Strategies for Sustainable Development of Industrial Park

-EIP Pilot Project of Ulsan, Korea

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Outlines of Presentation

- Introduction of Ulsan City
- Sustainable Development and EIP
- Policies supporting EIP in Korea
- Pilot project for the development of EIP in Ulsan
- Conclusions

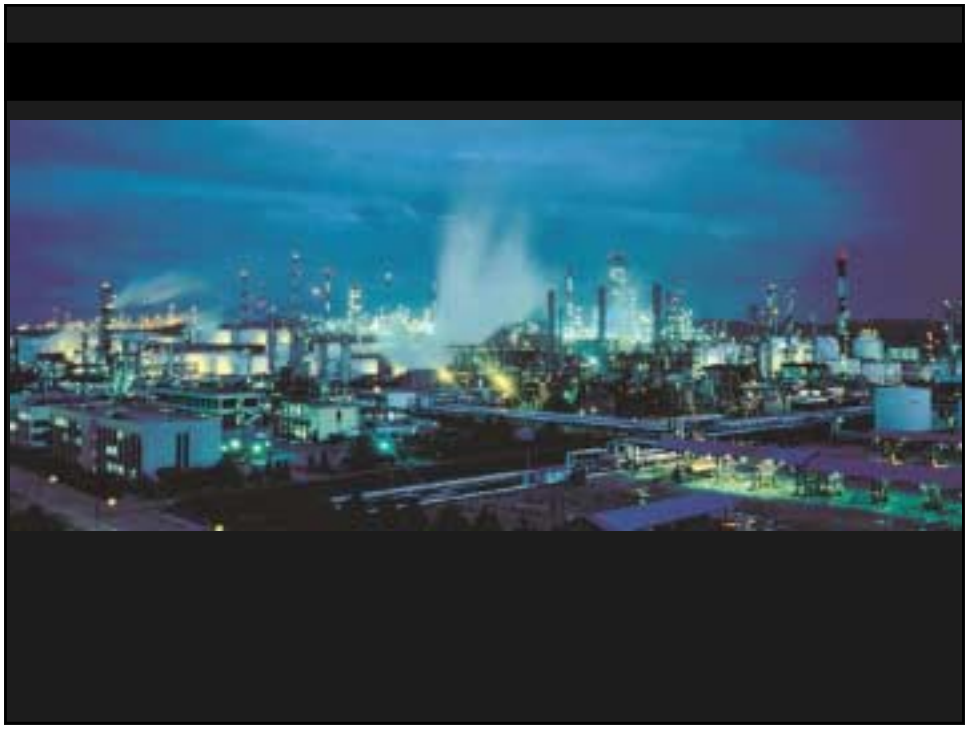
1. Ulsan Metropolitan City

- From Past to Present

- Ulsan was designated as a special industrial zone in 1962
  1962(pop. 85,000) -> 2003(pop. 1,070,000)
- Most Polluted city in ’70 – ’80
  Onsan disease -> residents relocation
  Special air pollution control regions (1986)
- Ulsan Metropolitan city(1997)
- Declaration of “Eco-polis Ulsan”(2004)
  based on “The Mater Plan for Eco-polis Ulsan”
  include renovation of industrial parks to EIP
  sustainable industrial capital of Korea

Village View of Ulsan Petrochemical Plant Site(1962)

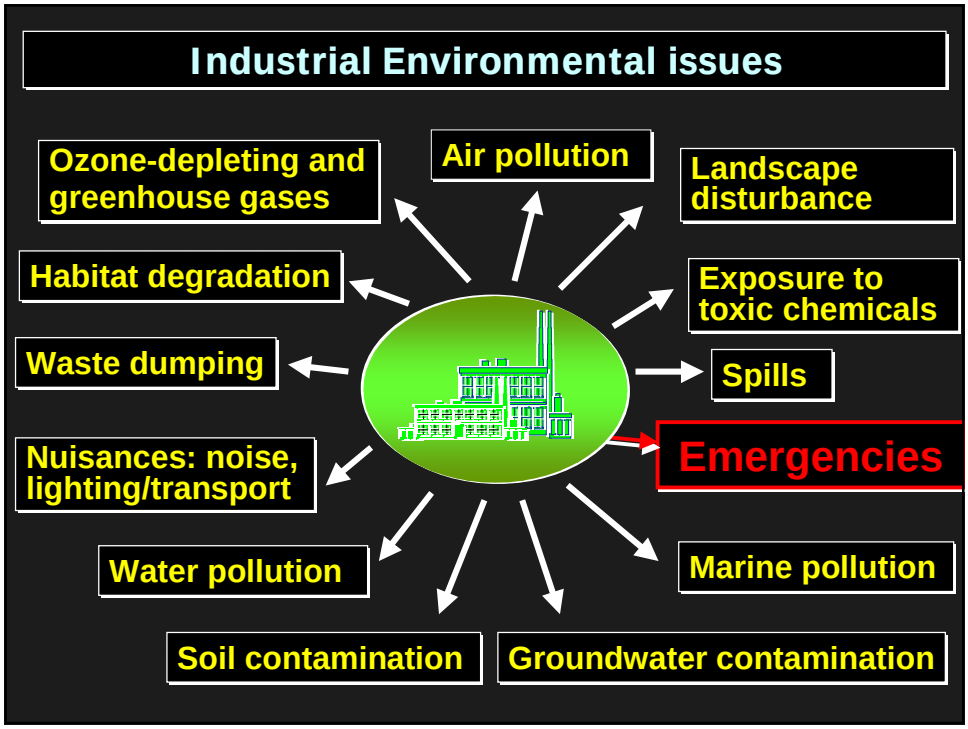
View of Onsan Industrial Park Site Preparation

