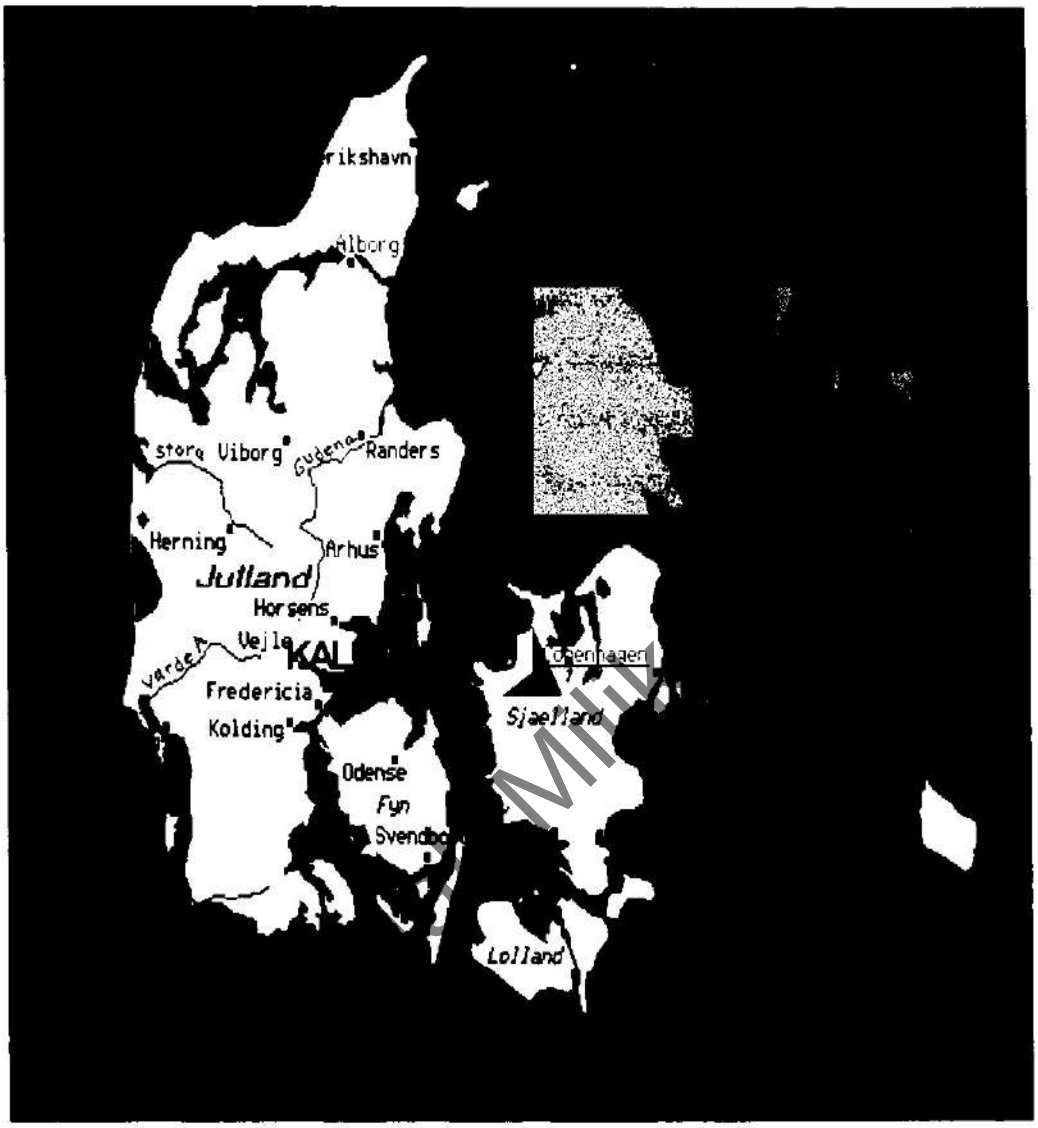


Figure 3 Location of The City of Kalundborg , Denmark

Table 1: Kalundborg Industrial Symbiosis Chronology
[From, Holger Enberg, "Industrial Symbiosis in Denmark"]

1959 Asnæs Power Station commissioned

1961 Statoil Refinery commissioned; water piped from Tissø Lake

1972 Gyproc A/S established; gas is piped from Statoil Refinery

1973 Asnæs Power Station draws water from Tissø Lake through a pipeline after expansion

1976 Novo Nordisk starts delivery of sludge by trucks to farmers

1979 Asnæs Power Station starts to supply fly ash to cement producers, including Aalborg Portland

1981 Asnæs Power Station produces heating for the municipality of Kalundborg

1982 Asnæs delivers process steam to Statoil and Novo Nordisk

1987 Statoil pipes cooling water to the boilers of Asnæs Power Station

1989 Novo Nordisk is hooked up to Tissø Lake for freshwater, replacing groundwater use

1990 Statoil Refinery starts delivery of hot, liquid sulfur to Kemira in Jutland

1991 Statoil delivers treated waste water to Asnæs power plant to meet various water consumption needs (but not for use as boiler feedwater)

1992 Statoil pipes fuel gas to Asnæs Power Station after installing desulfurization plant.

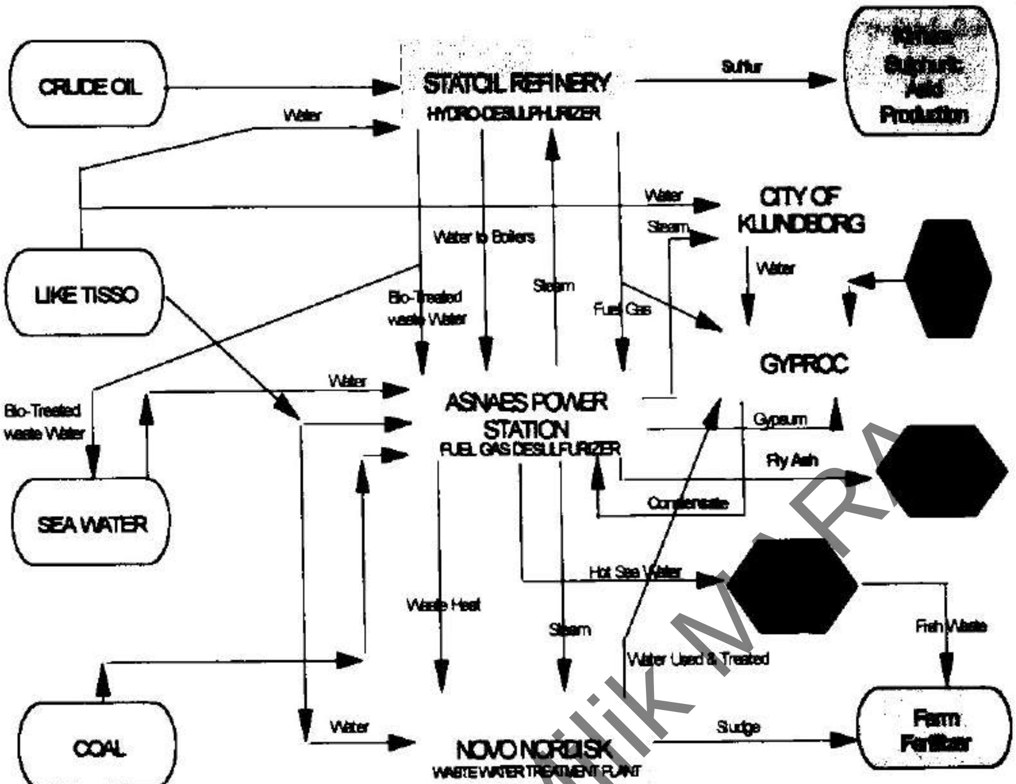
1993 Asnæs supplies gypsum to Gyproc after installing scrubber

Lately however, the links have tended to be dependant on, and are a direct outgrowth of, the application of pollution control technologies. These newer links do not simply move regular process byproducts around, but alter the processes and disposal practices to make them more environmentally benign. The symbiotic relationships that comprise these links are the direct results of and dependent on these pollution control measures.

For example, it was the community and regulatory pressure to eliminate thermal pollution of the fjord, along with general water scarcity, that was a major impetus for the power station's use of the oil refinery's cooling water. Changes in regulations regarding water pollution rendered the treatment and distribution of Novo Nordisk's sludge the least-cost disposal alternative. Scrubbing for SO_2 by the power plant, and desulfurization at the refinery, have conditioned the waste streams so that what used to be pollutants have been turned into flue gas, sulfur, and gypsum. And pressure to alleviate water pollution compelled the refinery to invest in a water treatment facility which now renders the water clean enough to be reused by the power plant.

The stricter environmental regulations have been one of the main driving forces for the more recent linkages. But the Danish approach relies on performance standards, rather than technology standards. As a result, it has allowed local firms to choose pollution control technologies which render their waste streams usable as feed stocks elsewhere, yielding additional benefit beyond pollution reduction. AsnBEs Power Station chose the pollution control technology that allowed them to produce gypsum as a byproduct which they sell to Gyproc, thus reducing AsnBEs' pollution control costs.

In general, the intermediate processors and processes that condition the wastes that are produced by an industrial ecology system are necessary to achieve maximum economic advantage and pollution prevention.



PARTICIPATING COMPANIES

NOVO NORDISK
ASNBES POWER STATION
STATOIL REFINERY
ASNBES FISH FARM
GYPROC
KIMARA ACID PRODUCTION
LOCAL FISH FARMS
ADBORG PORTLAND ROAD COMPANY
KALUNDBORG CITY COUNCIL

Figure 4: Kalundborg Industrial Symbiosis Model.
(Source: Holger Enberg, "Industrial Symbiosis in Denmark", 1995)

3.6.4 Types of linkages

Approximately eleven physical linkages have been established by participants in the Kalundborg industrial symbiosis. There are four types of tangible benefits which have resulted from these symbiotic arrangements:

* **Reduced reliance on resource inputs** - especially water, also coal, oil, gypsum, fertilizer, etc. Inter-firm linkages have reduced the water demand for the four big participants by 20-25% (estimates vary). The most recent assessment by Statoil shows a reduction of water use from 4.8 million cubic meters per year to 3.6 million. A water treatment facility recently completed by Novo Nordisk is expected to make another 900,000 cubic meters available for reuse.

* **Reduction in pollution** - lessened thermal and chemical water pollution, reductions in CO_2 and SO_2 air emissions, greatly reduced pollution or potential contamination from land disposal. CO_2 emissions have been reduced by about 3% (130,000 tons). It is also noted that SO_2 emissions have been reduced by 25,000 tons or 58%. While this is the result of the installation of a scrubber, rather than direct industrial symbiosis, the scrubber byproducts are being used.

* **Increased efficiency of fuel-to-energy conversion** - D0 energy cascades have increased the efficiency of coal burning from 40% to over 90%; refinery flue gas is used instead of burned off. Oil consumption has been reduced by 19,000 tons per year, due to the substitution of power plant heat for municipal heating, and to the use of refinery flue gas instead of oil. Coal consumption is down 2% (30,000 tons) due to the use of refinery flue gas.

