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INDUSTRIAL ECOLOGY: ECO-INDUSTRIAL PARKS - THE PERSPECTIVES FOR THE NEW SMART INDUSTRIAL REVOLUTION

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ABSTRACT

The necessity of changing of the concept of industrial production is one of the crucial elements for sustainable development. According to the old concept, the resources are extracted from the nature, used in the production that creates waste, and finally the same product eventually becomes waste that is expelled into the environment. At each level of production and consumption wastes are generated, and natural environment is bound to be a recipient of these wastes. Nevertheless, one of the possible and necessary solutions for maintaining sustainable development is the implementation of Industrial Ecology, with special regard to Eco-Industrial Parks. The concept of the Eco-Industrial Park appeared in the early 1990s as a new form of industrial organization based on the principles of Industrial Ecology. EIPs are industrial areas in which a certain number of companies cooperate on sustainable resource use, by mutual reusing the waste they generate – the waste produced by one company is used as raw material by another. The goal of industrial ecology is to change the structure of industrial system from linear to closed structure, where industrial wastes are reduced and reused as energy or raw materials for another product or process. Because all resources are finite, besides solar energy, it is of crucial importance to minimize the exploitation and degradation of existing resources, in order to create a long-term sustainable industrial activity. The aim of this work is to demonstrate that the establishment of the Eco-Industrial Park is possible not only in the developed countries, but also in developing and under-developed countries, and in the later they are even desirable and necessary because of all economic and social, besides environmental benefits such parks could bring to those countries. The environmental, economic and social benefits gained through inter-firm networks in an Eco-Industrial Parks are substantial. In other words, eco-industrial networks offer a way to meet the needs of the present without compromising the ability of future generation to meet their own needs.

Key words: industrial revolution, environmental sustainability, eco-industrial parks, waste management, renewable resources

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LIST OF ABBREVATIONS

- **NGO –** Non-governmental organization
- **G77** – Group 77: The Group of 77 is intergovernmental organization of developing countries in the United Nations, which provides the means for the countries of the South to articulate and promote their collective economic interests and enhance their joint negotiating capacity on all major international economic issues within the United Nations system, and promote South-South cooperation for development
- **IE** – Industrial Ecology
- **EIP** – Eco-Industrial Park
- **GTZ** – Deutsche Gesellschaft für Technische Zusammenarbeit (The German Technical Cooperation
- **IEAT** – Industrial Estate Authority of Thailand
- **ISO** – International Organization for Standardization
- **SWOT –** Strengths, Weaknesses, Opportunities, Threats
- **SWOP** - Strengths, Weaknesses, Opportunities, Potentials
- **R&D** – Research and Development
- **RES –** Renewable energy sources
- **SME –** Small and medium enterprises
- **SEZ** – Special Economic Zones
- **GDP** – Gross Domestic Product
- **HVDC** – High-Voltage Direct Current
- **ASEAN –** The Association of South East Asian Nations
- **LNG –** Liquefied natural gas
- **IT** – Information technology

1.0 INTRODUCTION:

It was 150 years ago that John Tyndall, one of history's great physicists, published a scientific paper with the title On the Absorption and Radiation of Heat by Gases and Vapors, and on the Physical Connection of Radiation, Absorption, and Conduction. This topic is nowadays the basis for a vitally important branch of science and a particularly harmful brand of political discourse. What Tyndall had demonstrated for the first time was that gases in the atmosphere absorb heat to very different degrees - he had discovered the molecular basis of the greenhouse effect. His discovery, description and analysis of the molecular basis of the greenhouse effect came more than 30 years before the discovery of either radioactivity or the electron. Tyndall's lab experiments do not prove that humanity's CO2 emissions are warming the planet. But they did show how man-made global warming can work. And he did so 150 years ago. (Taken from the BBC correspondent Richard Black article "Tyndall's climate message, 150 years on", 28 Sept. 2011)

The end of the eighteenth and the beginning of the nineteenth century are associated with the most significant tipping points in the modern history of mankind, for it brought about the revolution that changed the face of nations, giving rise to urban centers and developed social welfare. That revolution created interdependent economic structures, and strengthened relations between capital and labor through laissez-faire doctrines. It caused the expansion of population by improving the standards of life, which remained a primary goal for the whole world in the years to come. Nevertheless, that revolution wasn't neither political, because for its greater and wider effect, nor the overnight revolution even by its definition (*Merriam-Webster dictionary: a sudden, radical or complete change; a fundamental change in political organization; especially: the overthrow or renunciation of one government or ruler and the substitution of another; activity or movement designed to effect fundamental changes in the socioeconomic situation*). It was the Industrial Revolution[1] that came gradually throughout centuries changing completely the life of people in the whole world.

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[1] Joseph A. Montagna, The Industrial Revolution, www.yale.edu

Because of its interconnectedness, the Industrial Revolution grew throughout years as a clew of string. It grew more powerful each year and decade, as new inventions added to the efficiency of machines and increased productivity, bringing economic, social and political changes. The year of 1733 and the James Hargreaves's invention of flying shuttle and spinning jenny 31 years latter was just the beginning of a new era. The inventions that followed were much more complex than the simple machines invented in the 18th century. Industrial technology represented major advances in the large-scale machines and mass production system. Since latter inventions were even more important and revolutionary, the period after the second part of the 19th century onwards earned the title the Second Industrial Revolution: "New scientific knowledge was applied to industry as scientists and engineers unlocked the secrets of physics and chemistry" (Lewis Hackett, 1992).

The world started to shrink: enormous organizations emerged with the necessity for managers to control large international businesses; advances in communication and transportation helped decision-makers to maintain control over their large companies. After the invention of electric telegraph in 1844 by Samuel Morse and telephone in 1876 by Alexander Graham Bell, it became easier to keep in contact with widely dispersed parts of businesses and subsidiaries. "Electric power replaced steam power in factories; it was cheaper, faster and more flexible. It allowed machine tools to be arranged more efficiently. In 1913 Henry Ford introduced the assembly line in the manufacture of his Model T Ford. Parts were assembled in the moving conveyor belt, and the Model T took shape as it moved from one work station to the next. The assembly line greatly increased the speed of manufacture and soon it was used in many industries" (Lewis Hackett, 1992).

But how did the Industrial Revolution affect the environmental changes and exacerbate the challenges to the global climate? Besides all above mentioned, Industrial Revolution also symbolizes the major challenge for the world ecology and human environment. The human impact on natural resources, health and energy use changed dramatically, and not earlier than

1960s has this become the part of statistics and monitoring when the impact was already enormous.

The most evident change is in the world population. Increased living standard resulted in the rapid population growth in almost all parts of the world[2]. From one billion in 1800s to seven billion world citizens today, the population has risen 7 times in just two centuries. One of the contributions to this growth is the development of modern medicine that raised the longevity of the average human life as well as the resistance to various illnesses and diseases. Human population growth is inevitably connected with the proportion of energy and resources use. Radical population growth led to the radical requirements for resources, energy, food, housing and land, and thus it led to drastic increase in waste production.

The illusion of inexhaustible resources was soon to be broken. Until the middle of the 20th century the supply of natural resources needed for industry production always over-exceeded the demand for them. Then the situation reversed. Not earlier than in the 1960s effects of the human outgrowth has been brought before the public. It happened with the publication of the Rachel Carson's book "Silent Spring" in 1962, which raised important questions about environmental impacts. This publication set the basis for the concept of sustainable production and development. No matter how difficult is to accept the fact that what we are facing today, with regard to environmental challenges, is actually the result of the activity that started over 250 years ago, there is no doubt that the lack of knowledge and negligence of the obvious realities has led us to the water and air pollution, degradation of land resources, over-exploitation of natural resources, brutal hazards to ecosystems and enormous and uncontrollable waste production.

So, the question is: are we entering the new era of sustainability? Despite of severe criticism from the side of civil society and various NGOs on the outcomes of the Johannesburg World Summit on Sustainable Development in 2002, the Summit brought some important documents and guidelines for the future actions. Criticism was mainly based of the resistance

[2] www.ecology.com

of the US government in taking responsibility and actions in preserving sustainable development and blocking progress on it, European Union was perceived as too weak a negotiator, and G77[3] and China were too focused on getting new funding on their development. *Civil society described the Summit as the missed opportunity to come up with meaningful plan of concrete targets, timeframes and funding for the implementation of the Agenda 21*(www.worldsummit2002.org). But, the Summit accelerated the necessity and urgency to realize the commitments given at the Rio Earth Summit one decade before, through the Political Declaration concerning world governments, and the Plan of Implementation that is created as a guideline for the governments in that respect. Amongst other concerns, the Johannesburg Summit paid special attention to the Industry - Environment interactions, with the aim of implementation of monitoring processes in industrial activities that could pose severe threats to human and natural environment.

The necessity of changing of the concept of industrial production is one of the crucial elements for sustainable development on the global, regional, and local basis. According to the old concept, the resources are extracted from the nature, used in the production that creates waste, and finally the same product eventually becomes waste that is expelled into the environment. Nature is already giving evident signs that it has no capacity of absorbing that amount of waste product. Industrial production activities begin its impact on the environment from raw material exploitation and extraction, transformation into products, and use and disposal of the products by the final consumers. At each level of these activities wastes are generated, and natural environment is bound to be a recipient of these wastes. Nevertheless, one of the possible and necessary solutions for maintaining sustainable development is the implementation of Industrial Ecology, with special regard to Eco-Industrial Parks.

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[3] The Group of 77 is the largest intergovernmental organization of developing countries in the United Nations, which provides the means for the countries of the South to articulate and promote their collective economic interests and enhance their joint negotiating capacity on all major international economic issues within the United Nations system, and promote South-South cooperation for development.

1.1 AIMS AND OBJECTIVES

The aim of this study is to prove the demanding but also challenging statement that the Industrial Ecology, and especially Eco-Industrial Parks, as one of the crucial tasks of the world today with the aim of sustainable development, are applicable in many types of economies and societies. The aim of this work is to demonstrate that the establishment of the Eco-Industrial Park is possible not only in the developed countries, but also in developing and under-developed countries, and in the later they are even desirable and necessary because of all economic and social, besides environmental benefits such parks could bring to those countries. Based on the existing case studies, the aim of this research is to explain the potential benefits and practically create a model for those countries where there are no designed Eco-Industrial Parks, but just scarce individual cases of spontaneous cooperation in waste management. Aims:

- To identify and select already existing designed Eco-Industrial Parks in developed countries;
- To identify and select already existing designed and/or spontaneous Eco-Industrial Parks in developing and/or under-developed countries;
- To identify if there are possible common patterns in establishment of Eco-Industrial Parks in both cases;
- To identify environmental, economic and social benefits of Eco-Industrial Parks in developing and/or under-developed countries compared to those in developed countries.