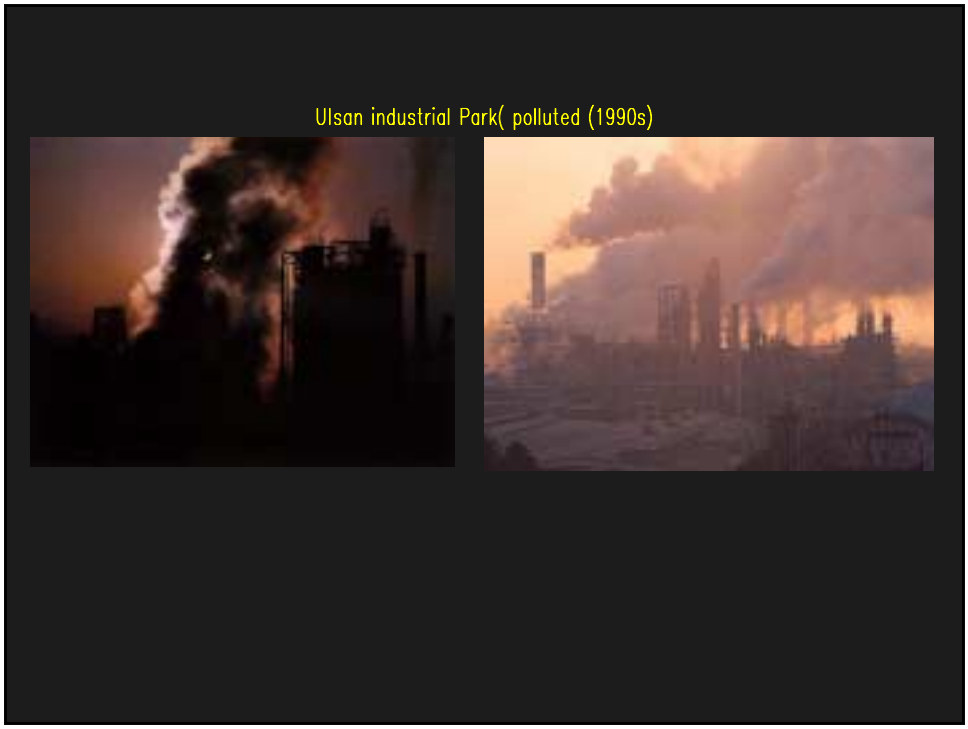


Industrial Park

- Industrial estate may be defined simply as "a tract of land, subdivided and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and the close proximity of firms.

- Though the industries located in industrial estate are afforded a number of benefits, including external economies of scale, reduced production costs, they also have disadvantages such as the increase of environmental issues.


Industrial Environmental issues
Ozone-depleting and greenhouse gases
Air pollution
Landscape disturbance
Habitat degradation
Exposure to toxic chemicals
Waste dumping
Spills
Emergencies
Nuisances: noise, lighting/transport
Water pollution
Marine pollution
Soil contamination
Groundwater contamination


Ulsan industrial Park(polluted (1990s)

Ulsan industrial Park(polluted (1990s)

2. Sustainable Development

❖ Development that meets the needs of present without Compromising the chance for future generations to satisfy theirs" [Brundtland Report, 1987]