* **Beneficial uses of materials formerly treated as waste**. Substantial disposal costs are avoided, and process byproducts are used as inputs elsewhere, avoiding the need for virgin materials. Gyproc, the plasterboard maker, gets about 80,000 tons of gypsum, 2/3 or its yearly requirement, as a byproduct o f the power plant's scrubber. It has also substituted a continuous stream of flue gas from the refinery for oil in its dryers. Other symbiotic relationships have involved the use of 135,000 tons of fly ash, 2800 tons per year of sulfur, 800 tons of nitrogen and 400 tons of phosphorus in the form of bio sludge fertilizer.

3.6.5 Reasons for successful symbiosis in Kalundborg.

There are certain conditions that have allowed the industrial symbiosis at Kalundborg to be successful:

The industries must fit together. Kalundborg is host to four different process industries. Asnbes and Statoil produce energy in the form of heat, steam, and fuel gas, while all participants consume energy in various forms. Linkages such as those at Kalundborg do exist elsewhere, though they are not as developed. For example, it is not uncommon in cold climates to use the excess head produced by power plants for district heating. Novo Nordisk operates a similar plant in North Carolina, which also spreads its sludge as fertilizer. The serendipitous mix of industry outputs and industry needs makes such a highly developed symbiosis possible in Kalundborg, but the potential exists elsewhere as well.

Industries must be geographically close. One of the potential advantages of industrial symbiosis is the savings on transportation costs, though the advantages vary widely, depending on the resources involved. For example, heat and steam are difficult and expensive to transport long distances. The construction of pipelines has been a major infrastructure investment for the firms in Kalundborg, and the larger the distance, the greater the cost.

On the other hand, geographic proximity is not an absolute requirement. Gyproc gets its gypsum from the nearby Asn-BEs power plant, and from a much more distant German power plant. Statoil sells sulfur to Kemira, which is many kilometers from Kalundborg. The Kalundborg example indicates that geographical closeness is very important for sharing energy, and is simply helpful in the transportation of material resources. The mental distance between participants must be short. It has been said that enough monkeys will type the collected works of Shakespeare, given enough time. Yet even though there are clear economic advantages to finding productive, profitable ways to utilize otherwise wasted resources, there are relatively few examples; the Kalundborg site has developed slowly over 25 years. It seems that the lack of the communication and trust that are necessary for these cooperative arrangements to develop, rarely develops spontaneously.

In Kalundborg's instance, the small size and relative isolation have been important elements in creating the symbiosis that has occurred. Looking at the size of the city , Kalundborg is a small society in which managers of the various firms often run into each other, providing opportunities to find out what is happening with their neighboring companies. The fact that the four firms are planted in the same interconnected society in which their employees live makes inter-firm cooperation more readily achievable.

Both cultural and regulatory pressures encourage environmental awareness. The Danish regulatory framework encourages innovative approaches to environmental protection. Firms are required to submit plans to the overseeing county government detailing their efforts to continually reduce their environmental impacts. A cooperative relationship is fostered between government and the regulated industries, and as a result the firms seem to focus their energies on finding creative ways to become more environmentally benign, rather than fighting the regulators. The flexibility afforded the firms for compliance allows the development of the kind of creative arrangements found in Kalundborg. In fact, the Danish Environmental Policy Act apparently goes even farther by attempting to help find uses for all waste streams on a case by case basis. As with the other aspects of this overall approach, necessity has been turned to an advantage.

4.0 METHODOLOGY

4.1 Objective

The objectives of the study can be summarized as below:

1. To Understand the Concept of IE and Industrial Symbiosis.
2. To Apply the Kalundborg Industrial Symbiosis Model for Port Dickson.
3. To Plan a Port Dickson Industrial Symbiosis.

4.2 Significant of the Study.

Drawing on the experience of what is happening in Kalundborg, Denmark, it is timely now to discuss the possibility of accepting the concept of Industrial Symbiosis and be put into action in the local scenario. The Town of Port Dickson, Negeri Sembilan is chosen as the case location for the development of Industrial Symbiosis based on the following rationale:

i. Port Dickson is a Coastal Town
ii. Major Industrial Development Project are either Power Generating or Oil Refineries
iii. Port Dickson is still in the early stage of industrial development
iv. There is greater potential for future development of related industries which can be promoted to comply with the Industrial Symbiosis concept

v. The importance of Industrial Development in Port Dickson contributing major shares in the total state revenues

The proposed Industrial Symbiosis in Port Dickson is to be based on in-situ development rather than a planned Industrial Estate/Park. At the same time, this kind of industrial development will enhance the environmental and social friendly industrial scenario.

4.3 Methodology of Investigation

The methodology used in this project consists of the followings:

a. Literature Review of IE, Industrial Symbiosis and the Kalundborg's Model of Industrial Symbiosis
b. Secondary Baseline Data Collection and Analysis
c. Factory Visit and Discussions
d. Formal Meeting with Related Government Agencies and NGO's
e. Modification and Adaptation of Industrial Symbiosis Model
f. Proposed Industrial Linkages
g. Mitigation and Potential Problem Analysis.

5.0 THE INDUSTRIAL SYMBIOSIS OF PORT DICKSON, N.SEMBILAN

5.1 General Background of the Proposed Project

Port Dickson is one of the districts in Negeri Sembilan, boardering with the District of Rembau on the East, District of Seremban on the North East, State of Malacca on the South and the State of Selangor on the West (**Figure** 5). By the natural location Port Dickson is considered as a Coastal District with 54 kilometers of natural beach. Summary of the baseline data for PortDickson is shown in **Table II.**

5.2 Industrial Development In Port Dickson

Industrial development in Port Dickson showed a specific trend whereby most of the industries attracted to the area are of large scale capital intensive type of industries. In term of revenue contribution, industries in Port Dickson have contributed more than 30% of the state revenue even though the number of industries is only 7.6% of the total industries found in Negeri Sembilan. As for the development of industrial estates, currently there is no specific industrial estates found in Port Dickson. All of the industries are operating on individual land without any central or common industrial facilities. The latest development has shown the implementation of Tanah Merah Industrial Area (1000 ha) and Springhill Industrial Area (459 ha). Under the Port Dickson Structure Plan, more than 1500 hectares have been designated to industrial estate. This is to cater for the expected high demand of industrial land as a result of the development of Kuala Lumpur International Airport (KLIA). The general location of Industrial Estates in Negeri Sembilan and the Proposed Land Use Plan for Port Dickson are shown in **Figure 6**. And **Figure 7** respectively.

Based on 1997 State Economic Planning Report, there are 17 companies are in operation under the industrial status in Port Dickson of which 6 of them are the major industries contributing to the total state GDP. The general information of the said industries are summarized in Table III. It is noted that power generation plants and petroleum refineries are the major players.

5.3 Special Requirements for the Development of Industrial Symbiosis in Port Dickson.

The development of industrial ecosystems requires information above and beyond that necessary for traditional development. Industrial symbiosis requires awareness and coordination among industries, which draws on an expanded base of information: From the standpoint of Industrial Ecology, the important message is that the wishes of the customers and the pressure from competition are efficiently incorporated into industrial decision making systems. **Figure 8** shows the information flow into corporation. Here in Port Dickson, the major players (Tunku Jaafar Power Station, PD Power Plant, SHELL and ESSO Refineries, CABOT (M) Sdn. Bhd., The PD District Office and The Fishery Department) should first recognize, then show the positive response and finally try to implement the potential symbiosis. These sequence of actions require a lot of information including data and literature and related legal framework.

5.3.1 System boundaries and who is inside

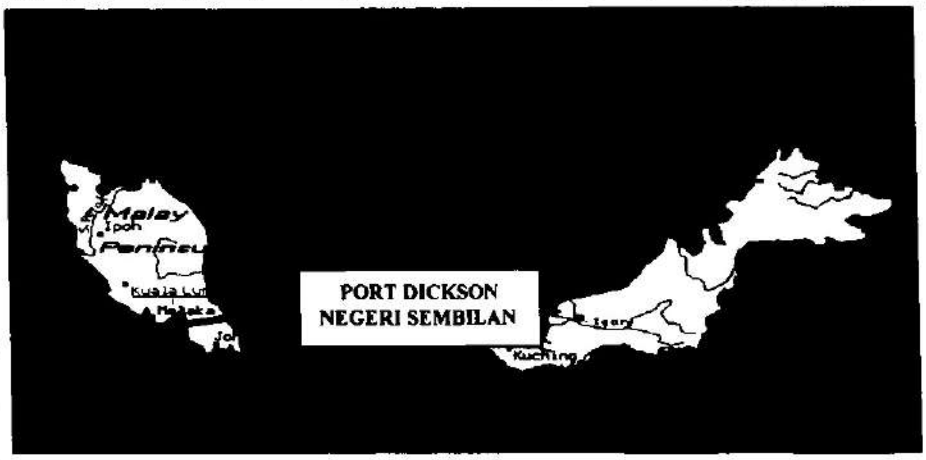
'The system in the case of industrial symbiosis is the set of companies or other economic entities who are potential suppliers or recipients of byproduct feed-stock. In lieu of a common EIP, a geographic area may delineate the system as is the case in Kalundborg. The same can be applied to Port Dickson. Due to the town's relative isolation and a non-existence of an enclosed industrial park, the proposed participants can form a natural locus of interaction, with surrounding smaller industries participating in the symbiosis. Here in Port Dickson, companies such as Tunku Jaafar Power Station, PD Power Plant, SHELL Refinery, ESSO Refinery, CABOT(M) Sdn. Bhd. and the Aqua-culture based projects

Table II: Baseline Data for District Of Port Dickson , 1990
(Source: Rancangan Pembangunan Daerah Port Dickson)

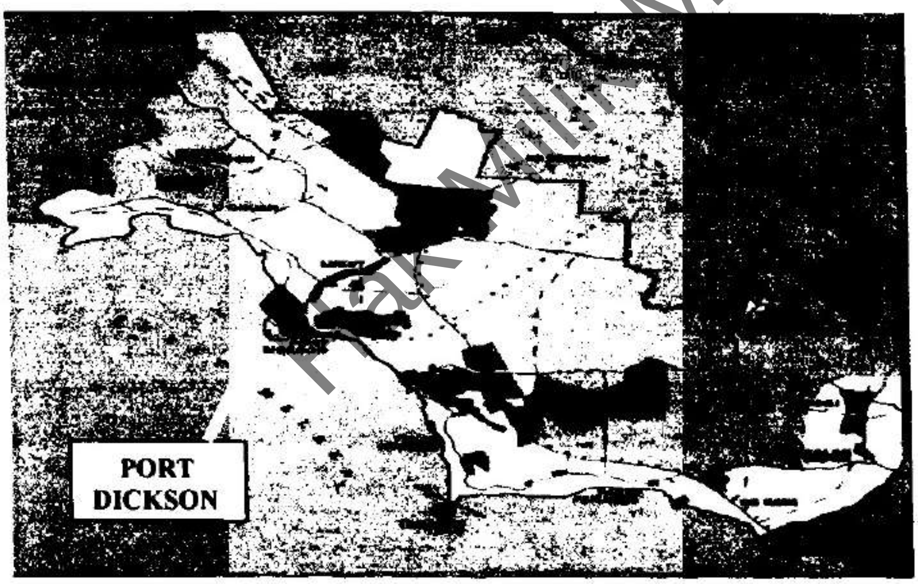
District Name	: Port Dickson
Name of Municipality	: Majlis Daerah Port Dicksion (MDPD)
District Area	: 57,320 hectares
Area Under Port Dickson Municipality (Project Area)	: 20,807 hectares
District Population	: 101,774
Municipality Population	: 82,620
Major Economic Activities	: Agriculture = 36.7%
	Government = 26.3%
	Manufacturing = 12.6%
	Hotel & Tourism = 12.6%
	Transportation = 5.6%
	Construction = 5.5%
	Others = 0.7%