2.0 THEORETICAL BACKGROUND

One of the eight Millennium development goals that need to be fulfilled by 2015 is the one of environmental sustainability, and one of four targets of the Goal 7 (environmental sustainability) is to *"integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources"*[4]. The Brundtland Commission at the 42nd session of the United Nations General Assembly in 1987 defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[5]

But with the accelerated industrial production and uncontrolled rise in world population, the world is facing many challenges in meeting the objective of sustainable development and environmental sustainability. Environmental issues are global and systematic and thus need a systematic approach in making parallel between human practices e.g. industrial activities, and environmental and ecological processes. Industrial Ecology is the crucial effort to create a new framework for understanding the impact of industrial systems on the environment - *to identify and then implement strategies to reduce the environmental impact of products and processes associated with industrial systems, with an ultimate goal of sustainable development* (Pollution Prevention and Industrial Ecology, National Pollution Prevention Center for High Education; Industrial Ecology: An Introduction, Garner et al. 1995).

Robert Frosch and Nicholas Gallopoulos, in their important article "Strategies for Manufacturing" (Scientific American 261, Sept. 1989, 144-152), developed the concept of industrial ecosystems, which led to the term industrial ecology. This metaphor between industrial ecology and natural ecosystems is fundamental in industrial ecology. This metaphor refers to the natural system which in its evolution through millions of years

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[4] UN Millennium Goals, www.un.org/millenniumgoals

[5] Our Common Future, www.un-documents.net

developed from an open to a closed, cyclical system with the balance and stability between all living creatures and chemical processes on Earth. This system is closed because nothing can actually leave the system: wastes from one organism are used as substrates for another; food chain is the concept of the cyclical network where organism feeds on one organism, or is a food to another one. And the waste produced is nutrient for simple forms of living creatures. The goal of Industrial Ecology is to practically "mimic" the natural system in reaching the dynamic equilibrium in high degree of interaction and interconnectedness.

"Both natural and industrial system has cycles of energy and nutrients of materials. The carbon, hydrogen and nitrogen cycles are integral to the functioning and equilibrium of the entire natural system; material and energy flaws through various products and processes are integral to the functioning of the industrial system." (Garner et al. 1995).

According to Jelinski (1992) industrial systems appear in three forms: linear unsustainable industrial systems, semi-mature systems and sustainable mature closed industrial systems. In the first case resources are extracted from the environment, used in production that generates waste, and dispersed in the consumption that also generates wastes. The second type is the closest to the present industrial systems, where some of the wastes are recycle, while most of it is exposed to the

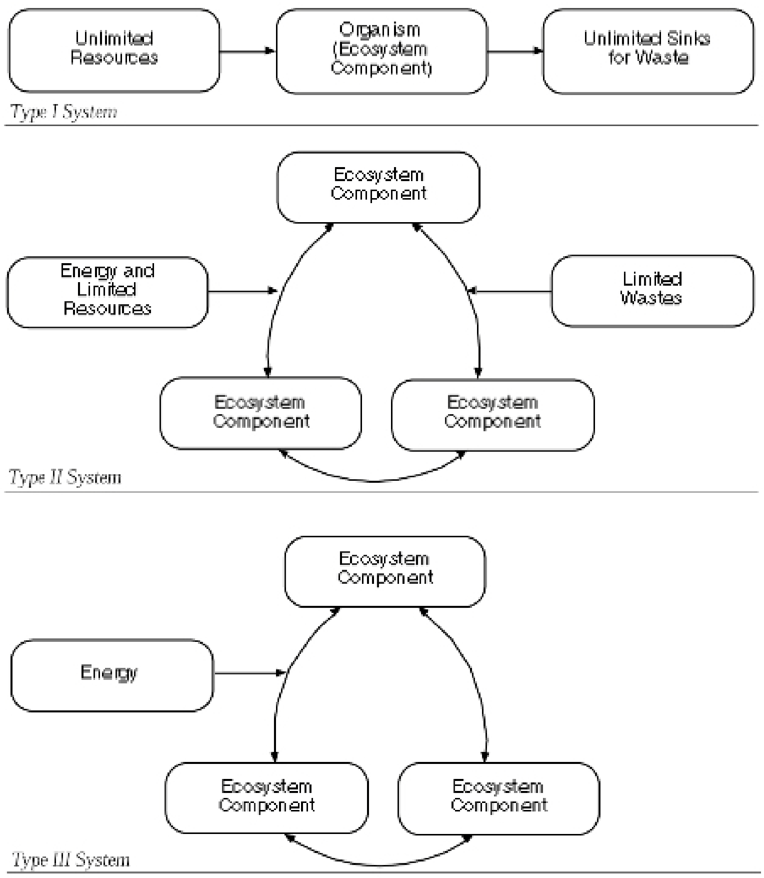

FIGURE 5: SYSTEM TYPES

Source: Braden R. Allenby, "Industrial Ecology: The Materials Scientist in an Environmentally Constrained World," *MRS Bulletin* 17, no. 3 (March 1992): 46–51. Reprinted with the permission of the Materials Research Society.

environment. And the third type is the hypothetical situation where energy and wastes are constantly recycled in the closed integrated system. In this perfect system, only solar energy would come from the outside, while all by-products would be constantly recycled and reused within.

The goal of industrial ecology is to change the structure of industrial system from linear to closed structure, where industrial wastes are reduced and reused as energy or raw materials for another product or process. Because all resources are finite, besides solar energy, it is of crucial importance to minimize the exploitation and degradation of existing resources, in order to create a long-term sustainable industrial activity. By input quantification and generation of residuals, decision-makers can minimize the environmental burden of their businesses. In recent years, governments and industries all around the world are focusing their efforts to reach environmental sustainability.

By using the Material Flow Analysis[6] they can manage conserving the resources and reducing by-products and wastes by affecting the entire life-cycle of materials, improving choices of materials and anticipating resource conservation *(Using Material Flow Analysis for Sustainable Materials Management, Allen, Halloran et al, Journal of Industrial Ecology, Volume 13, Number 5).* Therefore, IE refers not only to environmental issues, but also to the economics, new technologies, relations with businesses and financing, government policies, and a wide spectrum of many other related issues that can enhance the role of environmental sustainability in the decision-making processes, especially at a regional level. Special attention is given to the expansion of IE concept in the developing countries, where population growth along with the increasing need for production uncontrollably exhaust scarce resources.

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[6] The underlying idea is that one may be able to identify transitions from one type of societal metabolism to another by tracking these material and time measures or to distinguish alternative forms of industrial and post-industrial systems of societal organization (Using Material Flow Analysis For Sustainable Management, The Journal of Industrial Ecology, Volume 13 Number 5; Frederick W. Allen, Pricilla A. Halloran, Angela H. Leith and M. Clare Lindsay)

2.1. ECO-INDUSTRIAL PARKS

The concept of the Eco-Industrial Park appeared in the early 1990s as a new form of industrial organization based on the principles of Industrial Ecology. EIPs are industrial areas in which a certain number of companies cooperate on sustainable resource use, by mutual reusing the waste they generate – the waste produced by one company is used as raw material by another. Such an approach is directly addressing the corporate social responsibility and inter-organizational environmental management. The value of this concept is in the fact that it is not a sector-specific collaboration, and gives the opportunity for various businesses to enhance their environmental performance, as well as economic benefits. All the benefits of EIPs are not yet pursued due to the relatively short timeframe of their establishment throughout the world and the lack of a comprehensive model to evaluate the existing projects of such industrial symbiosis. There are around 150 EIPs around the world, concentrated in Asia, Europe and North America.

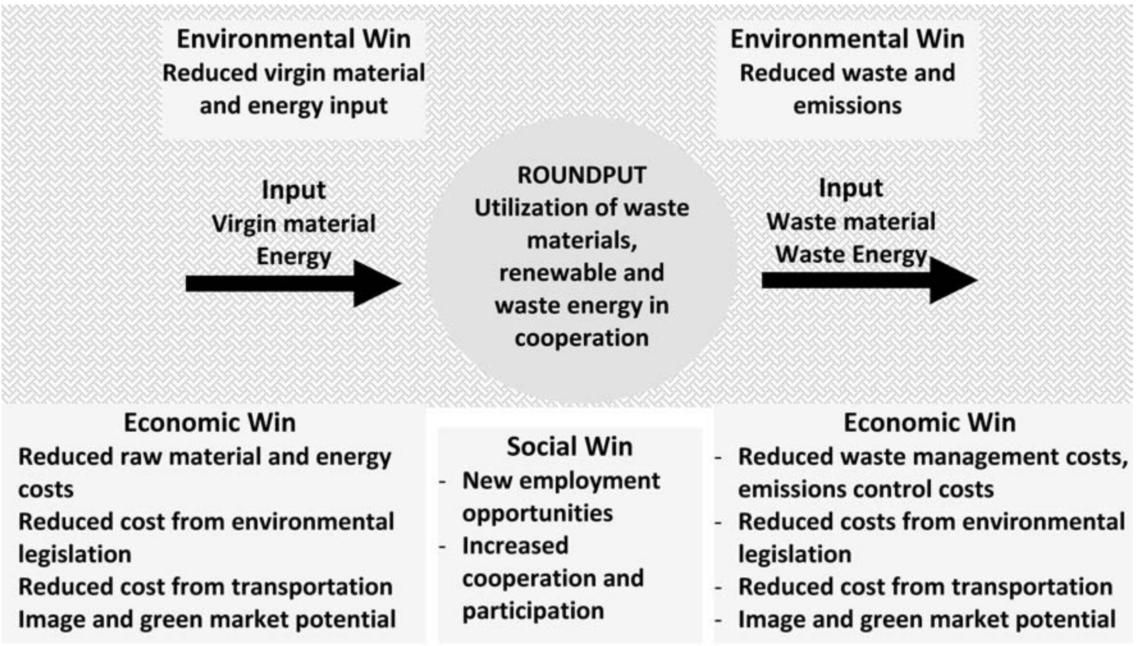
The idea is first to understand how the industrial system works, how it is regulated, and its interactions with the biosphere; then, on the basis of what we know about ecosystems, to determine how it could be reconstructed to make it compatible with the way the natural ecosystems function (*Industrial Ecology: a new perspective on the future of the industrial system, Suren Erkman, Institute for Communication and Analysis of Science and Technology).* "By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance. An eco-industrial park also looks for benefits for neighboring communities to assure that the net impact of its development is positive" (Lowe, 2001)

Cote and Cohen-Rosenthal (1998) defined EIP as a community in cooperation and interaction, efficiency in the use of natural resources and through its system view. The cooperation between companies can be established in two ways: spontaneously created linkages between companies that had mutually advantageous activity (self-designed EIPs), or constructed and designed parks. Self-designed EIPs vastly outnumber the designed ones as for they evolved without management and administrative planning. They exist all around the world and they are probably numerous, since in most cases such establishments are not identified and documented.