Sustainable Industrial Development

❖ Agenda 21 chap 30 : Strengthening the role of business and industry

→ Promoting Cleaner Production

→ Promoting Responsible Entrepreneurship

Eco- Industrial Park Concept

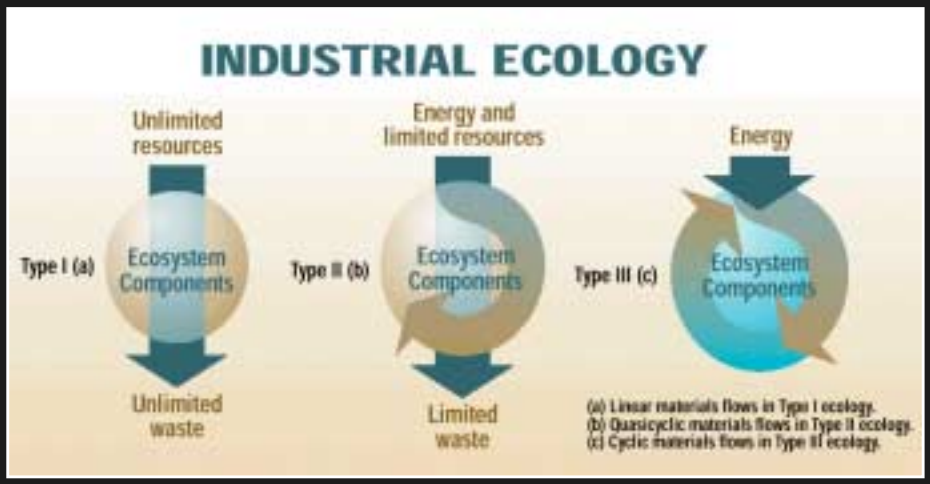
- Biological Ecology :
  The study of the distribution and abundance organisms and their interaction with physical world.
- Industrial Ecology :
  The study of technological organisms and their interactions with the natural world to enable sustainable development.
- Biological symbiosis :
  generally involves a long period of coevolution.
- Industrial symbiosis :
  may occur opportunistically or can be planned.

Definition of an EIP [Lowe, 2001]

An eco-industrial park or estate is a community of manufacturing and service businesses *located together on a common property*. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues including information, energy, water, materials, infrastructure, and natural habitat.

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.

Types of Industrial Systems



Source: Allenby

3. National policies driving IP to EIP

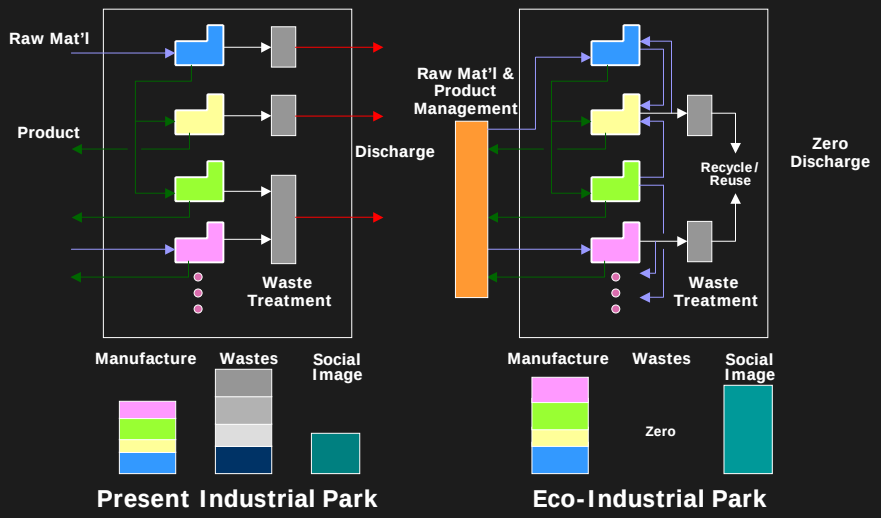
3.1 Industrial Policy(MOCIE)

- "Act to Promote Environmentally Friendly Industrial Structure" (1995)
- CP Technology development program(from 1995)
- CP Technology transfer and dissemination(from 1995)
- EIP development program(15 year 3-phase project)

3.2 Environmental Policies(MOE)

- Strengthening environmental regulation standard
- Environmental impact assessment system
- The prior environmental review system(PERS)
- Environment-friendly business management policy