Table III: Major Industries Operating In Port Dickson
(Source: Kajian Pelan Bertindak Perindustrian N.Sembilan ,1977)

NAME AND ADDRESS	OPERATION DATE	PRODUCT	MANPOWER
Tuanku Jaafar Power Station	1969	Electricity	200
ESSO (M) Berhad Mile 1 1/2 Jalan Pantai , P.D	1963	Oil Refinery / Petroleum product	188
SHELL Refining Co. Bhd. Mile 1 , Jalan Pantai P.D	1963	Oil Refinery / Petroleum product	278
CABOT (M) Sdn. Bhd. Mile 2 , Jalan Pantai P.D	1977	Carbon Black and related product	88
Guthrie Medicare Sdn. Bhd. Lot 2431 , Mukim Port Dickson.	1994	Latex Examination Glove	313



Map of Malaysia Showing Port Dickson



Port Dickson And Its Neighboring States of Malacca and Selangor

Figure 5 : Geographic Location Of Port Dickson

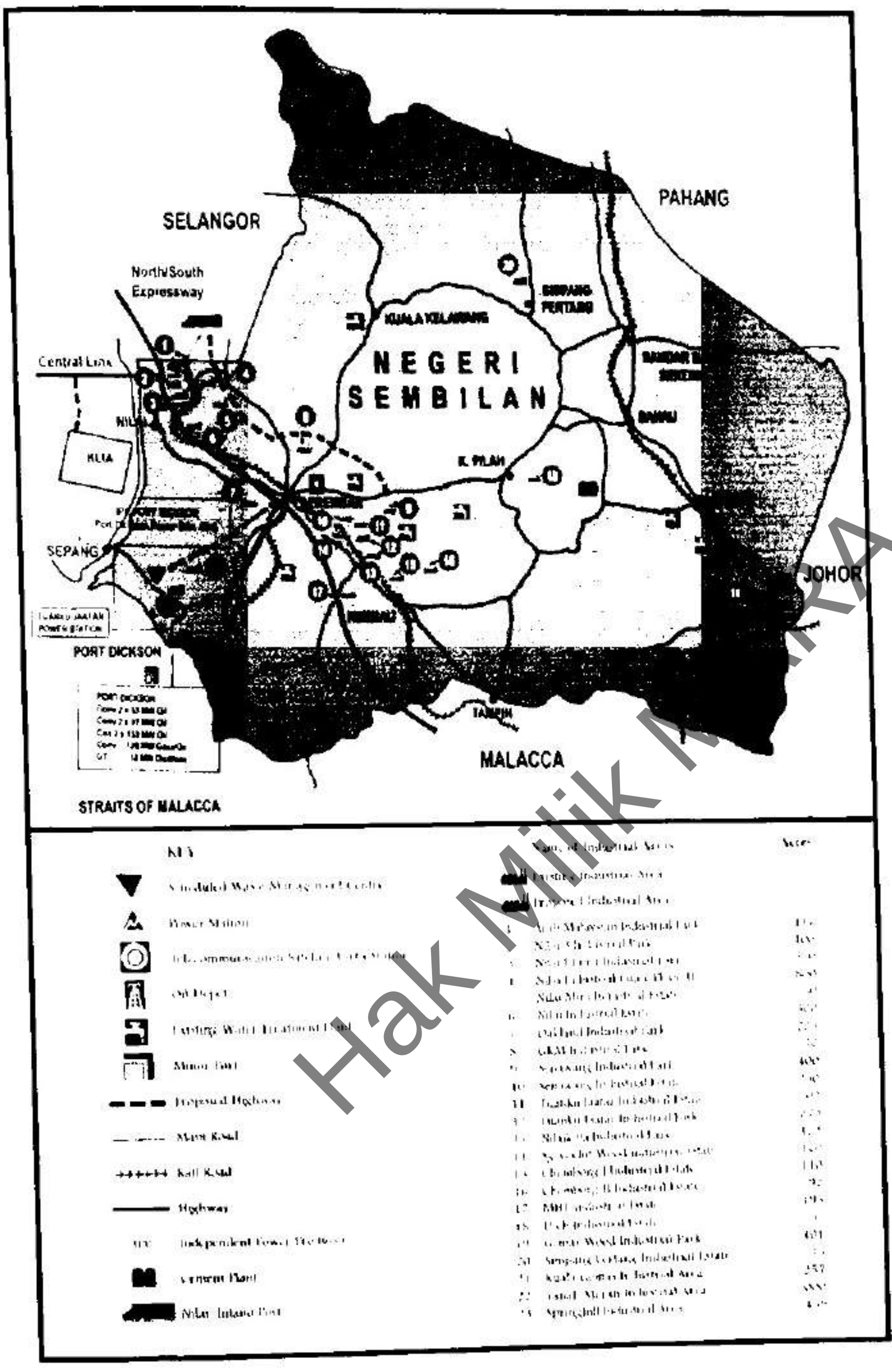


Figure 6 : Location of Industrial Estates in Negeri Sembilan
(Source: Kajian Pelan Bertindak Perindustrian N.Sembilan , 1997)

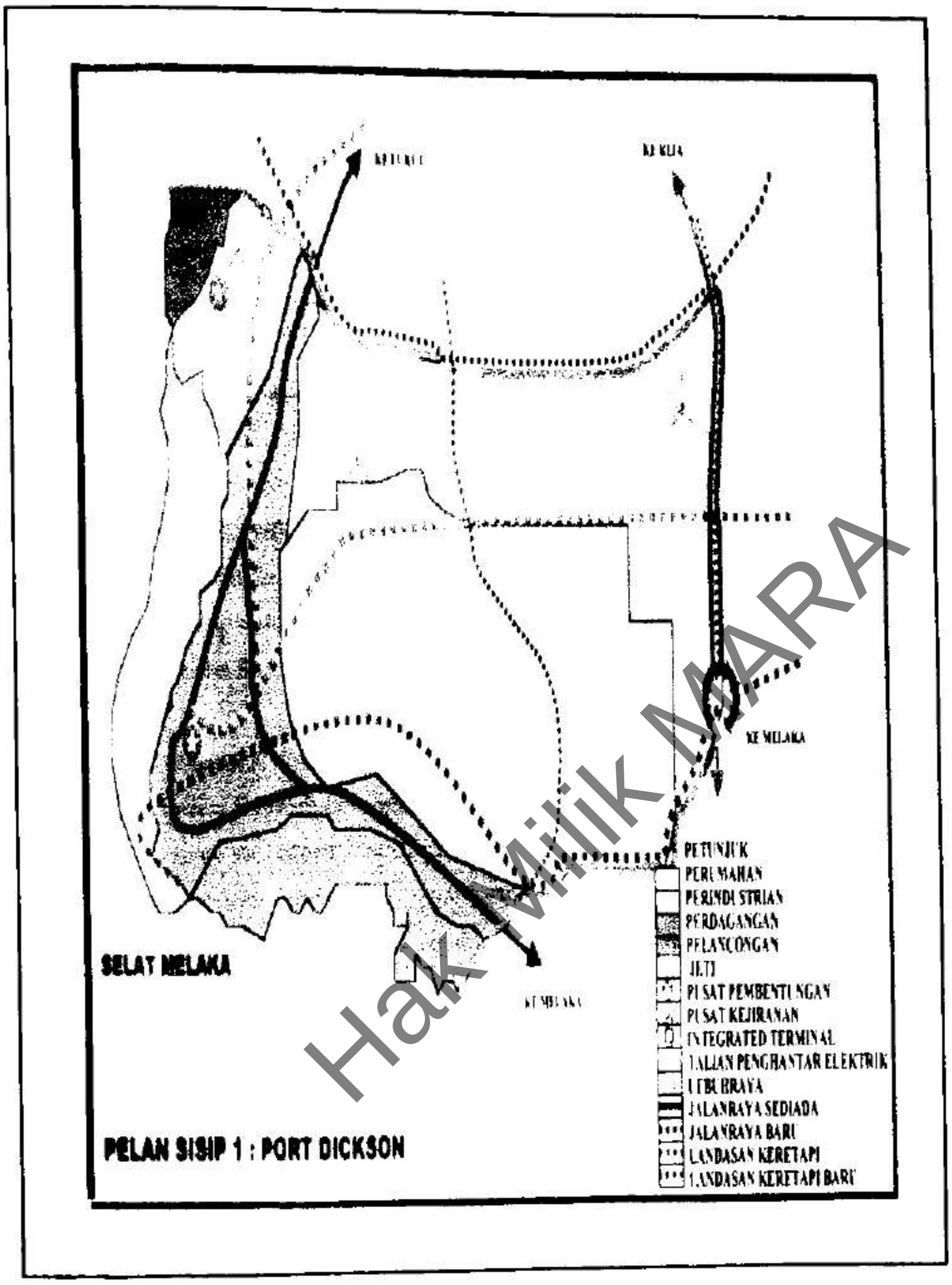


Figure 7 : Proposed Land Use Plan of Port Dickson

developed by the Fishery Department and the local community can be the set of companies inside the system boundaries. **Location of the potential players can be seen in figure 9.**

To the extent that the size of the system under consideration determines the number of possible inter-firm linkages, a large system is likely to produce more possibilities. At the same time, however, a small and clearly defined system, as envisioned in an EIP, is more manageable conceptually and makes it easier to foster a sense of community.

5.3.2 Material and energy flows

It is clear that the materials and energy exchanges among firms require a clear understanding of the inputs and outputs of each participant. It is less clear to what extent firms are aware of their byproduct streams. Eco-audits, which identify the environmental impact, energy use, and waste generation of a firm's activities, are well suited for providing that information. It is only appropriate that if a firm is to redefine its byproducts from waste to resources, then it take account of those byproduct streams. The input-output summary for the Port Dickson Industrial Symbiosis can be summarized in **Table IV**.

5.3.3 Amount and temporal distribution

This follows from the above. Byproduct re-use need not be all-or-nothing, meaning that another firm's byproducts need not cover the entire feedstock needs of a firm which uses those byproducts to substitute for virgin feed-stocks. Re-users of byproducts can either mix byproducts with virgin feed-stocks as needed or receive byproducts from multiple sources for the rest of the year. Symbiotic arrangements therefore need to accommodate cyclical variations and be sufficiently robust to respond to irregular fluctuations in byproduct availability and feedstock demand

5.3.4 Quality and reliability

Byproducts can only compete with virgin materials if they are comparable in quality and reliability. By approaching byproducts as resources, industrial ecology enables companies to expand the range of their products that have economic value. Such an expansion requires a concomitant expansion in management responsibilities. The sale of byproducts as feeds-tocks requires quality control for what was formerly the waste stream. Such expanded responsibility can be expected to cause some loss of flexibility and to require the commitment of resources to fully manage the byproduct stream.