EIPs aim at achieving not just environmental, but also economic and social benefits. By reducing necessary raw materials and waste, energy and emission control costs, they contribute to the reduction of production costs, and therefore enhance business advantages and competitiveness of companies. Enterprises collaborate to ensure optimal resource management. Companies are competing on the market with their competitive advantages. But raising effectiveness of energy and material flows can decrease the need for resources/inputs, and that will ensure increased performance of companies and industries. Therefore, it would directly lead to higher competitive advantages, and that is the main reason why small and medium enterprises actually put industrial ecology principles into practice, since, unlike large corporations, they cannot normally afford corporate social responsibility activities, or environmental protection standards in their performance.

Eco-Industrial Parks also give the opportunity for small companies to have various benefits besides immediate profits. It is not the matter of excessive expenditures; it is the matter of managing business, regardless of its size. Industrial Ecology and Eco-Industrial Parks are focusing on a long-term development of the entire industrial systems, and environmental issues are just one part of the whole picture they are trying to deal with. Virgin raw materials and energy use are reduced and replaced by wastes and by-products in the area. Emissions are also reduced and the biodiversity is protected. The social benefits in the area create more jobs and improve working conditions. Attention is also paid to the total well-being of the entire community.

Benefits of Eco-Industrial Parks[7]



Kurup et al. (2005)[8] have developed a set of indicators allowing for improved identification and reporting of the economic, social and environmental benefits of industrial symbiosis, and with it eco-industrial projects.

Economic Indicators:

• generate local business opportunities

• generate capital works

• sales

• profit

• wages paid

• taxation revenue

• tangible environmental costs

• transport costs

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[7] Eco‐Industrial Clusters in Urban‐Rural Fringe Areas, A strategic Approach for Integrated Environmental and Economic Planning, Asian Institute of Technology Thailand

[8] B. Kurup, W. Altman, R. Van Berkel, Triple bottom line accounting applied for industrial symbiosis. *Australian Life Cycle Assessment Society Conference.* Sydney, Australia, 2005

It is essential to indicate that the direct costs are often a poor indication of total waste disposal costs. When calculated, it should include loss of raw material within the waste and their replacement, labour to collect and transfer the material for collection, cost of management systems, licencing and administration cost and cost of equipment to handle or treat waste etc.

Environmental Indicators:

- land use
- biodiversity
- energy consumption
- water consumption
- air, land and water emissions
- material consumption

Kurup et al. (2005) argue that these environmental indicators should comprehensively reflect on short and long term environmental impacts of the project throughout the project life cycle stages. They also suggest that environmental indicators can be very difficult to quantify and it would be useful to list the potential impacts and assign the direction of the impact with an estimate of the size ranging from minor to major.

Social Indicators:

- job creation
- job security
- skill level
- health and well being
- community stability
- education standards
- level of community services
- crime rates
- sensory stimuli (such as, aesthetic or visual, noise, dust and odour)

Like environmental impacts, it is difficult to quantify social impacts as well. Kurup et al. (2005) argue that they should be listed with an indication if the impact is negative or positive and some indication of the magnitude from minor to major to assist decision makers.

There are no general principles or guidelines for designing an Eco-Industrial Park. There are no general codes that are applicable universally, since EIP projects are site-specific. Nevertheless, there are some principles that could be followed in the realization of an EIP (Cote and Cohen-Rosenthal):

- Define the community of interests and involve that community in the design of the park.
- Reduce environmental impact or ecological footprint through substitution of toxic materials, absorption of carbon dioxide, material exchanges and integrated treatment of wastes.
- Maximize energy efficiency through facility design and construction, co-generation, and cascading.
- Conserve materials through facility design and construction, reuse, recovery and recycling.
- Link or network companies with suppliers and customers in the wider community in which the Eco-Industrial Park is situated.
- Continuously improve the environmental performance of the individual businesses and the community as a whole.
- Have a regulatory system that permits some flexibility while encouraging companies to meet performance goals.
- Use economic instruments that discourage waste and pollution.
- Employ an information management system that facilitates the flow of energy and materials within a more or less closed loop.
- Create a mechanism, which seeks to train and educate managers and workers in new strategies, tools and technologies to improve the system.
- Orient its marketing to attract companies which fill niches and complement other businesses.

Business characteristics and location are crucial factors in designing a functional and successful EIP[9]. Therefore, economic and geographic environment set the guidelines for each EIP project. For a success of an attempted EIP it is important to find a match in the exchanges of materials and energy between companies involved, so they can provide more or less perfect flow among themselves, which has to be continuous and sufficient. Collaboration between companies within an EIP is different than in ordinary circumstances, because companies are not focused just on bare competence and profits. The decision-making process is therefore different, and some decisions are delivered above the company level. That means that companies included in the EIP must be willing to lose a certain level of autonomy and flexibility in their decision-making process. For this reason, all the benefits must be perfectly understood and clear to all the actors of the EIP project. The companies have to be convinced of the economic and environmental improvements to be gained when included within an EIP. This is especially important to small and medium enterprises.

Since most of the companies are not fully aware of the advantages of the efficient use of natural resources and eco-industrial networking, this kind of collaboration is most effective when it is applied to large corporations which already have existing environmental activities. Previously established cooperation and institutional and/or infrastructural platforms are essential in developing the EIP project. This networking is the source of already established mutual trust and interactions between the actors of the EIP. With already established cooperation, it would be easier to maintain the information flow and the transfer of ideas and know-how. It is important to companies to share similar corporate values and culture. This can prevent conflicts, delays, transaction costs etc.

There is a risk of a potential power imbalance within the EIP when companies in the network are very different in the size, especially when there is a large power plant as a central actor of the organization, and the others are small companies in size, number of employees and

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[9] Eco-Industrial Parks, A background report for the eco-industrial park project at Rantasalmi, Publications of Regional Council of Etela – Savo 71:2006

revenue. Contracts are important control mechanism between them. An imbalance of power can pose the threat of monopoly phenomenon if one company becomes dominant within the network, as an exclusive provider of services or products.

It is also important to include the community in the planning phase of the EIP project. Eco-industrial parks can provide jobs in the area, contribute to education, engage the community in emergency preparedness, and integrate services like recreation, well-being and day-care with the community.

Any industrial park is interdependent with the surrounding community and relies on it for human and material resources, services, and trade. Local citizens are usually involved in hearings conducted by planning agencies, which must approve the developer's master plan and environmental impact assessment. The workforce for park tenants generally comes from nearby towns and may require training given by local educational institutions. Employees new to the area also require housing. Local businesses provide materials, parts, and services to companies in the park. Water and sewage, energy, solid waste, and transportation infrastructure is usually operated by local jurisdictions. Local and state/provincial environmental agencies require reports and are responsible for enforcement of regulations. Citizen activists may mount major protests if industrial park developers and managers ignore their concerns about pollution and other impacts. Company site-location teams often evaluate the quality of life of the community, not just the industrial location.

For all of these reasons, it is very important that the leaders in an eco-industrial park initiative build strong relations with their host communities. Community involvement is supported by the many benefits industrial parks offer through the new jobs and businesses they create. The project may also invest in community enhancement programs to provide return for the support the public sector offers. Companies, developers, agencies, and citizens need to work together closely to capture the benefits of this innovative concept.

3.0 METHODOLOGY

Since this study is not based on quantitative data analysis, the methodology included the analysis of qualitative data available and comparative analysis of selected groups of Eco-Industrial Parks. By this study I tried to assess the environmental performance of industries involved in various symbiotic associations. In this study, the success in environmental performance of Eco-Industrial Parks used as case studies was measured indirectly, by using the reports of their performance, mostly on annual basis, using information gathered from a wide range of literature, and then compared with each other. For every case study I tried to gather information on the economic and social environment of the country where a certain EIP is based, the existence of legal background for enabling the establishment of an EIP, and the actors and performance of the existing EIP. At the end, I tried to summarize the lessons learned from all the cases included, with the special focus on environmental, as well as social benefits from the establishment of EIPs.

3.1. DATA COLLECTION

Since this field of study is still evolving there is a problem in gathering standardized data on the topic. In 1993 the United Nations published guidelines for a System of National Environmental and Economic Accounts with the aim at systematization for the use of statistical institutions worldwide as detailed accounting for material and energy flows in physical units. Various classification schemes have been developed for environmental accounts, but they are still not standardized as for instance Standard Industrial Classification, that collects and analyses economic data about production. The challenge in the impact assessment is to evaluate the significance of hundreds of inventory items in terms of small number of indicators (Hertwich et al. 1997). The various methods employed in analyzing the data obtained from a diverse literature search are explained here. Information contained in the majority of the consulted literature includes basically qualitative and to some extent, quantitative data of the selected reference cases. Relevant literature for this study was taken from scientific literature analysis and abstracts, scientific journals, magazines, e-books, as well as web-based case studies.

3.2. SELECTION OF ECO-INDUSTRIAL PARKS USED IN THE STUDY

Since the most EIPs are located in South East Asia, Europe and North America, one criterion for the selection of the case studies was geographic location. This attribute leads to another criterion, and that is the fundamental difference in the socio-economic, cultural, historical demographical and political background of these regions.

- Kalundborg Eco-Industrial Park, Denmark, Europe
- Kawasaki Zero Emission Park, Japan, Asia
- TaigaNova Eco-Industrial Park, Alberta, Canada, North America
- Map Ta Phut Eco-Industrial Estate, Thailand, Asia
- Additional Case: Hyderabad Eco-Park, India, Asia

4.0. RESULTS

4.1. KALUNDBORG, DENMARK

The town of Kalundborg is situated 112km from the city of Copenhagen. The Danish Government offered a number of incentives for industries to move to this area as part of a Government strategy to locate industries away from the city of Copenhagen. It consists of five municipalities, with a population of approximately 20,000. There are five major processing industries and a waste processing facility located within a 130 square kilometre area. The EIP in Kalundborg[10], Denmark is the establishment of cooperation between participating companies developed spontaneously over a number of decades. This example of EIP is mostly used as a benchmark for designing a new EIP, because every project in Kalundborg Park is environmentally and financially sustainable.

There are around 20 projects carried out in this EIP. In short, the beginning of the symbiosis was in 1959 with the Asnaes Energy Power Station, a coal-fired power plant, which produces heat for the town of Kalundborg. It produces heat also for pharmaceutical plant Novo Nordisk, then enzyme producer Novozymes, and process steam for oil and refinery Statoil. Excess heat is transferred to a fish farm. Cement manufacturers started receiving fly ash from power plant in 1979.

Kalundborg municipality started receiving waste heat from power plant for district heating in1981. Use of refinery treated effluent water by power plant in fly ash stabilization. Use of flare gas from Statoil as a supplementary fuel by power plant started in 1992. Green houses use a residual waste by refinery and power plant.