Conceptual Diagram of KNCPC EIP

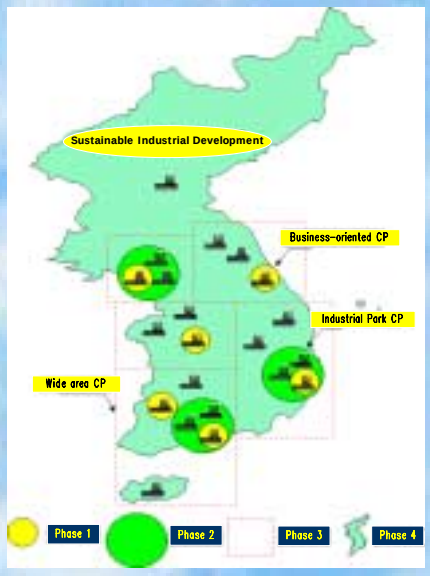


Source: Kwiho Lee, Korea NCPC

EIP Establishment Plan in Korea

Phase	Objectives	Scope	Term	Remark
Phase 1	EIP infrastructure Construction of existing IP	Eco-networking between plants for 5 national industrial parks	2005 -2009 (5y)	-Implementation by KNCPC & KICOX
Phase 2	Spreading EIPs. Success story	Transfer and disseminate to other industrial Parks(20 sites)	20010 -2014 (5y)	- Individual projects - Consortium
Phase 3	EIP Design (Zero emission IP)	EIP design on the basis of industrial ecology	2014 -2018 (5y)	- Voluntary participation

Stepwise EIP Establishment



4. EIP Pilot Project for Eco-Polis Ulsan

Objectives

- ❖ Maximum Utilization of Energy, Water and Resources
- ❖ Promotion of Environmental Industry
- ❖ Establishment of Korean EIP Model

Status of Ulsan Industrial Complexes

Ulsan/Mipo & Onsan Industrial complexes

Item		Ulsan	Onsan
Area (1000㎡)	Total (km²)	40,340	15,237
	Factory area (km²)	34,567	13,422
Construction		1975. 6. 23	1974. 4. 1
No. of Companies	Moved in	558	212
	In operation	485	158
Water Supply capacity		641,000/day	340,000 /day
Waste water		250,000/day	150,000 /day
Production (million $)		44,294	9,937
Employ (person)		87,494	9,716

Economic Status of ULSAN Metropolitan City

- Imports and exports

(unit : million $)

year	export			import		
	national	ulsan	%	national	ulsan	%
1992	76,632	9,137	11.92	81,775	11,893	14.54
1993	82,236	9,987	12.14	83,800	10,861	12.96
1994	96,013	11,417	11.89	102,348	13,205	12.90
1995	125,058	14,905	11.92	135,119	17,695	13.10
1996	129,715	16,079	12.40	150,339	20,001	13.30
1997	136,164	18,624	13.68	144,616	19,930	13.78
1998	132,313	17,289	13.07	93,282	13,336	14.30
1999	143,685	19,103	13.30	119,752	15,593	13.02
2000	172,268	19,972	11.59	160,481	14,268	8.89
2001	150,439	19,951	13.26	141,098	18,272	12.95
2002	162,471	24,177	14.88	152,126	18,943	12.45
2003	193,817	27,485	14.18	178,827	22,651	12.67

Classification of industrial structures in Ulsan/Mipo and Onsan National Industrial Estate

Category	Ulsan	Onsan	Total
Food Products	9	–	9
Textile Products	5	1	6
Wood Papers	13	3	16
Petrochemical	105	52	157
Nonmetallic	24	9	33
Steel	8	13	21
Machinery	149	43	192
Electric, Electronic	45	4	49
Transport Equipment	97	28	125
Others	13	2	15
Services	54	23	77
Total	522	178	700

(data : 2004)

Environmental Pollutants Generation from Ulsan Industrial Complexes

	Air[1)]				Waste Water		Solid Waste	
	SO_2	NO_2	TSP	VOC	Generation	Discharge	General[1)]	Hazardous
Ulsan (ratio)	82,971 (15.8)	63,569 (6.1)	22,849 (24.6)	82,666 (11.8)	367,216 (8.7)*	345,234 (23.4)*	6,672 (3.3)	296,611 (10.2)
Korea	526,599	1,045,33	92,720	699,214	4,226,321*	1,477,166*	204,428	2,914,546

Data: MOE(2003)

note: 1) Data for air and general solid waste are from 2001

2)* Neglecting generation ratio of Kwangyang complexes, accounting for over 50% of total and discharge ratio 3.4%, generation and discharge of waste water from Ulsan industrial complexes are accounting for 27.0% and 24.2%, respectively.