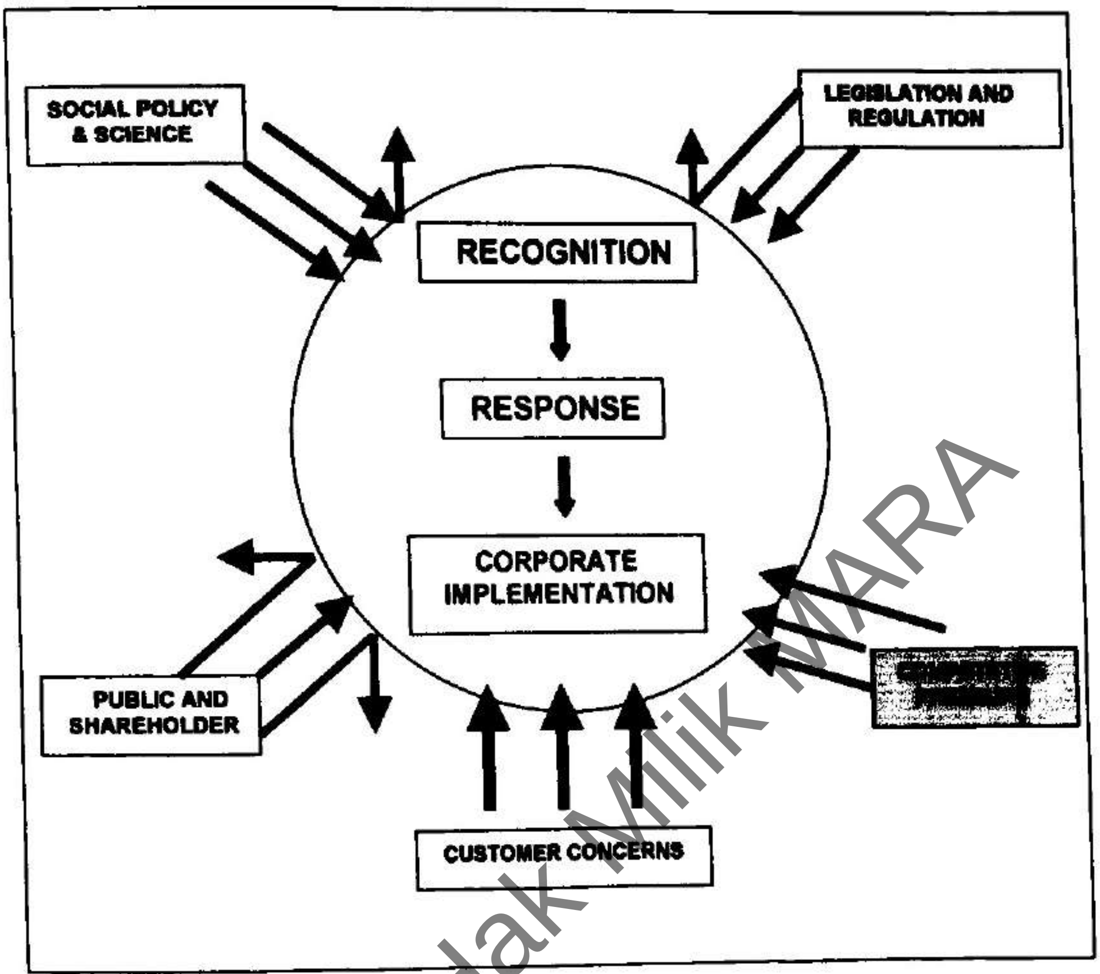


Figure 8: The Information Flow Into A Corporation, Showing Types of Information and Sources. (Source: B. Paton. Design For Environment 1994)

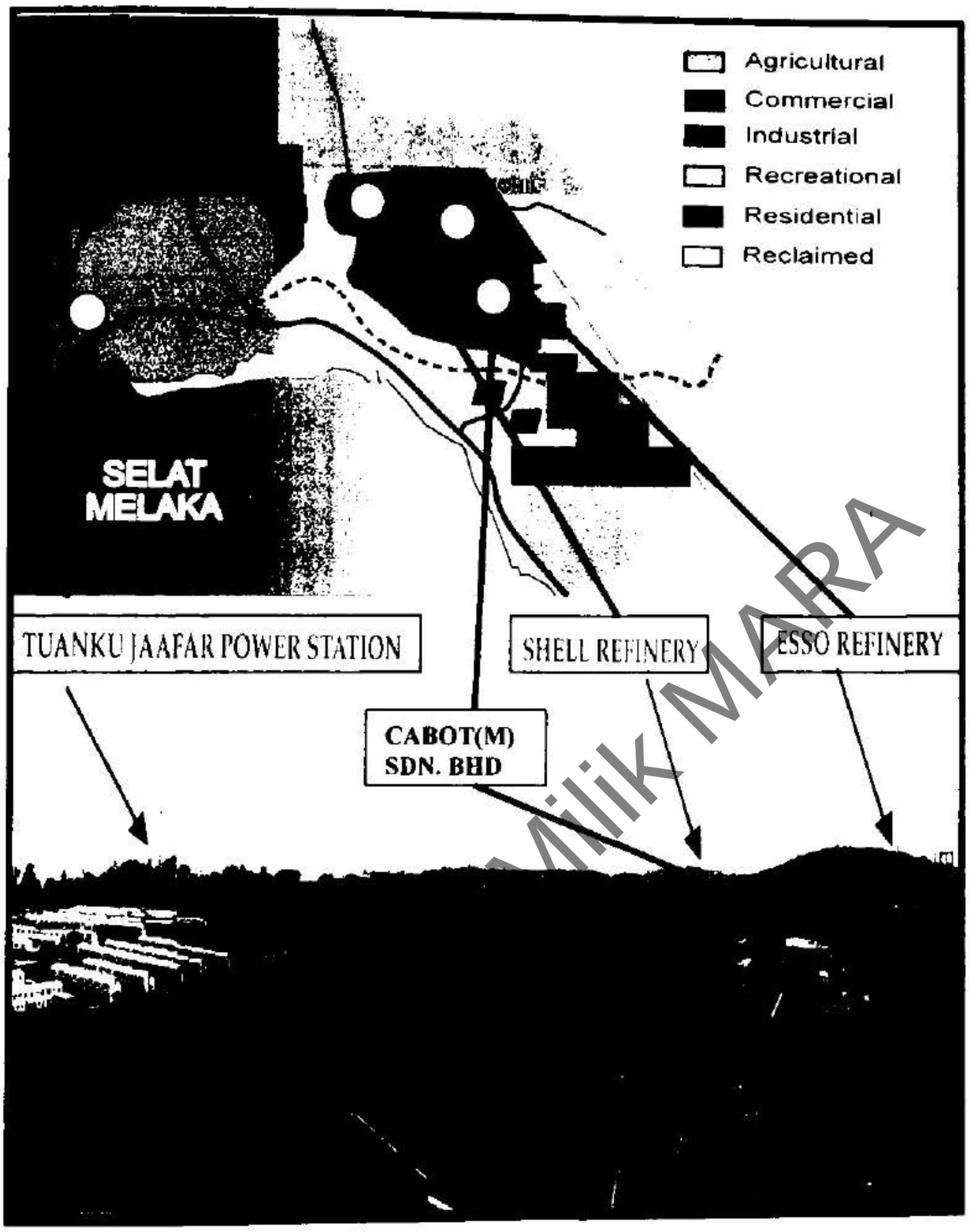


Figure 9: Location of Potential Industries for Port Dickson Industrial Symbiosis

Table IV: Summary of Production Inputs and Waste Output of Selected Industries in Port Dickson

INPUT/WASTE / COMPANY	MAJOR RAW MATERIAL		WASTE OUTPUT	
	TYPE	QUANTITY	TYPE	QUANTITY
TUNKU JAAFAR POWER STATION	FUEL GAS RAW WATER FORM JBA SEA WATER FUEL OIL SODA ECP ACIDS	1730860GJ 326618CM N.A 6056TON/MTH 37TON/MTH N.A 20TON/MTH	GAS (COs, SOx, NOx, SOOT) W/P WASH WATER SEA WATER (40 degree Celcius) HYDROGEN HYPOCHLORIDE USED LUBE OIL OIL SPILLAGE	N.A N.A 50KG/HR 10KG/HR 2TON/OCCATION N.A
ESSO REFINERY PORT DICKSON	CRUDE OIL CRUDE LONG RESEDUE RAW WATER AMMONIUM HYDROXIDE NALCO CHEMICAL DRY-O-LITE XYLENE LUBE OIL DETERGENT(SOFT SOAP)	302,000 TON 16,500 TON 250,000 CM 3,500 KG 2,000 KG 4,000 KG 1,500 KG 700 KG 1,000 KG	OILY SLUDGE TARRY RESIDUE SPENT CATALYST FLARE GAS USED PAPER TANK SCALES PAINT FINES	80 TON/YEAR 1 TON/YEAR 3TON/YEAR N.A 1200KG/YEAR 1 TON/YEAR 12/YEAR
SHELL REFINERY PORT DICKSON	CRUDE OIL CRUDE LONG RESEDUE RAW WATER AMMONIUM HYDROXIDE NALCO CHEMICAL DRY-O-LITE XYLENE LUBE OIL DETERGENT(SOFT SOAP)	300,000 TON 17,000 TON 250,000 CM 3,000 KG 2,000 KG 4,200 KG 1,500 KG 850 KG 1,100 KG	OILY SLUDGE POLYPROPYLENE USED PAPE,PLASTIC,BOXES SPENT CATALYST	526 m/TON/YEAR 3CM/YEAR 100 TON/YEAR 5CM/YEAR

5.3.5 Regulatory considerations

The management of solid waste is tightly regulated in cases where the waste qualifies as hazardous. Since industrial symbiosis deviates from common waste management practice, the regulatory response to it is not well established. There is reason to believe that most if not every symbiotic linkages are possible given some regulatory flexibility. Proposing an Industrial Symbiosis in Port Dickson need to comply with the current Legislative Framework and related Laws regarding the waste disposal and reuse. Thus, we need to work closely with regulators to ensure public-sector approval and support.

5.4 Proposed Inter-firm Interaction In Port Dickson Industrial Symbiosis.

5.4.1 Potential Players

As being mentioned earlier in the paper, Industrial Symbiosis in Port Dickson can be realized with the active participation by the at least 5 major industries currently operating in the vicinity of the town of Port Dickson, namely the Tunku Jaafar Power Station, the SHELL and ESSO Refinery companies, CABOT(M) Sdn. Bhd. and both of the aqua-culture projects managed and monitored by the Fishery Department and privately operated plots. It can be expended with the inclusion of newly developed industries which will utilize the waste of the existing industries as their production inputs. **Figure 10, 11, 12 and 13** shows the photos of the potential players for this proposed Industrial Symbiosis.

5.4.2 Existing Practice of Waste Disposal

Currently, all the industries concerned are found to practice good procedures of waste disposal, agreeing with the local and national laws and regulations. This can be proven by the Environmental Quality Report which describe the industrial pollution in Port Dickson is satisfactory and within the approved limits. The wastes are either sold, recycled and reused or being transported to proper and legal waste dumping area. In this case the popular dumping areas are:

a. Municipal Sanitary Landfill
b. Kuality Alam Waste Complex
c. Bukit Palong Dumping Site
d. Release to the Sea

As for certain waste product, they were sold to industries outside Port Dickson. **Table V** outlines the types of waste produced and the current practice of waste disposal by the industries concerned. **Figure 14** shows examples of waste disposal practice found in Port Dickson.