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[10] Eco-Industrial Parks, A background report for the eco-industrial park project at Rantasalmi, Publications of Regional Council of Etela – Savo 71:2006

Fly-ash from Asnaes is used for cement making, and nickel and vanadium are recovered from the ash, whilst gypsum from the desulphurisation of the flue gas is supplied to Gyproc for construction materials. Statoil send wastewater to Asnaes for reuse, some of which is returned as steam. Novo Nordisk supply by-product yeast slurry from insulin production for pig fodder, and Novozymes provide by-product biomass by pipeline to farmers for replacement fertiliser. The system of exchanges developed because of the openness, close cooperation and mutual trust that existed in the relatively tight knit business community (Jacobsen, 2003).

4.1.1. REVIEW

Location: Kalundborg, Denmark, Europe

Actors:

- Municipality of Kalundborg
- Asnaes Power Station – Denmark's largest power station, with three active units. It produces the district heating for the Municipality of Kalundborg
- Plasterboard factory BPB Gyproc – Takes delivery of the recycled gypsum powder for the use in the production of new virgin boards.
- Pharmaceutical plant Novo Nordisk – Manufactures and markets pharmaceutical products and services, with the focus on diabetes prevention and treatment
- Enzyme producer Novozymes – Company's core business is industrial enzymes, microorganisms, and biopharmaceutical ingredients. A company is based on bio-innovation, fermentation and the production of proteins.
- Oil refinery Statoil
- Bioteknisk Jordrens Soilrem – A company set up with the aim of remediating contaminated soils. They are experts in the treatment of soils that have been contaminated with petrol or other fuels, organic solvents and heavy metals.
- Waste company Noveren – Company's basic activities are reloading of waste for incineration, reloading of Iron and Metals, compositing of waste from gardens and parks, handling of compostable household-waste, reuse of concrete from construction and demolition.

Achievements:

- Diverts tons of waste materials from being absorbed by earth
- Reduces water consumption by 1.200.000m3 per year
- Reduces coal consumption by 30.000t per year
- Reduces oil consumption by 19.000t per year
- Reduces CO_2 emissions by 130.000t per year
- Reduces SO_2 emissions by 25.000t per year
- 2.1 million tpa potable water replaced by surface water
- Energy savings equivalent to 30,000 tpa coal and 19,000 tpa oil
- 280,000 tpa waste diverted from landfill (fly-ash, scrubber sludge etc)
- Replaced 200,000 tpa gypsum use and 2,800 tpa sulphur
- Total investment U$ 75 million
- Total annual savings U$ 15 million
- Accumulated savings U$ 160 million

Outcome:

Reduced consumption of resources and a significant reduction in environmental strain are achieved. Waste exchange comprises some 2.9 million tons of materials each year, collective water consumption had been reduced by 25%, and the power station has reduced its water use by 60% through recycling. The collaborating partners also benefit financially. Other benefits for industries are related to sharing of personnel, equipment and information.[11]

[11] Henning Grann, The Industrial Green Game, National Academy Press, 1997

4.2. KAWASAKI ZERO EMISSION INDUSTRIAL PARK, JAPAN

Kawasaki City[12] is home of one of Japan's oldest and largest industrial parks. Established in 1902, Kawasaki Coastal Industrial Area[13] houses over 50 heavy industrial enterprises in a 250-acre area. Its largest tenants consist of oil refineries, steel manufacturers, power generators, and chemical manufacturers. The City of Kawasaki is located adjacent to Metropolitan Tokyo and has a population of 1.2 million. The strength of Kawasaki City is that it has a well-established transportation infrastructure that includes ports, railroads, canals, and energy facilities, which are indispensable to resource-related companies. In addition, this area has a high concentration of Japan's leading large industrial firms, and also a large number of medium and small size enterprises in the field of resource recycling, and various environment-related facilities.

Through the close integration of existing infrastructure and industrial elements, Kawasaki found an amazing opportunity to create an operationally competitive resource-recycling system. The existing synergies involving the exchange of materials among participating companies in the Kawasaki Zero Emission system are as follows: use of fly ash in cement manufacture, use of plastics as injection material in blast furnaces of iron works, recovery of home waste electronics appliances, use of incineration ash in the production of molten slag, conversion of gasification treated shredder dust to carbon dioxide and hydrogen, which are generated to chemical plants for the manufacture of products such as ammonia, methane, and methanol.

[12] www.icett.or.jp

[13] Wuppertal Institute for Climate, Environment and Energy, Eco Town Program, Bettina Bahn-Walkowiak, Raimund Bleischwitz, Atsuko Takano, 2007

4.2.1. REVIEW

Location: Kawasaki City, nearby Tokyo, Japan, Asia

Actors: 16 businesses operating in the Complex

Achievements:

- Diverted 1.816 tons per year of industrial wastes from being absorbed in the land;
- Reduction in 30.000 tons per year of plastic wastes by recycling and injecting industrial plastic wastes;
- Reduction of 400.000 – 500.000 units per year of waste home electronic appliances through recycling;
- Reduction in 360 tons per day of municipal discharges and solid wastes to produce chemical synthesis as intermediary for ammonia production;
- 21.070 tons per year reduction of CO2.

Outcome:

Acquisition of joint certification of ISO 14001 for the entire complex, setting of higher reduction targets than emission standards of the generated environmental burden, joint reception by the neighboring businesses of the electricity from the surplus electricity, effective use of sewage water offer advanced treatment as an alternative for water for industrial use, utilization of sewerage sludge ash as raw materials in cement in a nearby factory.

The practice of near zero-emissions production among Japanese breweries and manufacturing industries is a step in the right direction. While this practice is, for now, clearly a result of business responding to increased environmental concerns of consumers and the public and to the initiatives of their business competitors, the amount of waste materials generated and the number of potential uses for them suggest that there may be clear economic and cost advantages to be had as well. Tighter waste management regulations and the increasing cost of waste disposal will promote this increasing tendency toward zero emissions.

4.3. ALBERTA, CANADA

Fort McMurray is the urban center of the Regional Municipality of Wood Buffalo, Alberta, and is one of the Canada's youngest, fastest-growing and most dynamic places. Taxes are among the lowest in the country and contribute to the cost-effective advantages of doing business. Alberta EIP[14] is located 7km north of Fort McMurray's town center, on the east side of Highway 63. This highway is the main route connecting the town to the major oil sands operations to the north and the city of Edmonton to the south. Alberta has the lowest unemployment rate in the country at 6% (compared to the 7.6% nationally as of December 2010) and a recent report by economists Todd Hirsch and Dan Sumner confirms that the "job market in the province remains among the best in the North America".

4.3.1 REVIEW

Location: Wood Buffalo, Alberta, Canada, North America

Actors:

Businesses:

- Athabasca Chipewyan First Nation Business Group (ACFN Business Group): manages business ventures which benefit the ACFN. Among others, their ventures include:
- Waste management and maintenance service
- Full-service repair of heavy and light duty automotive equipment
- Janitorial cleaning
- Specialized ultrasonic industrial cleaning
- Tire collection and recycling
- Survey, engineering consulting, environment project management
- Road building and earth works

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[14] Aromatic Availability and Utilization Study For Alberta Economic Development and Alberta's Industrial Heartland, T. J. McCann & Associates, 2001

- D’Laundromat: provides personal, commercial and industrial laundry services; they provide commercial and industrial eco-friendly laundry services to all plant sites in Fort McMurray.
- P-Ban Trucking: major business activities – boom pumping, industrial and commercial concrete floors, laser screening. P-Ban Enterprises has a very versatile fleet of pumps for this area. P-Ban received the Work Safe Alberta 2007 Best Safety Performer for Exceptional Performance in workplace health and safety.
- Stony Valley Constructing: company with its head office in Fort McMurray. It is a multi-faceted business, from managing the supply and production of aggregates to light civil earth projects. Some of the services they provide: aggregate exploration, approvals and permit applications, development, engineering and design including final reclamation, delivery of processed materials to site, light civil work, hydraulic excavators, rock trucks and dozers etc.

Contractors / Service Providers:

- ATCO Gas – owning and operating a safe, reliable natural gas distribution system to municipal, residential, business and industrial consumers, offering energy efficiency programs for businesses
- Camdon Construction – specialists in the design build and project management methods of construction for light industrial and commercial projects
- Denali Construction – full-service general contractor in the field of engineering
- ESC Automation / Delta Controls – provides clients with cost-effective building automation solutions for new construction projects, retrofits, mechanical maintenance and monitoring systems
- Ledcor – a full-service construction company offering project and construction management, pre-construction management, general construction and design-building services, with experience in “green” building projects
- Otis – Gen2 L-Series Elevator – a cost-effective and environmentally friendly traction system for the low-rise market
- Superior Safety Codes – FAQ and information on building permits

Green Products – Materials:

- Green Alberta – free, searchable database of green building products and materials
- Light House Sustainable Building Center – free, searchable database of green building products and materials, includes western Canada distribution

Commercial Lenders: a. Business Development Bank of Canada, and b. TD – Alberta Commercial Banking Group (they provide commercial lending and financial services to businesses involved in green development projects).

Green Incentives and Funding:

- EcoENERGY Retrofit Incentive For Industry – financial incentive of up to 25% of project costs to maximum $50.000 per application and $250.000 per corporate entity to help small and medium sized industrial facilities which implement energy-saving projects
- EcoENERGY Renewable Heat – incentives are offered to the industrial, commercial and institutional sector to install active energy-efficient solar air and/or water heating system.

Achievements:

- Landfill biota not destroyed
- Life-cycle energy saved from 438 tons of virgin spent caustics (corrosive substances, mostly strong bases like sodium hydroxide NaOH) in place of virgin materials;
- Energy savings through 951.720 tons per year of wood wastes used in pulp industry, building paperboards etc;
- Reduced Chloride content by more than 200% in 2000 tons of Salt Cake (sodium sulfate) per year
- Reduction in 30.000 tons per year of Ammonia used in industrial/municipal wastewater treatment
- Destruction of spent caustic Sulfurous odors in the mill recovery boiler
- Reduction in 40 million tons per year of Carbon Dioxide emissions used in wood and beverage industry.

Outcome:

Address to current shortage of industrial land in the Fort McMurray area, support the business needs of the resource sector and the local economy, to take a leadership role in sustainable industrial development, minimize environmental impact and enhance quality of life, make buildings that will be at least 25% more efficient than the Model National Energy Code, reduce environmental impact during construction, consider strategies to reduce resource use, reduce waste generation and increase land use efficiency, effective use of land management strategies which increase the amount of serviced industrial land brought to market.

Safety objective is “zero loss”, their processes adhere to the roles and policies of customers, regulatory agencies and good industry practices. Loss Prevention Program is effectively designed to identify and control or eliminate practices and conditions which have the potential to cause personal injury, financial loss or adverse effect upon the environment.

Different types of infrastructure technologies are constantly being developed from more efficient green sewer systems to high speed telecommunications cables. Industrial parks can easily become obsolete due to old, inefficient infrastructure technology. Green infrastructure comes in many forms, but is usually interconnected, site-appropriate, and has a lower environmental impact than traditional infrastructure.