Project Summary

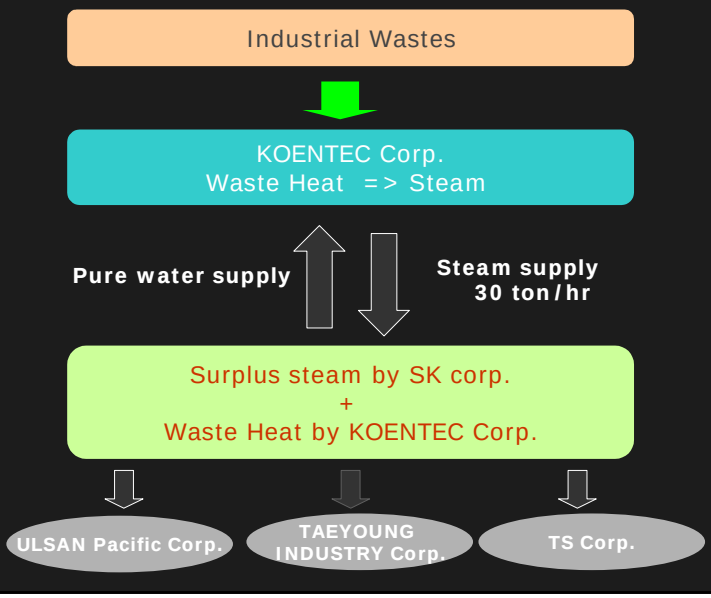
Title	Pilot Project for the development of Ulsan/Mipo, Onsan Eco- industrial parks
Periods	2004.7 2005.6 (planning), 1 st phase(2005 2009)
Host	Ulsan Regional Environmental Technology Development Center
Supervisor	Prof. Hung-Suck Park(Univ. of Ulsan)
Participants	Hyundai-motor car, SK Corp., SK Chemical Corp., LG-Nikko Corp., KOENTECH Ltd, Sunkyongwatech Ltd., Energy Ltd.
R&D	University of Ulsan, Ulsan Science college, Kyeungsung Univ.
Cooperation	Ulsan metropolitan city, Ulsan Regional Innovation Agency, KICOX Eastern chapter Ulsan office

Case study of Industrial symbiosis

Environmental Management in Ulsan

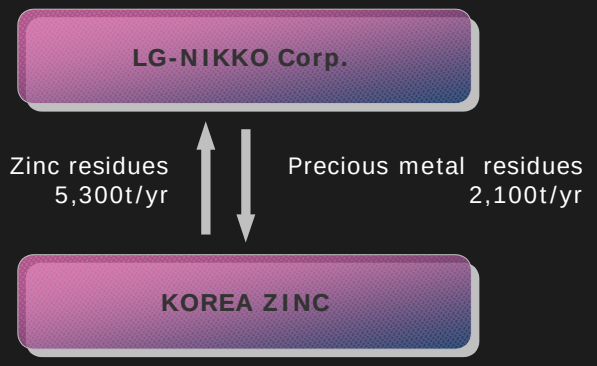
Case of Industrial Symbiosis(1)

KOENTEC-SK Corp. Industrial Symbiosis



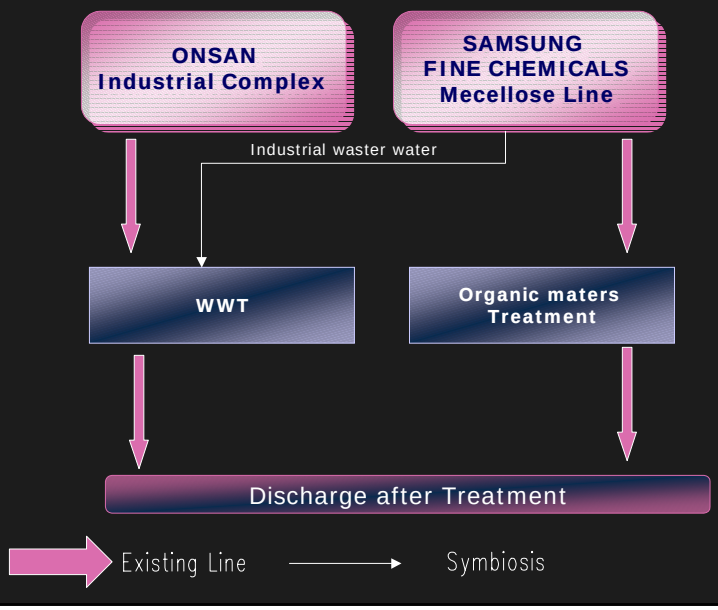
Case of Industrial Symbiosis(2)

LG-NIKKO Corp. - KOREA ZINC Residues Recycling

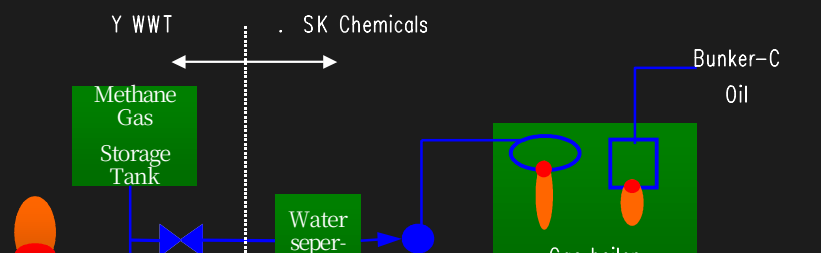


Case of Industrial Symbiosis(3)