Table V: Major Type of Waste and Waste Disposal Practice By Selected Industries - 1998

(Source: SHELL, ESSO and Tunku Jaafar Power Station)

WASTE PRODUCT	QUANTITY	DUMP LOCATION
ESSO REFINERY PORT DICKSON		
1. Oily Sludge	80 ton/year	Treatment at Own Land Farm
2. Asbestos & Calcium Silicate	20CM/year	Municipal Sanitary Land Fill
3. Used Papers and Boxes	100kg/month	Send to Paper Recycle Industry
4. Lubrication Oil	20 ton/year	Send to 2nd Grade Lubrication Oil Manufacturer.
5. Polypropylene	N.A	
6. Flare Gas	N.A	Burned
SHELL REFINERY PORT DICKSON		
1. Oily Sludge	526 m/ton/year	Dumping at Sludge Farm
2. Polypropylene	3CM/year	Bukit Palong Dumping Site
3. Lubrication Oil	15m/ton/year	Sold to Recycler
4. Flare Gas	N.A	Burned
5. Metal Scrap	21m/ton/year	Recycler
6. Papers, Plastic, Boxes	100 ton/month	Recycler
7. Spent Catalyst	5 CM/year	Factory dumping place
TUNKU JAAFAR POWER STATION		
1. Sea Water Outfall (40 degree Celcius)	N.A	Release to the sea
2. Lubrication Oil	2 ton/year	Sold to 2nd Grade lubrication Oil Manufacturer.
3. NO_x	105 ppm v/v	Release to the atmosphere
4. Hydrogen + Hypochloride	100 kg/hour	Release to the atmosphere
5. Steam	4000 CM	Discharge to the sea
6. Metal Hydroxide	1.5 ton/mth	Municipal Dumping Area