4.4. MAP TA PHUT ECO-INDUSTRIAL ESTATE, THAILAND, ASIA

The Map Ta Phut is the largest in industrial estate in the Rayong Province and was established in 1985. It was reserved for the petrochemical industry and its downstream processes, and houses 89 factories with 11,500 employees (GTZ/IEAT, 2001). The local Industrial Estate Authority of Thailand (IEAT) provides the management platform to identify and realise industrial symbiosis opportunities. There are seventeen examples of industrial symbiosis including (GTZ/IEAT, 2001): five cogeneration plants supplying electricity and steam to the petrochemical industry; waste solvents recycled through distillation; waste oil used as an alternative fuel for cement kilns; ferrous chloride and hydrochloric acid are collected (~640,000 tonne/yr) and used in ferric chloride production. Map Ta Phut[15] is a pioneer in the application of the principle of eco-industrial development in the country.

The development of this industrial estate is based on ecological concept. It presents the nucleus for all the factories in the estate, to promote cooperation in resource and environmental management in relation to the utilization of raw materials, energy and water, and enhancing the quality of life of the nearby communities. Every factory of this estate applies the principle of eco concept at the final stage, following its use and application of waste minimization technology, clean technologies, ISO 14001, and responsible care.

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[15] Fostering Industrial Symbiosis for Regional Sustainable Development Outcomes, Steve Harris, Rene van Berkel and Biji Kurup, 2008

4.4.1. REVIEW

Location: Map Ta Phut Sub-district, Rayong Province, Thailand

Actors: The actors involved are factory owners and entrepreneurs, industrial estate developers, service companies, resource recovery enterprises, waste management enterprises, government agencies and the local community.

Achievements:

- Diverts tons of waste materials from being absorbed in land;
- Energy savings by alternative use of 6.300 and 5.500 tons per year waste oil as the fuel for cement manufacture and as raw materials for oil paints;
- Reduced 4.200 tons per year of Fe, Cu, and Al by recovery.
- Reduced 165 tons per year of sludge oil and oily catalyst due to incineration;
- Reduced industrial gas production of Hydrogen and Nitrogen by 80 tons per year.
- 80 tpa solvent recovered
- 11,800 tpa waste oil reused as fuel and/or for oil paints
- 20,000 tpa scale, dust and refractory material used as cement raw material
- 640,000 tpa ferrous chloride/hydrochloric acid recovered

Outcome:

Minimize production costs by increasing efficiency of resources, energy and waste recycling management; improves the potential for business success by minimizing the costs of raw materials, energy utilization and waste treatment and disposal; promotes competitiveness in the global market since the production and operation processes are based on environmentally-friendly principles. It reduces sources of pollution and waste products; rationalizes natural resources utilization; supports the principle for sustainable development; provides good exemplary models of environmentally-friendly businesses. As for communities, it minimizes the negative impacts on communities and enhances their quality of life; strengthens the communities economically by creating new jobs and professions; minimize wastewater and solid waste discharges, and reduces construction costs of wastewater treatment system and solid waste disposal system.

4.5 ADDITIONAL CASE – HYERABAD ECO-INDUSTRIAL PARK, INDIA, ASIA

Novel approach to raising environmental awareness is developing in India. What makes this case interesting is that the women are taking a great part in its functioning. Many of them come from the countryside, without education and a chance to find employment. Some of them are driving trucks for collecting rubbish in the EIP, and then sort it by their own hands, separating plastic, paper, glass and metal, so it can be sold. Although they have modest incomes, before this employment they in most cases did not have any income at all, at least not on a regular basis. In the not so remote past, the garbage was left to rot in dumps or burnt. Now it is sorted and recycled by women employed in EIP. On a daily basis, about 9 to 10 tons of garbage is managed properly in this park.

Hyderabad in southern India is a rapidly growing industrial metropolis, of about 6 million people. In the area, there are dozens of industrial parks, but factories stand in the middle of residential areas and heavy trucks fill the streets, and all the exhaust fumes are simply pumped up in the air. Until now, not a lot of thought was given to environmental protection, mostly for economic and demographic reasons.

Managers of the industrial parks wanted to raise awareness of environmental protection. Their first step was to build special channels for collecting rain water. In the past, heavy monsoons often flooded the entire factories and toxic substances were washed out and then left to soak into the ground. Now the rain water is channeled away. The park is looking to collect all the industrial waste water and purify it in the “Common Effluent Treatment Plant – Macharam & Mallapur I.E.’s”. Their job was to convince the companies’ directors that protecting the environment is a worthwhile investment. Chemical and pharmaceutical company “Salicylates & Chemicals Ltd” consumes a lot of power. Poorly isolated pipes meant that the company was using more energy than necessary; now the pipes are isolated properly and the company is already saving nearly 9000Eur annually. Solicylates is a supplier for the chemical industry, and going “green” is also good for a company image, besides the fact that it is now saving nearly 1200 tons of CO_2 a year with a growing potential for the future. The boiler, for example, is still heated by the coal fire.

Right next-door is the printing company "The Times of India". Outside the premises is 42 degrees Celsius, and the air-conditioning alone consumes a lot of electricity. But with the few adjustments to it, they have already cut the electricity consumption by over 22000 kWh a year, which means several thousands of Euros. On the roof there are simple, but effective adjustments – sun shades, which protect the heat exchanges for the air-conditioning from the blazing sun. They are planning to introduce solar power lamps, and the first ones have already been installed. The German Developing Agency GIZ believes there is still a lot more to be done; it's looking to get more company managers on board and is reaching out for women directors in particular.

Potential to the Hyderabad EIP to cut carbon emissions for 3.8 million tons a year is a major achievement[16].

[16] Report International Conference on Eco Industrial Parks July, 2009, Hyderabad, India

5.0. EIPs ANALYSIS – SWOP (STRENGHTS, WEAKNESSES, OPPORTUNITIES, POTENTIALS)

Usually, in the evaluation of a business performance a strength/weaknesses/opportunities/ threats analysis is used as a part of the development of strategies and plans to enable the organization to achieve its objectives. SWOT is commonly used as part of strategic planning and looks at:

- Internal strengths
- Internal weaknesses
- Opportunities in the external environment
- Threats in the external environment

The result of the analysis is a matrix of positive and negative factors for management. But, in this analysis instead of threat factors, the attention will be paid to the future aspect of the EIPs in the sense of its potentials for further development. Here are some common points of EIPs in Europe, North America and South East Asia, with the above cited cases as representatives of these regions:

Strengths:

- One-time costs lead to multi-year benefits
- A leading technology and best available practices among the shareholders for the EIP
- Availability of residues in quantities suitable for undisrupted functioning of the EIP
- Expansion of existing local business activities
- New markets and new sources of technology
- Ecological gains in reduction of pollution, waste management and zero emissions
- Social gains: good relations between companies due to equally shared gains and balanced interdependence
- Economic gains: production costs reduced, shared investments with lower risk

Weaknesses:

- Insecurity in renting the land to a big number of actors in the sense of the consequences of redrawing of one actor makes imbalance in the whole system
- Lack of a lasting successful business model of EIP in general
- Since all projects are still in early phases of development, despite the actual duration of their existence, sufficient data to make a definite evaluation of project success are unavailable.
- Untested technology systems and business models remain risky and uncertain for widespread diffusion, especially in South East Asia
- Lack of the funding model for EIPs, no public grants allowed
- Still not developed advertizing opportunities, which would lead to expanding the model of particular EIP as well as its further development
- Still under-developed and undefined communication channels between actors
- No standardization of management procedures between actors

Opportunities:

- Creating additional jobs for residents
- Improving profitability by reducing labor requirements and production costs
- Preventing and controlling pollution through reduction of pollution, waste management and zero emissions
- Increasing government funding for R&D activities
- The continuous technological modernization of energy facilities, systems and sources
- The economical use of quality energy products and an increase in energy efficiency
- The use of renewable energy sources (RES) and environmentally acceptable energy technologies
- Investment in new power sources and in new technologies
- Development of new energy infrastructure facilities and electric and thermal power sources within the domestic, national energy sectors, as well as within the frameworks of the existing regional infrastructure systems

Potentials:

- Community participation in environmental management and local industry development
- Decentralized and small and medium scale biomass-based power generation systems
- Eco-tourism business based on eco-industrial clusters
- Potential renewable energy sources:
    I. Biomass fuels: wood and agricultural biomass
    II. Unused potential of hydro-energy
    III. Geothermal sources
    IV. Wind energy
    V. Solar energy
- Development of housing for employees of EIP businesses
- Creation of a community strategic plan for reducing the total waste stream (residential, commercial, public, and industrial)
- Development of a highly effective regional by-product exchange, providing markets for materials now discarded as wastes
- Strengthening economic development planning to encourage businesses that fit the recruitment profile of the EIP or that turn wasted resources into products and jobs
- Mobilizing educational resources to help the community's businesses and government operations increase energy efficiency and prevent pollution
- Reducing greenhouse gas emissions through a community action program led by the EIP
- Financing of some EIP development costs through public private partnerships

Nevertheless, there is a differentiation in the level and intensity of these characteristics in cited EIPs. In Kalundborg case, the municipality is a receiver of produced energy as a result of EIP's industrial activities, but the residents of Kalundborg are not included in the decision-making process of the EIP itself. This could be explained by the fact that this Eco-Industrial Park emerged as a result of a several decade long process of integrating businesses and step-by-step waste and control management amongst its actors.

The same could be said for Kawasaki City EIP which industrial foundation exists for over a century. The eco-industrial activities are the outcome of the operational cooperation between companies' management. The residents are employees in these companies, but not decision-makers. Both are a residential area, which means they are not physically separated municipalities and Eco-Industrial Parks.

Unlike these EIPs, the Alberta EIP is located nearby the town Forth McMurray, not in it. Also, Alberta park is a designed one, with not only heavy industries as participating actors, but as well small and medium enterprises as residents' private-owned businesses, which means active residents' role in the establishment and the development of this EIP. Environmental principles are incorporated in the root of this area from the very beginning of its existence, and are inseparable ingredient of all business plans carried out in it, no matter if it is private-owned or public, SME or business conglomerate.

Unlike Kawasaki City EIP, Map Ta Phut is relatively young establishment of a designed industrial symbiosis. But, just like Kawasaki area, its main actors are heavy and petrochemical industries, which are in tight collaboration with state authorities. The common point of both Asian EIPs is that residents do not actively participate in the management of EIPs, nor are they actors as business providers through, for example, SMEs in them. Social dimension of these EIPs is that they provide jobs and new professions for residents, thus increasing their quality of life, together with minimizing the negative environmental impacts of businesses in the Parks.