SAMSUNG FINE CHEMICALS – ONSAN WWT Wastewater disposal System



Case of Industrial Symbiosis(4)



. Y WWT – SK Chemicals industrial symbiosis

Y WWT:

Digester(7,000 m3) 2 tanks,

Gas Storage tank(2,000 m3) 1 tank

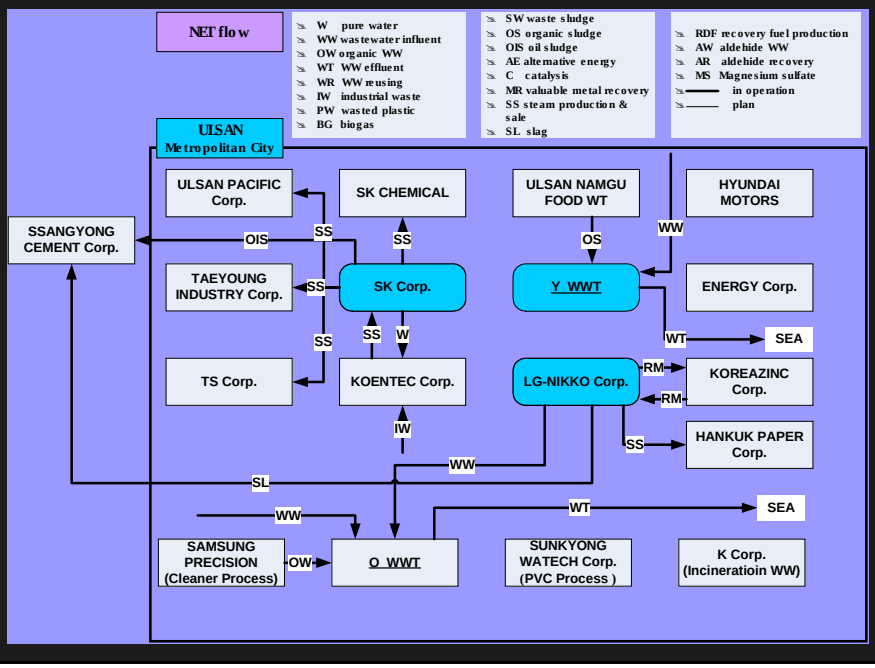
o SK chemicals:

Water seperater, gasline(Dia.150mm, Leng. 450 m)

Revenue 300 million won/yr

CO2 reduction 700 /yr

Industrial symbiosis in Operation at Ulsan Industrial Complexes

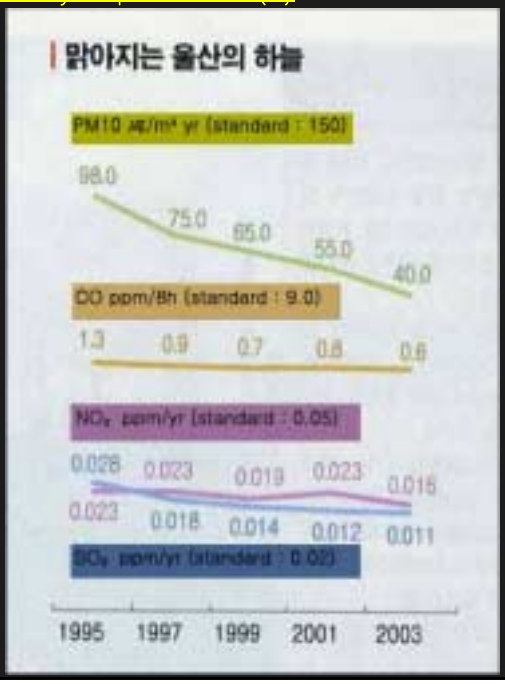


Case of Industrial Symbiosis(4)