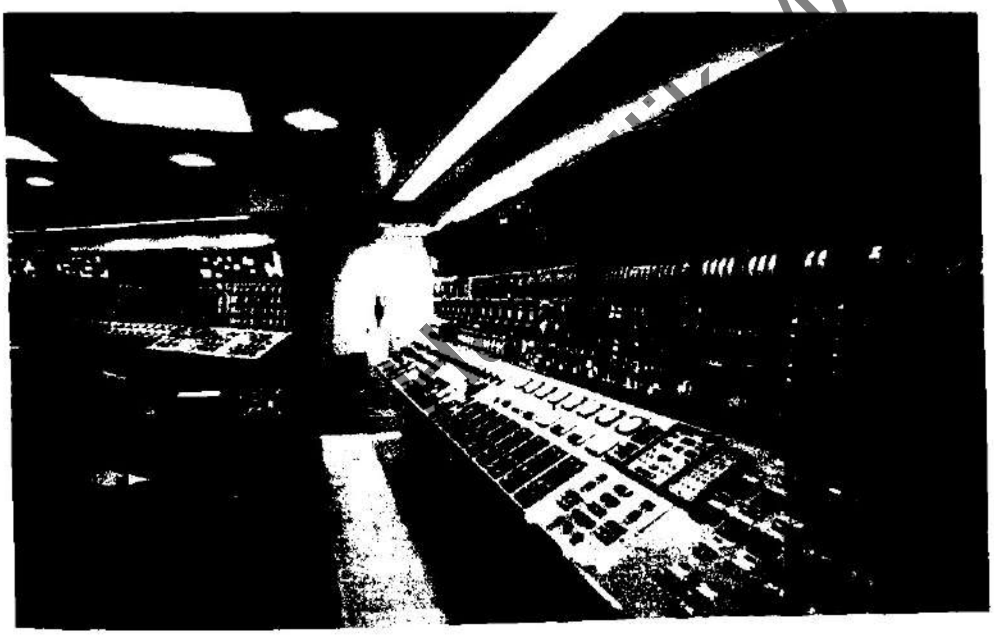


Figure 10: Tunku Jaafar Power Station Port Dickson

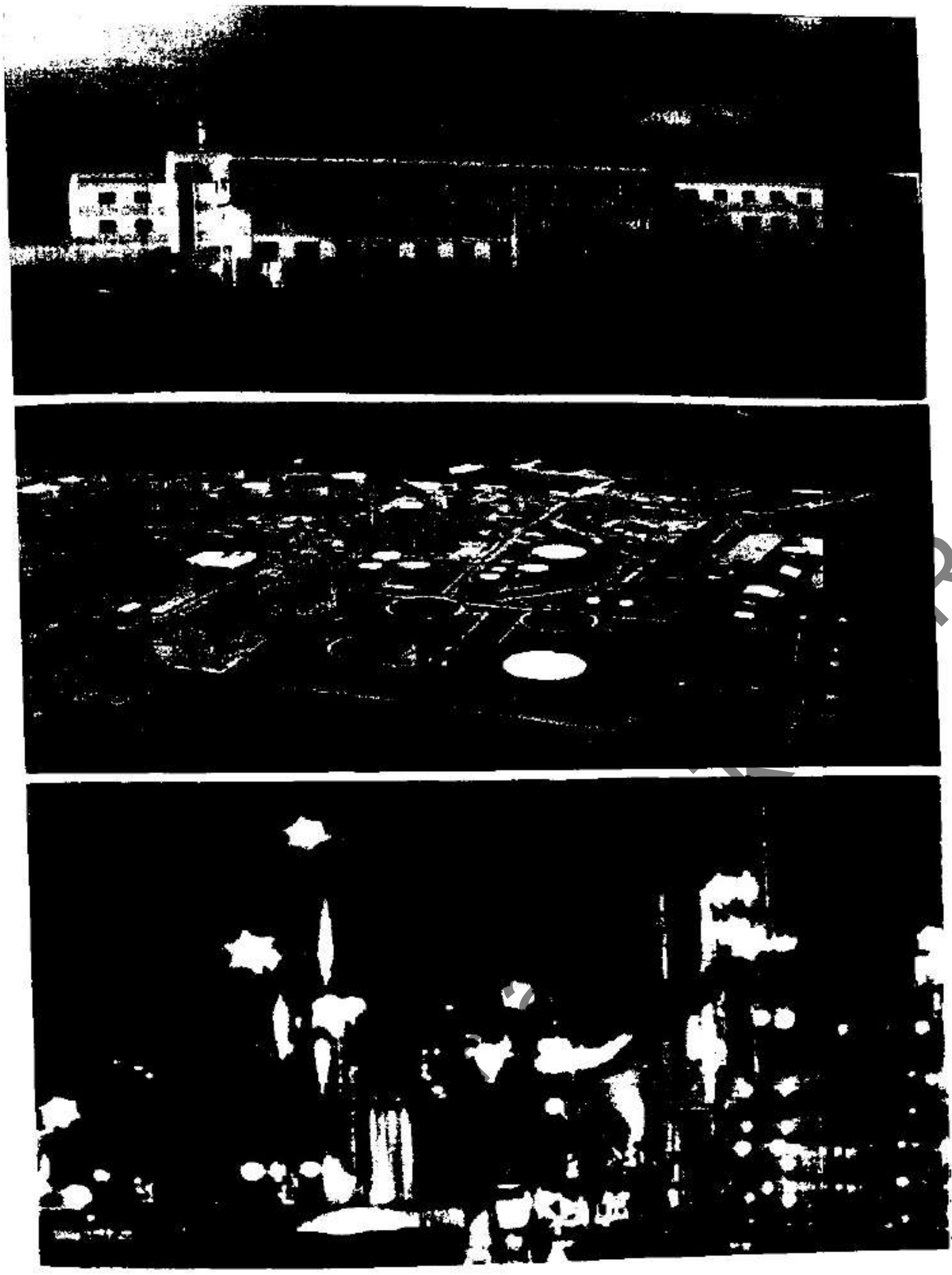


Figure 11: ESSO Refinery Port Dickson

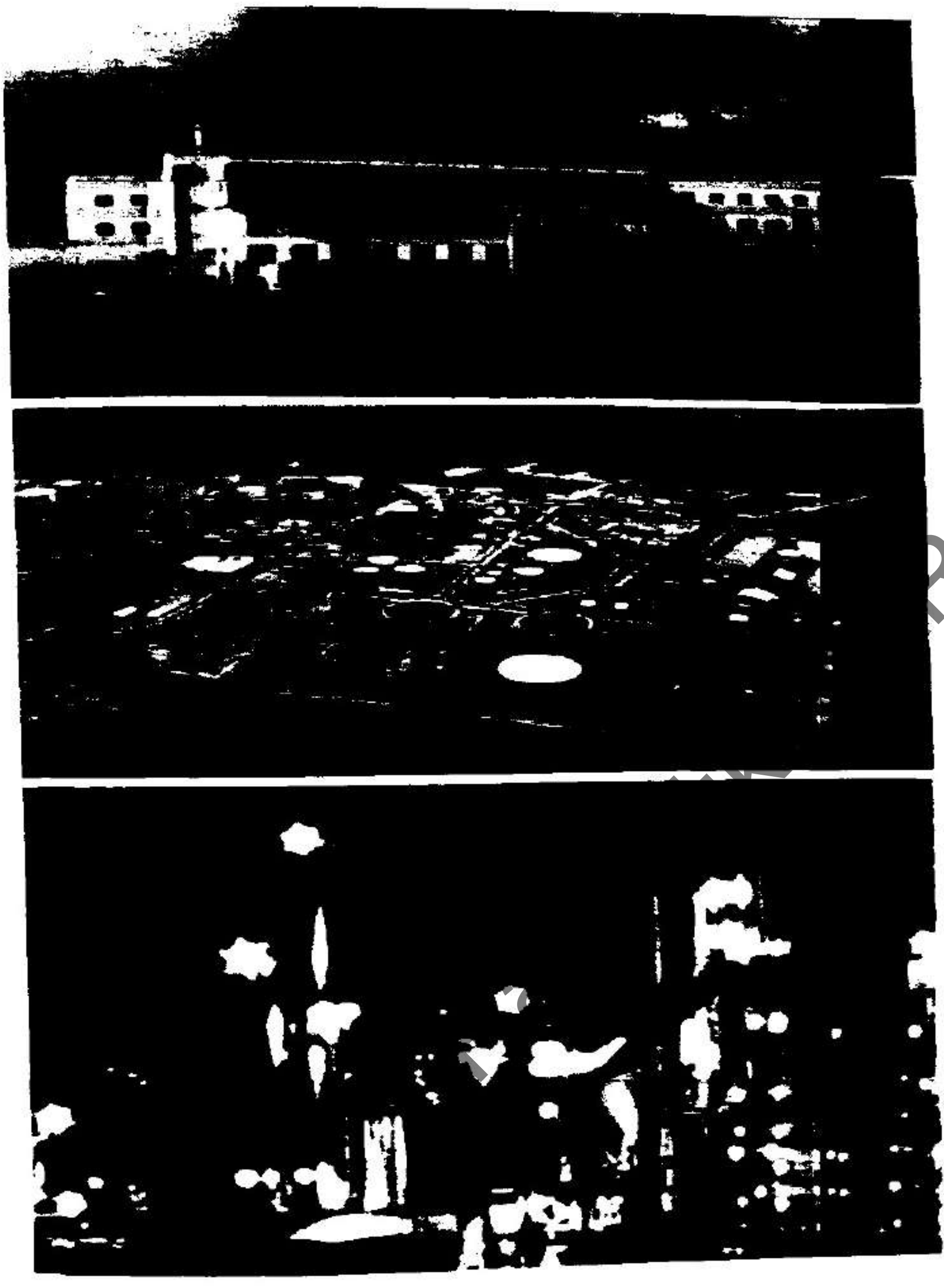


Figure 11: ESSO Refinery Port Dickson

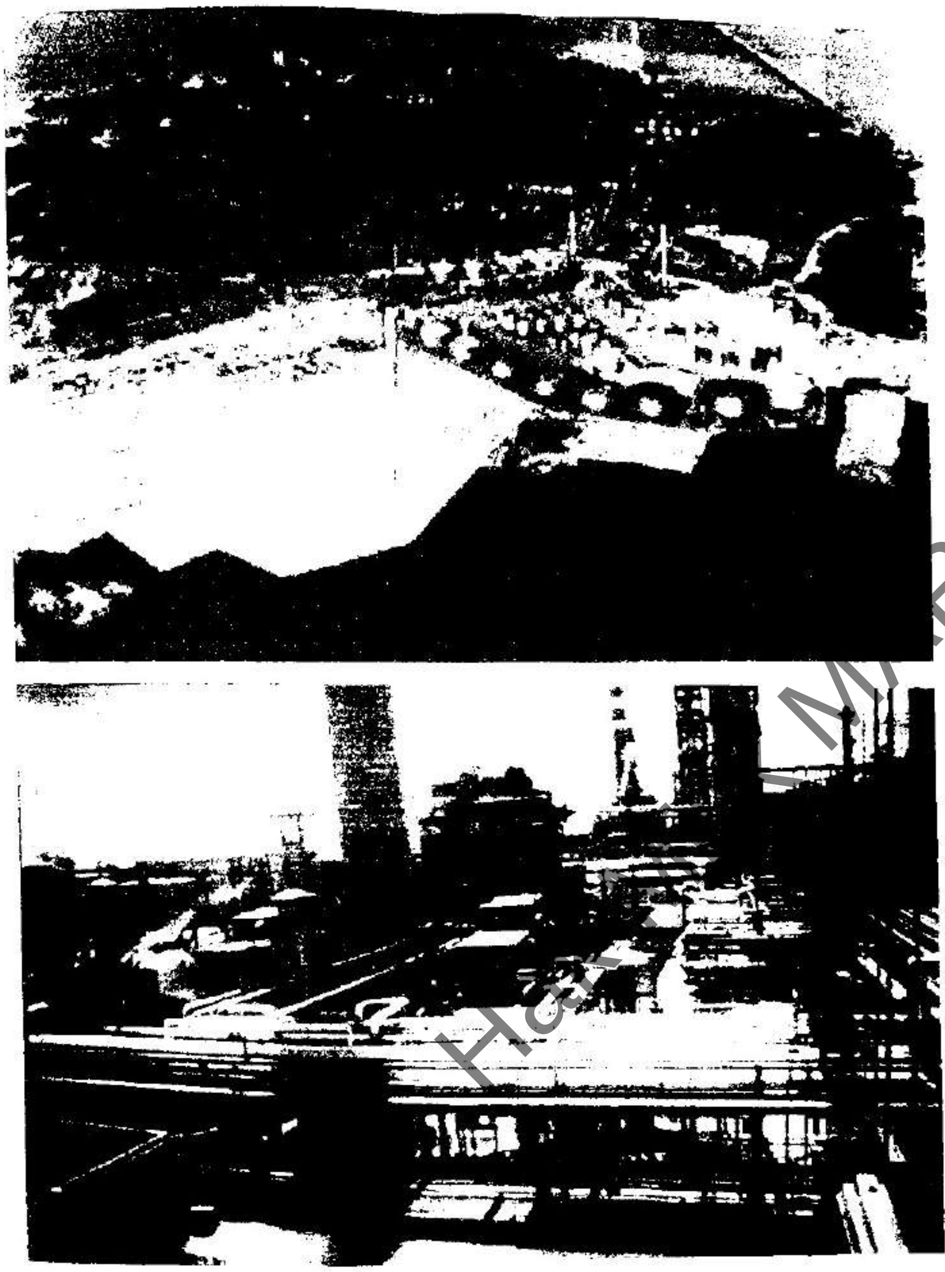


Figure 12: SHELL Refinery Port Dickson

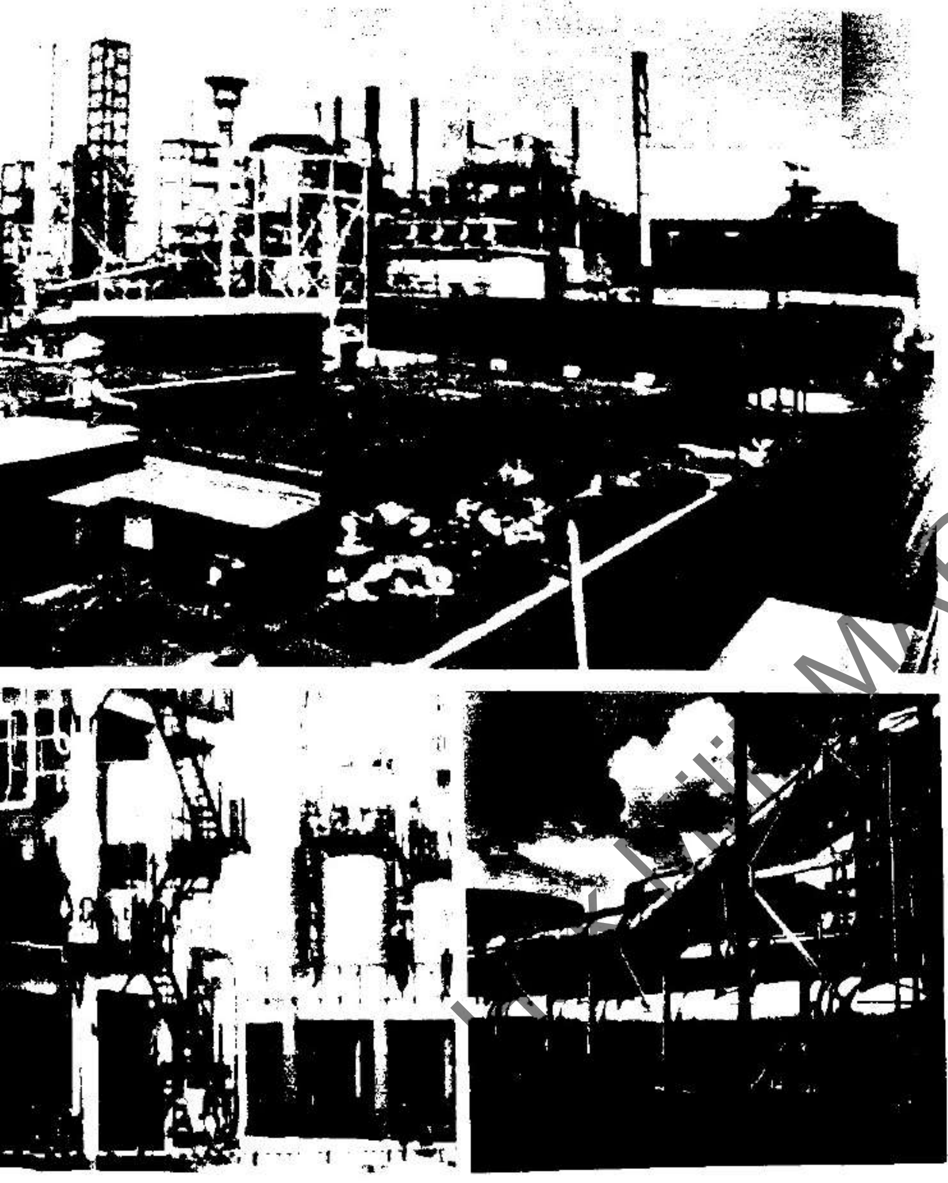


Figure 13: CABOT (M) SDN. BHD.