In this analysis special attention is given to the Indian case of Hyderabad EIP in Andhra Pradesh, because of very specific economic and demographic background when compared to other cases and regions mentioned above. Even 63 special economic zones (SEZs) out of roughly 150 in India are located in Andhra Pradesh[17]. What is unique in this case comparing to others is that social dimension is perceived as a driving force in the transformation of existing industrial parks into eco-industrial ones. The emphasis is on the importance of economically and environmentally sustainable industrial development for the developing countries[18]. The eco-industrial development of the region can be achieved by implementing policies that aim to achieve a balance between economic development, social progress and environmental protection. Job creation and environmental protection are of equal importance for these countries, especially when demographic and cultural background is like that in India.

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[17] Report - International Conference on Eco Industrial Parks, July 6-8, 2009, Hyderabad, AP, India

[18] Since the year 2004, the Andhra Pradesh Industrial Infrastructure Corporation Ltd. (APIIC) and the German Technical Co-operation (GTZ) are cooperating under the Indo-German Bilateral Programme on Advisory Services in Environmental Management (ASEM) for developing "Eco Industrial Parks" in the state of Andhra Pradesh in India.

6.0. COMPARATIVE ANALYSIS – NORTH AMERICA, EUROPE, SOUTH EAST ASIA

Although Eco-Industrial Parks are located worldwide, the majority of them, be they spontaneously developed or designed, are located in most developed parts of the world: North America, Europe and South East Asia. In numbers, there are 149[19] existing or planned EIPs in these three areas:

- Europe: 53
- South East Asia: 34
- North America: 62

Although EIPs are at more or less at the same progress level in the three most developed parts of the world: North America, Europe and East Asia, there are still significant differences among them.

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[19] Maria Trofimova and Guillaume Thouvenin, under supervision of Laetitia Carles, Benoît Charièrre and Suren Erkman, Analysis of symbiosis potential in Chablais region, École Polytechnique Fédérale de Lausanne, 2011

Built largely upon the achievements of Kalundborg, the concept of eco–industrial development has grown popular in parts of Europe. The Netherlands have adopted the creation of Eco–Industrial Parks as national policy (Eilering & Vermeulen, 2004). Other examples of eco–industrial development can be found in Germany, France and Italy (Gibbs, 2003). In the United States during the 1990s there were numerous planned eco–industrial developments. In reality their success has been very limited. With the lack of standard procedures and models, these projects are diverse in nature and cover a range of geographical locations, but the high attrition rate clearly indicates problems with eco–industrial development. Although these have been described as resource recovery parks, they do not appear to fit the model of private enterprise and development as they are district government controlled facilities which incorporate some private operations.

An important difference between the European and American cases[20] can be found in the project objectives. The first and most important objective in the American projects seems to be the creation of family wage jobs for the local population. The economic factor in the American projects reviewed is generally valued as more important than the environmental factor. Generally, today economic growth is only desired when this does not adversely affect the natural amenities. In the European cases however the projects are, in general, initiated for both economic and environmental reasons. Majority of European projects were initiated in hopes of improving business economics and the environmental performance, of participating companies, at the same time. The environmental and economic aspects of the project seem to be equally important.

In Europe, local entrepreneurs or employers association is often, on behalf of its member companies, the initiator of the project. The local association, in turn, closely coordinates its actions with local and regional government. The important role of the association in the

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[20] Eco-industrial park initiatives in the USA and the Netherlands: first lessons; R.R. Heeres, W.J.V. Vermeulen, F.B. de Walle Journal of Cleaner Production 12 (2004)

overall project organization also insures the active participation of its member industries. The individual companies that are represented in the local association usually contribute their vision and ideas on the project through various project groups established by the overall EIP project organization. The local and/or regional government on the other hand initiates the North American cases, in order to improve the local/regional economy. Local industry remains, in general, more passive throughout the course of the project compared to their European counterpart. This difference can be explained by the fact that European industry has more experience with government industry project participation, especially on regard to the EU. American companies also seem to have more distrust towards the motives and actions of the government.

The participation level of the local community (residential) and NGO's in the development of the various North American cases seems to be very high compared to that in the European cases. In fact, the American project management often stimulates community involvement in project development. People are encouraged to present their vision and ideas on EIP development. The above level of community participation is still not evolved in Europe. The community is not encouraged to give its opinion and ideas on the EIP that is to be developed.

Overall, East Asia and the Pacific regions[21] are less generously provided with natural resources where higher number of population needs to share these resources, than Europe or North America. The demand for resources proliferate everyday which has increased the environmental pollution and depletion of resources. Hence, the rapid depletion of resources should be reduced and its success is based on how fast the resource consumption is being controlled. Asia is the globe's largest and densely populated continent which covers 30% of the earth's total land area with more than 4 billion population by 2008 which is 60% of the total population in the planet. The industrial revolution in Asia has redefined the global economy, global environmental issues and geopolitical landscapes. The gross domestic

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[21] Eco - Industrial Clusters in Urban - Rural Fringe Areas, A strategic Approach for Integrated Environmental and Economic Planning, Asian Institute of Technology Thailand

product (GDP) of Asia has risen to the third position among the continents due to rapid industrial revolution and economic development. In addition, it is expected that China will have the largest economy in the world followed by India, Indonesia, Japan, Malaysia, Thailand, the Philippines, Pakistan, Vietnam and South Korea in the next 20 years. This drastic economical development instigated the industrialization and urbanization which has accreted the waste production in the urban areas of many Asian countries. As a result, the negative impacts on public health and environment have become the center of attention during the last few decades due to rapid population growth and industrialization in the continent.

In the Asian continent the population is mounting at a sensible rate predominantly. The outbreak of inhabitant numbers in the continent mingles with poverty to reduce and pollute local resources. Despite the fact that the relationship between population growth and adverse environmental impacts is complex, the size and growth of the population incline to enlarge and accelerate the human impacts on the environment with stresses like biodiversity, air and water pollution and increased pressure on fertile land. Despite Asia's thriving economical improvement, almost half the continent's population struggling to live, in other words are living in absolute poverty. Poverty is the main cause of environmental degradation where poor people rely on natural resources more than the rich. This accelerates the depletion of natural resources like land, air and water as the poor people have no prospects to access the other type of resources. In addition, the poverty and the population growth has direct link and reinforce each others rapid growth. Hence, the downturn of natural resources and unsafe living conditions due to poverty in the Asian region affects the environment and health of the poor people.

Since the beginning of the industrial revolution, the energy demand has been increasing more rapidly in the Asian continent than anywhere else in the world and is expected to grow steadily in future. It is estimated that the Asian continent will consume more energy than the combined consumption of Europe and North America by 2030. In 2000, around 18.7% of the global emission was imputed by East Asian countries alone. Additionally, in recent years

USA and China were accounted for around 28% and 20% of the global emission respectively which ranked them to the first and second position in the list. It is predicted that by 2025, the emission will be increased by 118% in China. These emissions are going to result in water supply disruption, increase of floods and rock avalanches, crop yield reduction in Asia, as well as drought affected areas are likely to increase in the future.

The common point in all three regions is the economic, environmental and social benefits from the establishment of Eco-Industrial Parks. However, while in Europe the focus is on sustainable development and pollution prevention, and in North America economic benefits are emphasized between these goals, the establishment of EIPs in South East Asia is a necessity because of decades of uncontrolled industrialization and severe pollution of scarce natural resources. Today, Asian industrial activities combined with environmental principles' implementation in those activities are a driving force for not only economic development, but also for the improvement of complex social circumstances as well as reducing sources of pollution in the region.

In recent years, this region is giving vast efforts to change the bad side of their economic success[22]. China is adding huge amounts of new electricity generating capacity. It's also laying High-Voltage Direct Current (HVDC) transmission system to get that electricity to market. The Association of Southeast Asian Nation (ASEAN) states are deepening interconnections between their 10 electricity grids and natural gas pipeline networks. The aim is to increase cross-border energy trade. In Australia, nearly $200 billion of natural gas projects are planned, primarily for export. Meanwhile, $100 billion of electricity transmission infrastructure upgrades are needed. These networks can and should grow together.

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[22] www.eco-business.com

What emerges will be a “Pan-Asian Energy Infrastructure”. This infrastructure will be based upon ever-present, low-loss transmission capacity, carbon-adjusted pricing and expanded energy trade across borders. In short: undistorted, frictionless properly-priced markets. The end result of more open, properly-priced, cross-border markets will be falling regional greenhouse emissions due to enhanced innovation created by a marketplace ‘virtuous circle.’

US and Chinese researchers estimate China has enough wind blowing across its Inner Mongolian steppes to power the nation several times over. Meanwhile, Australia has enough sun falling on its largely-unoccupied deserts to satisfy the entire world’s energy needs. China should build out wind energy capacity and Australia should develop solar.

For this to work however, Australia and China must be connected. This can occur through the interconnected national networks outlined above. All these, in turn, will result in a ‘Pan-Asian Energy Infrastructure’ stretching from Australia to Inner Mongolia. This, over time, can be operated on ‘common carrier’ (i.e. open to all users) principles. As a Pan-Asian Energy Infrastructure passes through Southeast Asia, it can pick up Indonesian geothermal, Malaysian biomass and Vietnamese wind for cross-border sale. And as these new energy resources come online they can replace aging, dirty coal-fired power plants. Renewable energy delivered over a Pan-Asian Energy Infrastructure represents a big, ambitious vision of an interconnected infrastructure that can solve a host of problems, not only in Asia but in the entire world.

On the other side, India is the fourth largest carbon emitter in the world and if its reliance on conventional energy continues, emissions will increase further. The country’s carbon dioxide emissions are expected to triple by 2030 if the current dominance of conventional resources in the energy mix continues. The country’s National Action Plan on Climate Change has categorically called for keeping the per capita greenhouse gas emissions below that of developed countries at any given point in time. By 2020, India aims to reduce its emission intensity to 25% of the 2005 levels. Power from green energy plays an important role in the portfolio of options pursued under the National Action Plan on Climate Change.

However, players in Indian green electricity generation still face a number of critical challenges today, some of which traverse all renewable technologies. These include inconsistent and unreliable incentive schemes; limited grid infrastructure/connectivity; difficulty in passing on the additional cost of renewable power to final consumers; outdated or unavailable resource maps; as well as the currently limited size and scale of domestic component production.

7.0 CREATING AN ECO-INDUSTRIAL PARK

In the last decade a local and regional approach to creating more sustainable industrial parks and estates has emerged. Networks of collaboration among companies to improve environmental and economic performance, and networks to exchange by-products are some of the approaches used in industrial areas (Chertow & Lombardi 2005).

Since there is no standardized model for creating an Eco-Industrial Park, based on previous findings, there are some requirements necessary for the establishment of such a complex cooperation between potential actors. EIP is a cite-specific one location limited entity, whose actors are companies which may, and in most cases, differ in performance and activity. The lessons on the enabling mechanisms are being combined and expanded to provide support for synergy developments for both companies and regional facilitators.