Table 5 Material Exchanges in Ulsan Industrial Complexes

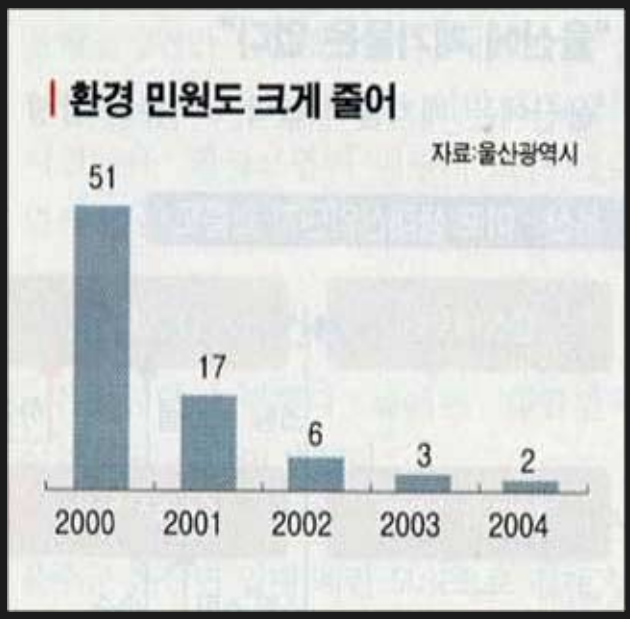
Material	From	To	Sold/ Free	Investment (10000$)	Revenue (10000$/year)
Pure Water	SK Corp.	KOENTECH	Sold	209	411
Stream	KOENTECH	SK Corp.			
Stream	SK Corp.	ULSAN PACIFIC TAEYOUNG IND. TS Corp.			
Recovery Zn	LG-NIKKO	KOREAZINC	Sold		461
Recovery Cu	KOREAZINC	LG-NIKKO	Sold		1,739
Steam	LG-NIKKO	HANKUK PAPER	Sold	696	261~348
Biogas	Y WWT	SK CHEMICAL	Sold		26
Waste MeOH	SAMSUNG	O WWT	Free		130

Environmental Quality Improvement(1)

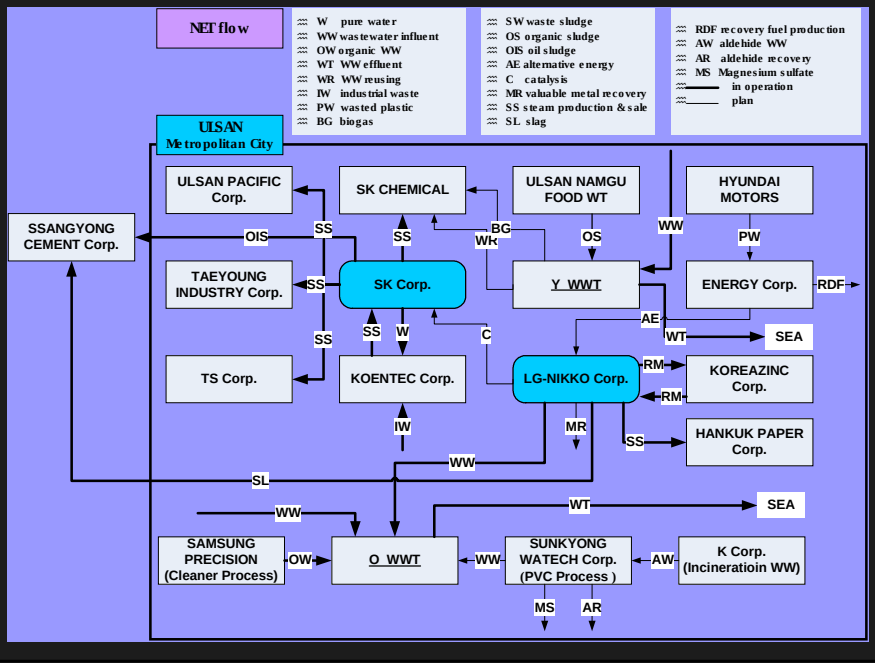


Environmental Quality Improvement(2)

Environmental Quality Improvement(3)



Conceptual industrial symbiosis at Ulsan Industrial Complexes



Strategies for the construction of EIP in Ulsan

How to develop ?
optimizes the use of available resources, materials, infrastructure, and human resource to reduce costs, increase profits, improve the environment.