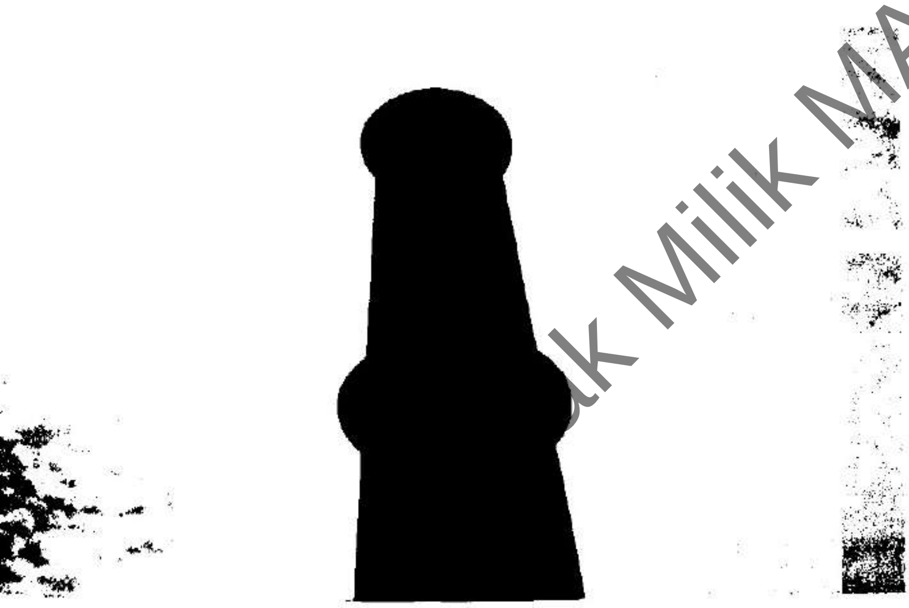


Figure 14: Examples of Waste Disposal Practice

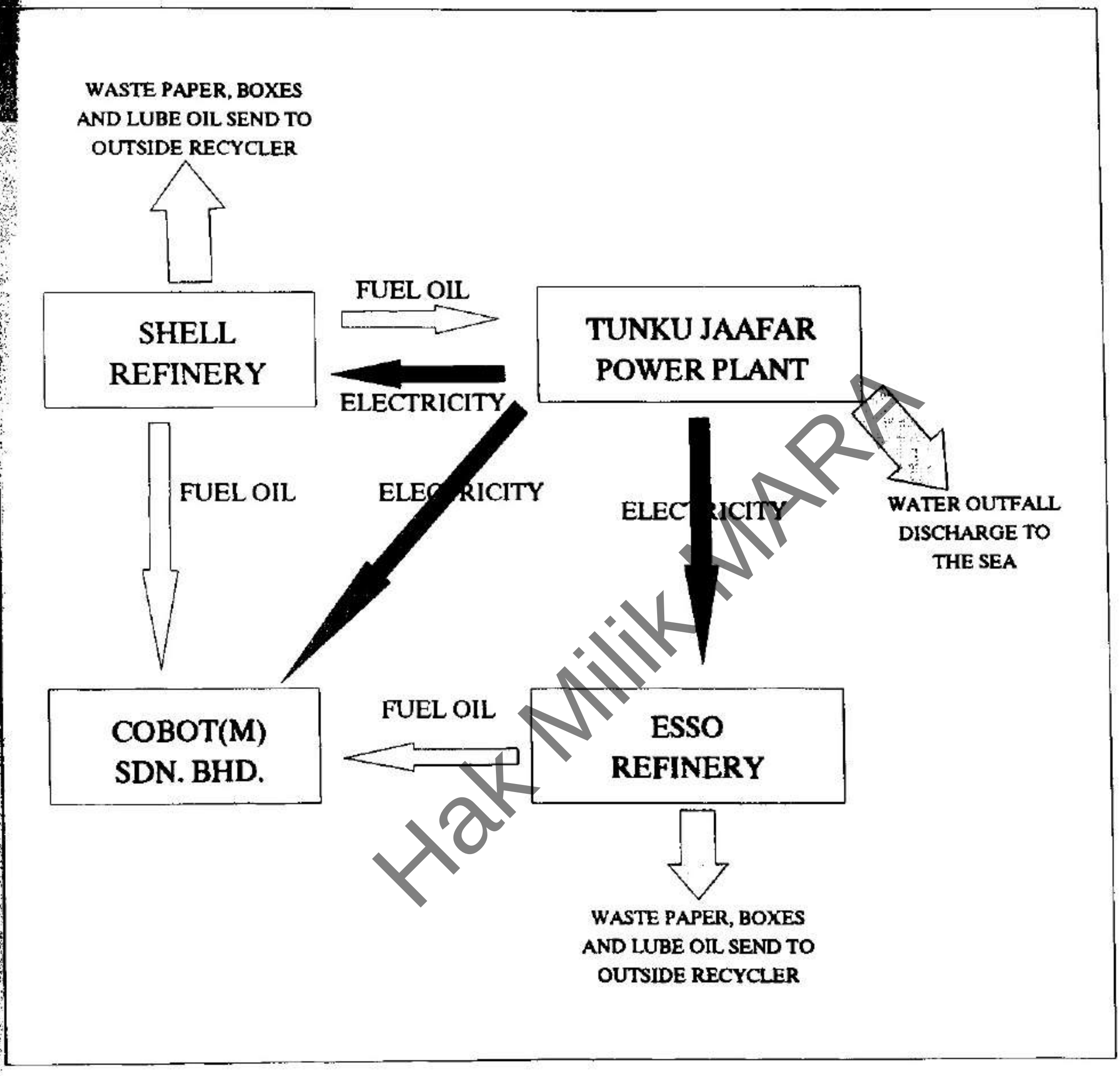


Figure 15: Baseline Industrial Symbiosis Participants and Production

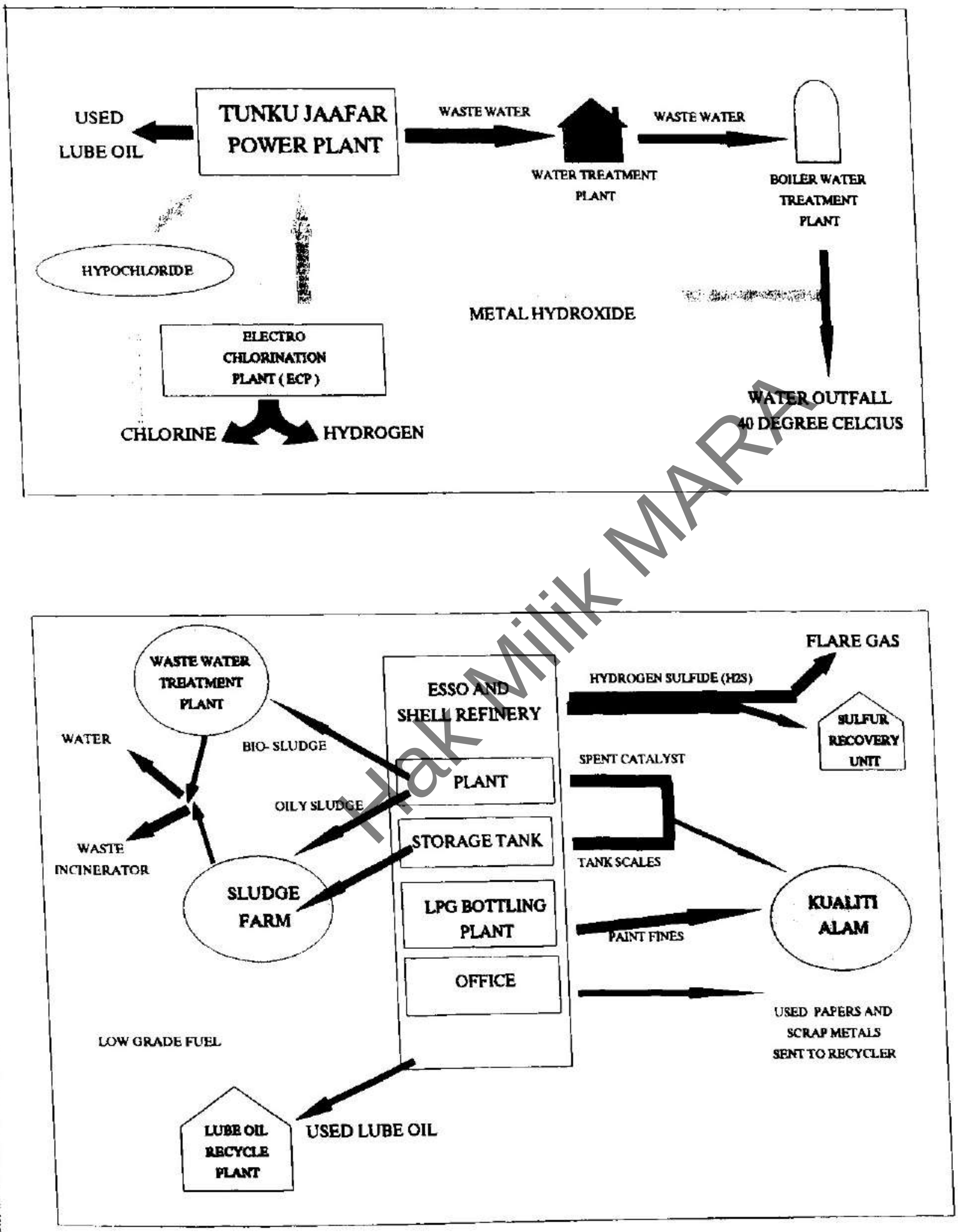


Figure 16: Scenario 2, Pollution Prevention Programme

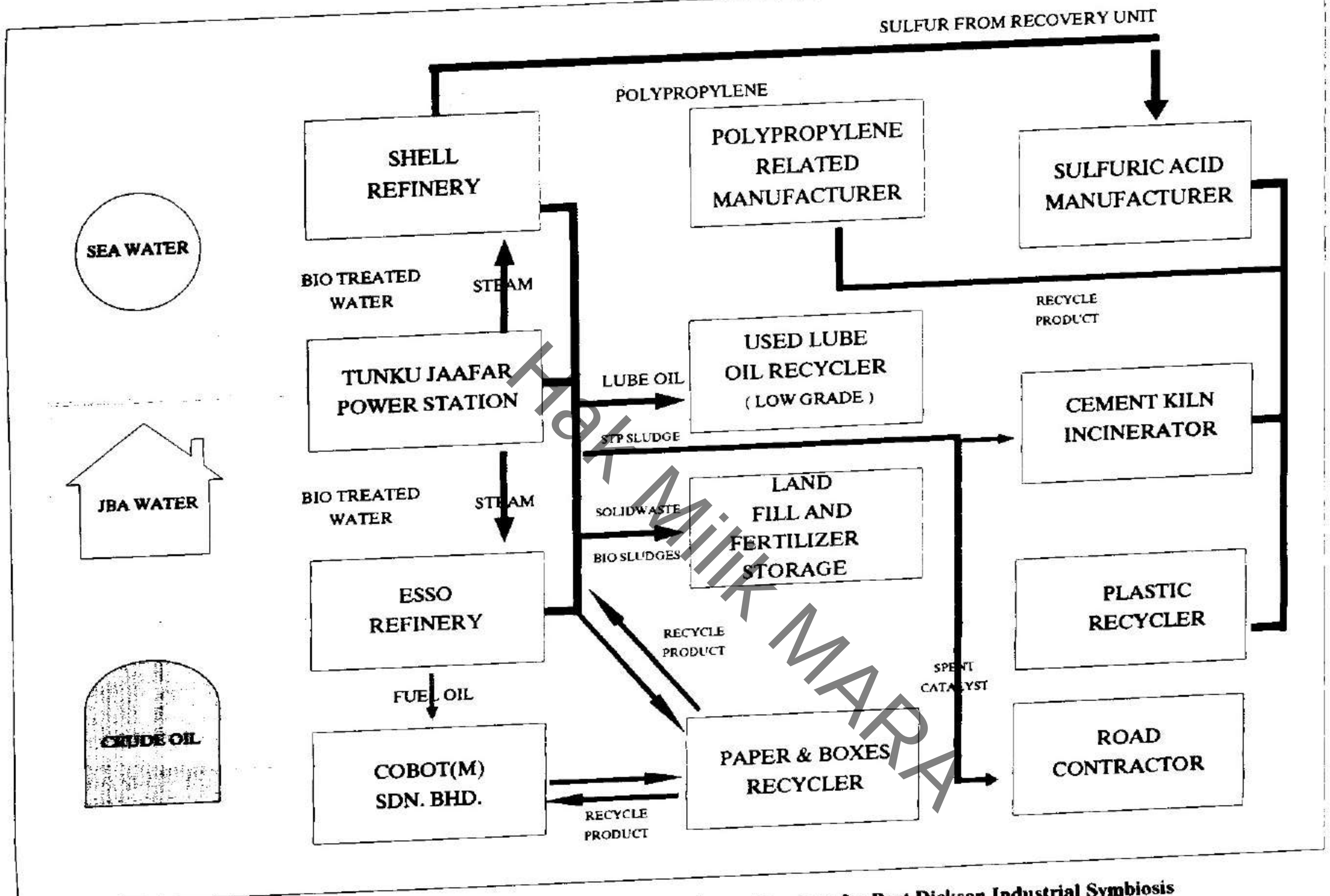


Figure 17: Scenario 3 & 4, Industrial Symbiosis and New Industry Members for Port Dickson Industrial Symbiosis

- ESSO and SHELL can provide adequate sulfur for sulfuric acid manufacturer. They can also act as a polypropylene supplier.
- Power Plant, Refineries and COBOT can provide enough used lubrication oil to the potential lubrication oil recycler producing 2nd grade lubrication oil. Currently, these industries sell their used lubrication oil to the factories located outside Port Dickson namely Port Klang and Kuantan
- All the existing industries can sell the scrap plastic, used boxes and used paper which is currently land-filled, to the recycler. In return the recycler can sell back the recycled products to the industries

Scenario 4: Pollution Prevention, Industrial Symbiosis, and Collocation; Joint EIP Services

In this stage, we assume that the remote partners are collocated with the remainder of the EIP members. We do not analyze their decision to move to Port Dickson from their current location; we only show the additional benefits that could be derived from collocation. We also analyze the provision of several joint services, which we assume the Port can provide once the EIP has enough members to make these activities economically feasible. These joint services include a solvent recycler, oil recycling operation, sulfuric acid manufacturer aqua-culture farms and a water pre-treatment plant.