For the company the support tool helps decisions and provides guidance on:

1. Successfully engaging in an EIP network – guidance is intended to aid the companies in appreciating the benefits of EIPs. Networks have a number of benefits compared to individual efforts in finding potential synergies. The main advantage of a network is an increase in information flow between potential input-output partners, which increases the chances of finding a partner. The two most common methods of finding synergies are analysis of company inputs and outputs, and workshops. Virtually all synergy projects studied report that the majority of successful synergies emerge from workshops involving companies and not from software matching. Data collection can however help initially in isolating potential partners before a workshop to discuss potential synergies. Openness between companies (on information of outputs and inputs) is also highlighted as a strong contributing factor for successful synergy identification. Where there are severe confidentiality concerns, the data collection, its subsequent analysis and synergy identification can be performed confidentially by the network facilitating team (but again openness is often the key to success).

2. Identifying potential synergy inputs and outputs – a similar philosophy to eco-efficiency projects is taken: e.g. involving all members of staff, brainstorming, suggestion boxes and incentive programs, tracking and communicating progress with staff.

3. Assessing the benefits and motivational reasons for EIP projects – comprehending the full benefits of synergy projects. The evaluation tool, which is still being developed, will provide the basis for assessing the sustainability contribution. The key value elements of synergy projects can help to identify the wider benefits of specific projects as well as the industrial symbiosis network. Guidance is being developed on identifying the full cost savings (e.g. the full costs of waste creation and its subsequent handling is often not identified in company accounting methods) and other benefits such as innovation, technology development and knowledge/technology transfer within a network.

4. Finding and creating partners – although EIP network essentially provides the optimum platform to identify a synergy partner, in some cases there are ways that companies can begin to take on a more entrepreneurial role. This is especially true for companies that produce large by-product volumes.

5. Operational and contractual arrangements – the five key determinants (ownership of project assets); traded resources; supply risks (availability of a critical process input); demand risks (utilization of the recovered by-product or utility generated) and price (value of the exchanged resource for each of the synergy partners) provide the basis of guidance on identifying ways to share risks and benefits of synergy projects. This guidance then provides the platform for negotiation of successful synergy outcomes. It is useful in negotiation to split the process of utilizing a by-product into three components (to decide which company will be involved in which component) where differing technologies and assets can be involved: *capture* (material/heat/water is taken from the 'source' production), *recovery* (technology used when the resource stream is recovered, separated into valuable components, transformed or mixed with another resource to form a usable by-product) and *utilization* (technology involved when the by-product stream is used in a 'sink' production process).

Successful facilitation of industrial symbiosis appears to be based on five key ingredients: industry leadership; process management; synergy development activities (synergy workshops, input-output analysis, and third party identification); funding and promotion. These provide the basis for ongoing work to develop a model to support regional EIP initiatives, while the evaluation model and the five key determinants for operational and contractual arrangements, and provide the basis for developing support and guidance for development of EIP projects.

For regional facilitators the guidance being developed is based on a six stage process:

1. *Foundations* – assessing previous activities relevant to eco-industrial activities, building on local and regional strengths and sustainability projects; identifying key industry and other stakeholders; identifying common industry issues and problems for industry to collaborate on – i.e. beginning with simple projects that can help to build trust.

2. *Ownership and leadership* – forming a project steering group by giving ownership to key industry and other stakeholders (e.g. environment agency and local councils). Obtaining funding by linking in with regional and national strategies

3. *EIP development process* – identifying target companies and stakeholders to invite to a launch workshop with case study examples; assessing the best network strategy for the region, types of workshops and software use etc.; creating task forces to aid technology dissemination or for single project research and development

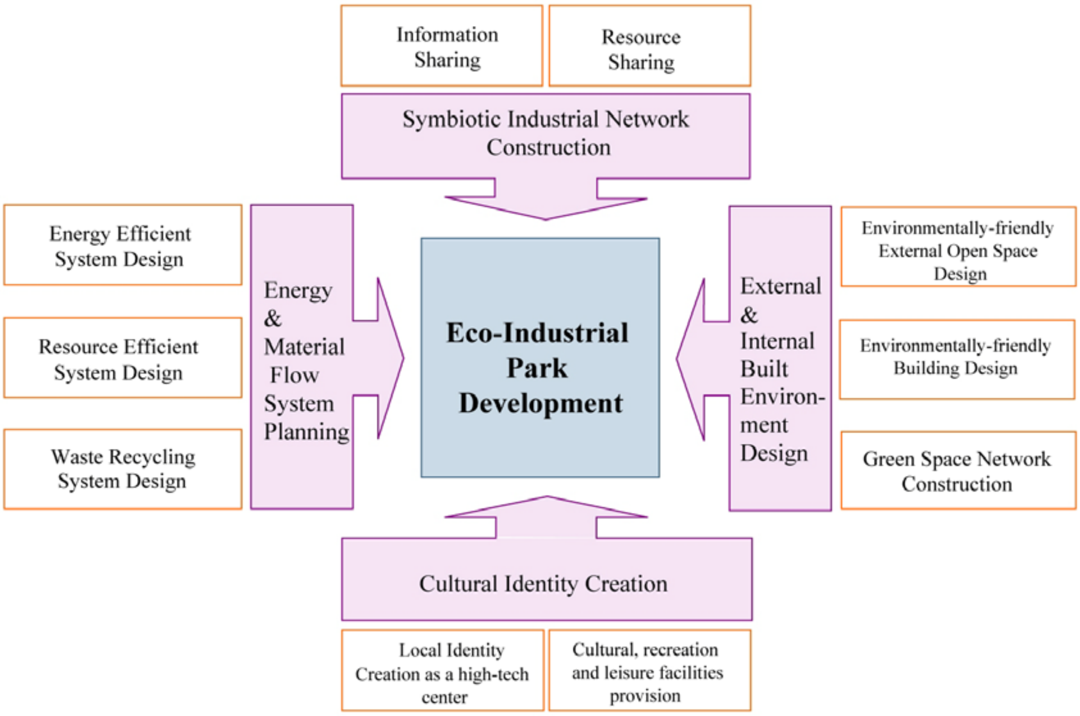
4. *Feasibility* – methods to screen out potential cooperation into categories, for example from easy, short term wins, to those that require extensive research; utilization of the evaluation tool to assess the benefits of potential synergies.

5. *Implementation* – assist where possible in the implementation of commercially viable synergies.

6. *Monitoring, maintaining momentum and organizational learning* – keeping up the regular workshops and facilitating company interaction. There is also potential to extend the eco-industrial network to become a central part of a regional sustainability strategy (thereby

continuing the focus on symbiosis and network momentum), and/or link the network with regional development.

Conceptual model of Eco-Industrial Park Development[23]



23 International Symposium on the Sustainable Management Mechanism for Industrial Parks, China, 2002

8.0 CONCLUSION

In the past few decades after the industrial revolution, undoubtedly, industries throughout the world have performed their activities without considering the impacts on the environment and natural resources. Apart from positive economic effects of industrial development, concentrating industrial operations on a limited tract of land tend to exceed the threshold of the carrying capacity of the ecosystem surrounded. It is now well recognized that industries have a major responsibility not only to lessen environmental problems, but also to do so in a socially acceptable way. These aims should not limit the economic benefits to core business itself, particularly for the long term. A 'triple P approach' (planet, people and profit) is therefore essential for industry to address sustainability issues (Elkington 2004).

The ever increasing use of the terms "sustainable development" and "sustainability" during the past decades in industrial sectors, government bodies and academia explains the measure of importance of this concept in the present world. It has now been realized that in order to efficiently utilize resources for the present generation as well as for future generations, there needs to be a different pattern of production and consumption of all kinds of resources.

Fresh water depletion has been identified as one of the most problematic issues that will have the impact on the entire humanity in the near future. But, in most developed societies treated fresh water is wasted in large amounts, while at the same time many places are facing immanent severe water shortages. Water scarcity will make its value understood. Only a small fraction of fresh water sources are available for consumption. Complex water treatment requires both vast energy usage and high costs. Fresh water is a scarce resource that takes a long time to renew itself through natural processes. In modern developed societies water usage is highly inefficient. Wastage occurs at all levels, from over-usage (domestic and industrial) to utilization of clean treated water for a number of non-necessary applications.

With industrialization also comes pollution, particularly the consumption of fresh water supplies. Stored underground water sources that use to be consumable have become so polluted that they now require expensive treatments. Despite recent improvements in water treatment, there is not a clear solution on how to provide clean water at low costs on a global scale. While most of our efforts have focused on technology improvements (desalinization and water waste management), relatively few efforts have been put into finding more passive ways of cleaning large bodies of water such as using natural filters or other means that do not require significant energy inputs; because in fact the water treatment challenge is an energy one. Another obvious step is to vary the degree of water treatment according to its end use. Still, today clean treated consumable water is wasted on applications which do not require it to be thoroughly treated (e.g. cooling in industrial processes, irrigation…). As a general rule the most purification required, the more energy intensive and expensive the process. Wastage could be greatly reduced with better management of clean treated water. The sources of water need to be diversified, including captured and stored rainfall, and reduction of the treatment costs to a level that can be deployed on a wide scale for all economies.

Energy prices will only trend upwards as fossil fuels are depleted even as global demand grows. Issues concerning an increasingly carbon-constrained world due to climate change risks, not to mention energy security, will also undoubtedly have a direct impact on the energy landscape and government policy. Investing and implementing intelligent energy systems, investing in energy infrastructure such as liquefied natural gas (LNG), increasing energy efficiency via incentives, education and legislation, promoting green transportation and capabilities of a green economy, making energy R&D a key priority are means of making a „smart“ sustainable world. But there were some issues that were clearly divisive. While investments and research into renewable energy are welcomed and renewable resources are more than acceptable, however they remain commercially unviable because of its high cost and long payback. Financing of green development is a lot like traditional financing, but additional detail and attention must be paid to those costs, benefits, and risks that most lenders and equity sources are not yet familiar with to ensure the lowest-cost financing on the best possible terms.

IT is estimated to be responsible for between two and five per cent of global emissions, and businesses and governments are well aware of how to lessen that impact. Technologies such as smart grids and intelligent transport systems are already well established as a means of reducing greenhouse gas emissions, but the potential for IT to be used to support climate adaptation efforts has been overlooked until fairly recently. For example, universal charger for mobile phones that is due to come into mass production in years to come and which reduces the consumption of electricity when no device is attached. The EU threatened legislation unless mobile phone manufacturers agreed to work on a standardized charger, after research revealed that they generate more than 51,000 tones of electric waste each year.[24] The global savings resulting from the new standardized design could be even higher.

In the recent years, academia, research institutes, industries, and policy makers have initiated appropriate solutions to cope with environmental and economic challenges brought by the industrial sectors. A small scale application of industrial ecology principle can become an innovative approach for eliminating environmental and economic sustainability threats. New eco-industrial systems aiming at efficient sharing and utilization of resources, technologies focusing on alternative use of discarded materials and policies enforcing in urban-rural fringe areas could play an important role in eco-restructuring of the world. This can be done through collection of industries along the value chain of the similar products to enhance the environmental and economic performance.