These changes produce the following opportunities:

- Each of the exchanges described in Scenario 3 takes place with lower transportation costs.
- The water pretreatment plant provides clean water to the power plant.
- The final product from solvent and waste oil recyclers can be used by several members.
- The participants can reduce treatment cost while at the same time collect revenue from the selling of the waste.
- Provide the enhancement of new and appropriate technology towards the pollution programme.
- Maintain the clean and harmonious environment for the surrounding communities.
- Induce the overall development of environmentally concerned industries in Port Dickson.
- Provide greater input to the overall state GDP and employment source.

0 ENVIRONMENTAL POLICIES AND LEGAL FRAMEWORKS.

Environmental regulation strongly induces companies to appreciate the environmental dimensions of their operations. Businesses must respond to local, national and international regulatory structures established to protect environmental quality. Although few questions postulate that regulations have helped to improve environmental quality, many argue that wiser, less commanding regulation would improve quality further at less cost. Agreements on hazardous waste tightly regulate the transport of these wastes across state and national boundaries, perhaps reducing opportunities for re-use encouraging greater extraction of virgin stocks.

With better understanding of the effects of past regulation, the government could explore regulatory reforms to provide greater incentive to recover materials from waste. This line of inquiry into the effect of regulatory reform should include a broader analysis of policies that favour more environmentally sound industrial ecosystems, such as rewarding firms that exploit materials symbiosis within and between facilities, providing incentives for investment in capital equipment that uses secondary materials inputs, promoting manufacturer responsibility for product after their useful life, encouraging disposal practices that do not prevent later access to materials, and discontinuing subsidies to virgin materials producers.

Like regulation, the risk of civil liability from handling industrial waste also affects how much is recycled. The question of how development in liability law affect decisions on the recovery of wastes from materials thus forms a further area for Industrial Symbiosis development. Such development would also permit the potential for legal reforms that would facilitate greater materials recovery, for instance by limiting the responsibility of parties handling wastes, while maintaining the societal protection that the statutes were meant to ensure.

Though ostensibly unrelated to environmental law, a host of other statutory bodies can affect the development of efficient industrial ecosystems. Anti-trust statutes can effectively bar the agglomeration of enterprises necessary to effectively close materials loops. Consumer protection law can encumber efforts to improve the environmental design of products.

As mentioned earlier, Malaysia has for so long a very comprehensive and well documented set of environmental laws and legal framework, which surely reflex the seriousness of the Malaysian government to protect and preserve the environment. The main framework environmental legislation in Malaysia is the 1974 Environmental Quality and the regulations enacted thereunder. The 1974 EQA has been substantially amended in recent years, principally by the Environmental Quality (Amendment) Act 1996 (Act A953). This act is applied throughout the countries together with the other departmental legislation and state laws and regulations (already mentioned earlier in para 2.2.2). Looking at all the existing laws and regulation one can safely say that there is no need for an additional legal frameworks to support and encourage the development of Industrial Symbiosis. The only potential set back is the lack of understanding and the ability to apply the right clause for making the Industrial Symbiosis concept an implementable and practical tool of Eco-friendly Industrial development.

7.0 RECOMMENDATIONS

7.1 The Role of The Government

The government has a role to play in the development of Industrial Symbiosis because Industrial Symbiosis can potentially provide benefits beyond the private benefits to their participants. However, the appropriate role of government at each level depends, in part, on how widely the benefits are to be shared. Some of the potential roles can be generalized as follows;

a. **Local government's** efforts are most appropriately focused on specific Industrial Symbiosis developments in their communities.

b. **State governments** may play a wider role, enabling the development of Industrial Symbiosis across a state through state regulatory innovations, tax policies, and the statewide technology transfer offices. **The federal government** can play an even wider role, encouraging Industrial Symbiosis through revision of federal legislation, development and transfer of technologies broadly supportive of Industrial Symbiosis, and support of information sharing among Industrial Symbiosis in different parts of the country.

7.1.1 The Role of Local Government of Port Dickson

The Local Governments of Port Dickson can play several important roles in the success of an Industrial Symbiosis. They can formally do the following acts:

- take the lead in the Industrial Symbiosis development process;
- include the Industrial Symbiosis as part of state and local economic development strategy through incorporating the concept in the Structure Plan;
- streamline zoning, permitting, and other laws related to industrial park development;

- participate in Industrial Symbiosis Financing (provide infrastructure, superstructure etc.)
- provide technical assistance, technology transfer, and training;
- remain flexible in their implementation of federal environmental regulations; and provide other incentives—such as tax breaks, industrial development bonds, and publicized award programs—and export support programs,

7.1.2 Federal Government Roles in Industrial Symbiosis Development

Like local government, the federal government can play a number of roles in the development of Industrial Symbiosis. The federal government can support Industrial Symbiosis by:

- enacting regulatory changes that allow to take advantage of their opportunities for reducing environmental burden while improving their economic performance;
- funding Industrial Symbiosis planning and development;
- funding R&D and technology transfer for environmental technologies;
- promoting voluntary initiatives for Industrial Symbiosis participants; and
- facilitating the transfer of information among Industrial Symbiosis.

7.2 Role of the Existing and New Industries Potentially Located

The most ideal form of Industrial Symbiosis is when the concept is implemented without the application of meta-management in the form the government, park authority or similar entity. This role is sometimes referred to as **"Optimization from within"**. Then each element of the system needs to act individually, or in cooperative arrangements, so that the system as a whole is optimized. That's optimization from within, also referred to here as auto-catalytic or self-organizing development.

Inter-firm collaboration and flexible networks indicate very strongly the importance of personal contact among firms as a starting point for collaborative arrangements. Being a small industrial and tourist town, Port Dickson, provides an excellent scenario for managers of the various firms to often run into each other, providing opportunities for face-to-face contact and informal discussion. The fact that the four firms are planted in the same interconnected society in which their employees live makes inter-firm cooperation more readily achievable.

Given the necessary reliance on network partners, owners and managers who do not know and trust each other are usually unwilling to put their businesses at risk by entering into collaborative arrangements. Given the importance of personal relationships, lack of institutional linkages among firms is a major impediment to inter-firm collaboration, a result that carries over to industrial symbiosis. Personal relationships are also important in that the personalities of those involved with creating symbiotic linkages have a strong influence over the form of the outcomes produced.

Actually there are many approaches available for the industries to overcome the general lack of institutional linkages among firms. Widespread creation of symbiotic inter-firm linkages will most likely require a broader shift in business culture, one that is conducive not only to the exchange and reuse of material and energy flows, but to increased collaboration in general. The symbiotic linkages among local firms should be expanded to other areas of collaboration, such as worker training and safety. In turn, experience with flexible networks and inter-firm collaboration indicates that collaboration in one area fosters collaboration in others. Thus, one way to promote industrial symbiosis is to strengthen inter-firm linkages in general.

Another point to note is that, symbiotic linkages will not come about unless the decision makers within companies begin to see byproducts as resources, not wastes. While all businesses market their products, few are versed at marketing their byproducts. Finding possibilities for symbiotic linkages with other firms is new to the realm of business practice. This distinction is significant because it has allowed the local firms to choose pollution control technologies which rendered their waste streams usable as feed-stocks elsewhere, yielding an additional benefit beyond pollution reduction. For example, from among several alternatives, Tunku Jaafar Power Station chose to have the electro chlorination plant to produce metal hydroxide as its byproduct. This metal hydroxide is then use as an input material and can also be sold to the open market, and at the same time reducing the cost of pollution control. The same thing is happening in the ESSO and SHELL Refineries. The installation of various treatment plants has open wider horizon for Industrial Symbiosis to take place.

From command-and-control regulation to pollution prevention, approaches to environmental problems that preceded industrial symbiosis should focused on individual plants and processes as the units of interest. Thus, Industrial Symbiosis calls for a broadening of focus to encompass the system in which production takes place. Closing loops and increasing the efficiency of material and energy use requires a holistic view of firms as part of their surroundings, both natural and human-built. This approach requires a heightened awareness and sensitivity to the interactions of a given process with its surroundings. From such awareness can spring novel synergies, such as finding valuable uses for byproducts.

7.3 Public Policy as Evolutionary Pressure

Regardless of any stories one can tell of closing loops and emulating ecosystems, businesses will only engage in symbiotic linkages if and when such arrangements are economically beneficial. Every single linkage in this model of industrial symbiosis, is either a sale of a byproduct or a least-cost way of complying with environmental regulations. Therefore, the single best way to foster the development of industrial ecosystems is to make them economically attractive and economically viable.

Imposing regulatory requirements and altering the price signals felt by industry are two ways in which public policy can apply pressure to encourage the evolution of industrial ecosystems. This strategy entails a form of 'getting the prices right.' Such external signals are not sufficient, however, since innovative and pioneering cooperation is required among companies for symbiosis to occur. Yet such cooperation is only viable if it makes economic, not just environmental, sense.

8.0 CONCLUSION

At its core, an Industrial Symbiosis is very simple. It strives simultaneously to increase business success while reducing pollution and waste. Rooted in the emerging discipline of industrial ecology, an Industrial Symbiosis mirrors natural systems. As single organisms can be viewed alone or in a larger ecology, single enterprises can organize themselves in more complex business ecology. By moving to higher levels of interdependent organization quantum level improvements can be realized in resiliency, flexibility and resource conservation. This pays off for the business and the environment. The evolutionary view of Industrial Symbiosis development would therefore hold that there is a natural progression towards symbiosis if every participating parties response to the environmental impacts of industrial activity sends the right signals and if the regulatory structure is conducive. Of course symbiosis does not necessarily follow from a regulatory push for pollution control; there has to be some propensity. Symbiosis should be seen as a gradual evolutionary process of entropy reduction which requires information, cooperation, and creativity, and these requirements are more difficult to supply by public policy intervention.

As Prigogine has written:

> *"We can consider the evolution of living organisms up to the stationary state as taking place under a certain number of constraints determined by the outside world...Whatever the nature of the [constraints], the stationary state may probably to a good*

approximation be considered as a state of minimum production of entropy per unit time. This description fits in excellently with some striking characteristics of living organisms. First, the well known stability against external perturbation has its analogue in the stability of stationary states corresponding to a minimum production of entropy. Further, the fact that during growth living organisms actually experience a decrease of entropy production during evolution to a stationary state. Also, the fact that their organization generally increases during this evolution corresponds to the decrease of entropy".

(I Prigogine, Thermodynamics of Irreversible Processes C.C. Thomas, Springfield IL 1955 p. 91)

Industrial Symbiosis in Port Dickson can apply this same line of reasoning to industrial ecosystems, when the optimization of material and energy flows results in a more sustainable industrial activity. This optimization is directly coupled to a state of minimum entropy production. For the economic system to be self-optimizing, then, decision rules need to be in place which reward increases in eco-efficiency and penalize the laggards.

The Industrial Symbiosis in Port Dickson as in the Kalundborg's Model, is expected to be developed according to same process of evolutionary development. The initial wave of links that made economic use of unexploited products was followed by a second wave that was the outgrowth of pollution control measures and pollution control technologies. These latter linkages are more expensive than no pollution control, but represent least-cost compliance strategies. As such, they are adaptations to the changing operating environment in which all the firms have been functioning. Regulatory and community requirements have applied evolutionary pressure, in the form of demands for reduced environmental impact. By setting performance standards, instead technology standards, public policy allowed this sort of evolution.

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