The environmental, economic and social benefits gained through inter-firm networks in an Eco-Industrial Parks are substantial. In other words, eco-industrial networks offer a way to meet the needs of the present without compromising the ability of future generation to meet their own needs. Environmental technologies for conversion of waste to energy, wastewater treatment and use of renewable materials have to widen between companies to attain the objective of the clustering approach.

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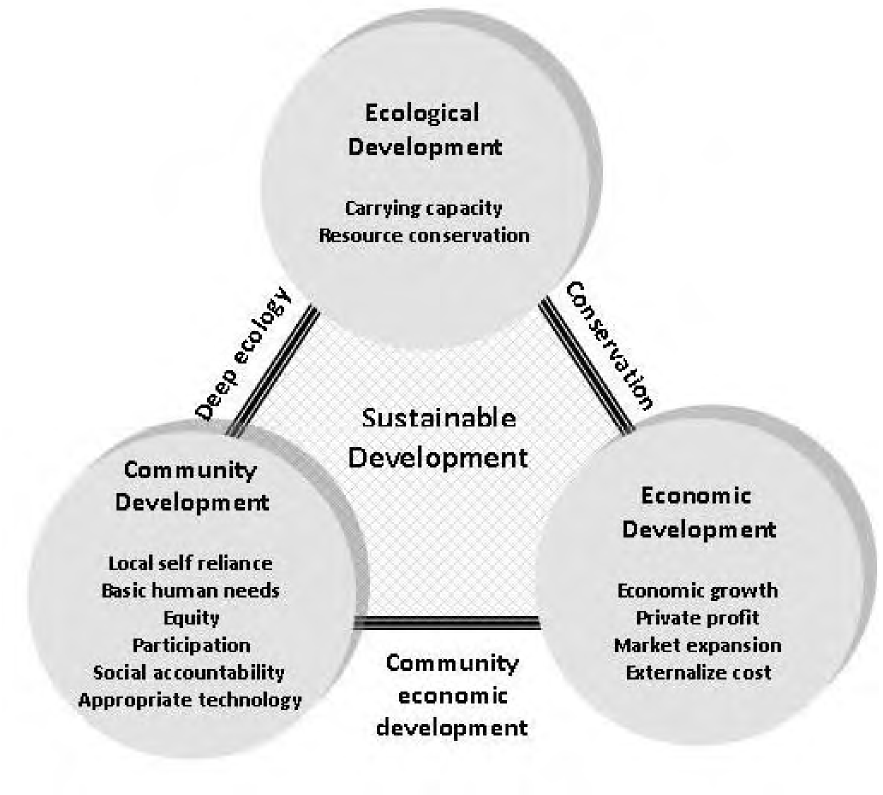
[24] www.eco-business.com

Factors involved in sustainable development[25]:



The initial focus of the EIP project should not be on the establishment of physical energy, water, and material waste exchanges but on the establishment of utility sharing projects. The project should initially be focused on such projects because these projects, compared to the physical waste exchange projects, require relatively small economic investments while at the same time they offer a possibility for a reasonable economic and environmental benefit. When such projects are deemed successful, companies will be more eager to explore the possibilities for the establishment of more symbiotic energy, water and waste exchanges. EIP development is a long-term process. In order to stimulate development, it is important to focus on the establishment of low cost, high benefit utility sharing projects and ‘‘simple’’

[25] Eco ‐ Industrial Clusters in Urban ‐ Rural Fringe Areas, A strategic Approach for Integrated Environmental and Economic Planning, Asian Institute of Technology Thailand

exchanges. Finally, when the project is well established—that is when companies are fully aware of the benefits that are to be gained—the development can move along to the more company-specific and economically challenging projects. Industrial ecology and EIP development are still promising steps towards a more sustainable society. The current ‘‘successful’’ development of the various EIP pilot projects initiated all over the world could come a long way in establishing a new international standard in industry development. The cases function as examples and help motivate other companies to follow their example. An ongoing international comparison of EIP projects could further help stimulate governments and companies to initiate EIP development projects.

9.0. WHY REVOLUTION AND NOT EVOLUTION

As a final note, a short explanation of the choice of word Revolution in the title of this work. Since the parallel of natural and industrial systems has been made at the beginning, either Evolution, synonymous with gradual and continuous development mostly in natural systems, or Revolution, which implies social and political changes more or less sudden in their action, could be equally used. The relation with the Industrial Revolution of the 18^{th} and the 19^{th} century is thus obvious. Still, there are some significant differences among these two words that defined the final choice.

Evolution and Revolution are two words that are often confused due to the appearing similarity in their concepts. Evolution refers to the change in the behavior of man over a period of time. It also speaks about the changes in social conditions over a period of time. In that respect we can connect the dispersion of Eco-Industrial Parks all around the world with the rising concerns about global environmental issues and making the “eco-sensitivity” a part of not just political and economic decision-making processes, but even simple, daily activities in every-day life.

On the other hand, Revolution consists in fundamental change in organizational structures or political power that takes place in a short period of time. This is the major difference between the two words evolution and revolution. Taking into account that the longevity is a relative term, as the Industrial Revolution confirms, the reorganizational aspect of implementation of Eco-Industrial Parks, the new system of production, new management responsibilities, and above all the political will to support the new way of organizing industrial activities, is the main reason why this term prevails. It is not about turning from one form to the advanced one, but the transformation within the same system.

The same phenomenon can be described as evolutionary and revolutionary at the same time, depending of the perspective whether we want to emphasize the continuity or the novelty. Neither of these two aspects excludes necessarily the other one.

Sophisticated technologies are and will become more superior, and their progress accelerates on a daily basis. The adjustment to them may be the evolutionary aspect of human development. But applying them in the acceptable way concerning economic, social and environmental aspects with regard to the generations to come requires revolutionary reorganization. Changing the way of thinking is evolutionary, but realization of these changes is revolutionary.

LIST OF REFERENCE

- Joseph A. Montagna, The Industrial Revolution, www.yale.edu
- Pollution Prevention and Industrial Ecology, National Pollution Prevention Center for High Education; Industrial Ecology: An Introduction, Garner et al. 1995
- UN Millennium Goals, www.un.org/millenniumgoals
- Our Common Future, www.un-documents.net
- Using Material Flow Analysis For Sustainable Management, The Journal of Industrial Ecology, Volume 13 Number 5; Frederick W. Allen, Pricilla A. Halloran, Angela H. Leith and M. Clare Lindsay
- Industrial Ecology: a new perspective on the future of the industrial system, Suren Erkman, Institute for Communication and Analysis of Science and Technology
- Eco-Industrial Parks, A background report for the eco-industrial park project at Rantasalmi, Publications of Regional Council of Etela – Savo 71:2006
- Henning Grann, The Industrial Green Game, National Academy Press, 1997
- B. Kurup, W. Altman, R. Van Berkel, Triple bottom line accounting applied for industrial symbiosis. Australian Life Cycle Assessment Society Conference. Sydney, Australia, 2005
- Wuppertal Institute for Climate, Environment and Energy, Eco Town Program, Bettina Bahn-Walkowiak, Raimund Bleischwitz, Atsuko Takano, 2007
- Aromatic Availability and Utilization Study For Alberta Economic Development and Alberta's Industrial Heartland, T. J. McCann & Associates, 2001
- Fostering Industrial Symbiosis for Regional Sustainable Development Outcomes, Steve Harris, Rene van Berkel and Biji Kurup, 2008
- Report International Conference on Eco Industrial Parks July, 2009, Hyderabad, India www.hrdp-net.in

- Analysis of symbiosis potential in Chablais region, Maria Trofimova and Guillaume Thouvenin, under supervision of Laetitia Carles, Benoît Charièrre and Suren Erkman, École Polytechnique Fédérale de Lausanne, 2011

- Eco-industrial park initiatives in the USA and the Netherlands: first lessons; R.R. Heeres, W.J.V. Vermeulen, F.B. de Walle Journal of Cleaner Production 12 (2004)

- Eco ‐ Industrial Clusters in Urban ‐ Rural Fringe Areas, A strategic Approach for Integrated Environmental and Economic Planning, Asian Institute of Technology Thailand

- Eco-industrial Park Handbook for Asian Developing Countries, Report to Asian Development Bank, Ernest A. Lowe , October 3, 2001 www.indigodev.com

- Eco-Industrial Parks - A Strategy towards Industrial Ecology in Developing and Newly Industrialized Countries, Pilot Project Strengthening Environmental Capability in Developing Countries (ETC), Anja-Katrin Fleig, Eschborn, 2000

- Eco-Industrial Parks – The Case for Private Planning, The Independent Review, volume V, n.3, Winter 2001

- Eco-Industrial Parks: A Case Study and Analysis of Economic, Environmental, Technical, and Regulatory Issues; Sheila A. Martin, Keith A. Weitz, Robert A. Cushman, Aarti Sharma, Richard C. Lindrooth; Center for Economics Research, October 1996

- Industrial Ecology: An Introduction; Andy Garner, Gregory A. Keoleian, University of Michigan School of Natural Resources and Environment; National Pollution Prevention Center for Higher Education, November 1995

- Value Beyond Cost Savings, How to Underwrite Sustainable Properties, Scott Muldavin, 2010

- Financing Green Development, Scott Muldavin and Andrew Fusscas, 2007 www.greenbuildingfc.com

- Eco-Industrial Parks: A Case Study and Analysis of Economic, Environmental, Technical, and Regulatory Issues, Final Report, Sheila A. Martin, Keith A. Weitz, Robert A. Cushman, Aarti Sharma, Richard C. Lindrooth, Center for Economics Research, Research Triangle Institute, October 1996
- Research on Construction of Modern EIP based on Conservation Culture, YU Dajin, HU Zhenpeng, Research Center for Central China Economic Development, Nanchang University China, 330029, School of Information and Management, Jiangxi University of Finance & Economics, China, 330013
- Energy Efficiency Financing Barriers and Opportunities, Namrita Kapur, Jake Hiller, Robin Langdon, Alan Abramson, July 2011
- A New Ethic for Humankind, Searching for solutionsin a troubled world, Fred G. Thompson, Futurescan Consulting, March 2009
- Empirical Analysis of Eco-Industrial Development in China, Yong Geng,Murray Haight and Qinghua Zhu, Institute for Eco-Planning and Development, Dalian University of Technology, China, School of Planning, University of Waterloo, Canada, November 2005
- Environmental Policy and Rural Industrial Development in China, Haiqing Xu, Department of Geography, Concordia University, Montreal, Human Ecology Review, Vol. 6, No. 2, 1999
- www.icett.or.jp
- www.eco-business.com
- www.ecology.com
- www.worldsummit2002.org
- www.ecoist.com
- www.inhabitat.com
- www.bbc.com