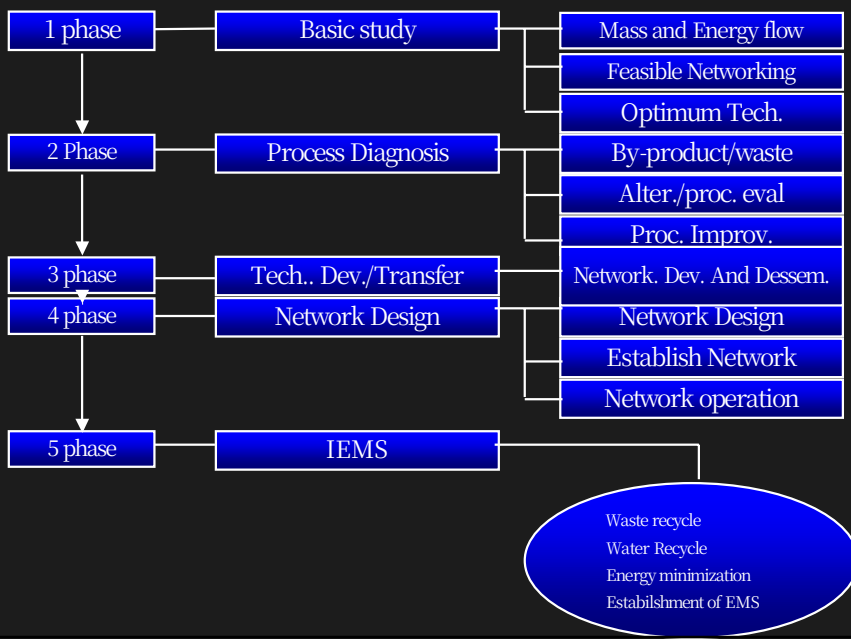
Transform the existing IP to EIP

- Industrial symbiosis : creates materials links, connects industries
- Community connections– involvement in Regional Planning
- Joint promotions (e.g.trade shows)
- Integrated logistics
- Common subcontractors
- Multi–media planning
- Wellness programs,
- Accident prevention
- Joint Benefits packages
- Flexible employee assignments

Eco-industrial Networking

(Local IP + National IP + EIN outside of Ulsan)

Procedure of Project



What are areas for further improvement

- Primary Component: Industrial – Metabolism
  - Resource Optimization
  - Product and Process Optimization
  - Information System
- Supportive Component
  - . How to carry out project ?. – Multi-stakeholder
  - Clean Policy in place among inter-agencies, Park-level Management, Programmatic actions on product and services, social needs.

Goal of Air quality Standard of Ulsan

	unit	Criteria	2001	2006	2011	2021
SO_2	ppm/year	0.02	0.012	0.008	0.006	0.005
CO	ppm/8hr	9	0.8	0.5	0.4	0.3
NO_2	ppm/year	0.05	0.023	0.02	0.015	0.01
O_3	ppm/8hr	0.06	0.02	0.018	0.015	0.01
PM_{10}	/(·year)	70	55	50	45	40

Goal of Water Quality Standard of Ulsan

		2001	2006	2011	2021
River	TEAHWA River	.	.	.	.
	HOEYA River	.	.	.	.
	DONG Stream	.	.	.	.
Coast	ULSAN	.	.	.	.
	ONSAN	.	.	.	.

5. Conclusions

. Existing industrial symbiosis in Ulsan industrial park are skewed to low-cost and no-cost approaches, or commonly termed as **"**low hanging fruit**"** approach in UNEP.

. Ulsan EIP project can lead the Korean EIP project by the support of new Ulsan regional strategic industry, . Environmental Industry. .

. Ministry of Environment must involve more actively in Korean EIP Project in cooperation with MOCIE.

. Exchanges of Asian EIP Experiences such as Japan, China and Thailand will be very helpful to the success of Korean EIP projects.

Thank you very much for you attention !

Strategies for sustainable development of industrial park

- planning for eco-industrial park in Ulsan, Korea

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1) Department of Civil and Environmental Engineering, University of Ulsan, Ulsan 680-749, Korea (*Corresponding Author, E-mail: parkhs@ulsan.ac.kr).

Abstract

An eco-industrial park or estate, alternatives of IE, is a community of manufacturing and service business located together on a common property, which seek enhanced environmental, economic, and social performance through collaboration in managing in environmental and resource. Korea National Cleaner Production Center(KNCPC) affiliated to Korea Institute of Industrial Technology(KITECH) has just started 15 year 3-phase Master EIP plan with the support of Ministry of Commerce, Industry, and Energy. 6 industrial parks, including industrial parks in Ulsan city, known as the industrial capital of Korea, are performing planning project to find the feasibility of shifting existing industrial parks to eco-industrial parks. This paper describes the Korean national policies to drive this global trends of innovation of industrial parks and existing inter-industry waste, energy, and material exchange developed in Ulsan industrial complexes. In addition, Ulsan EIP pilot project, which will be implemented for 15 years from 2005, is elaborated including regulatory issues and technologies to be applied.

1. Introduction

Ulsan was appointed as a special industrial zone in Korea in 1962 and, since then, industrial complexes have been built without considering of the environment. Though Ulsan city has grown up to be the industrial capital of Korea, as a stronghold of petrochemistry, nonferrous metals, ship building and auto mobile industries, Ulsan has been called "pollutants department store" and 'the worst polluted city' thereafter.

With the deteriorating environmental quality, Ulsan and Onsan industrial complexes were appointed as the special air pollution control regions in March '86. The special

emission standard 30 to 80% stricter than other areas was enforced and has been applied to newly-built factories since Oct. '91, thus these regulations were in operation 10 years earlier than in other areas. The 'stricter emission standard' 30 to 60% higher than other area has been applied in existing plants since Feb. '92, 5 years earlier than other areas. Enterprises have intensified investment on clean production, pollution prevention facilities and environmental management to meet the enhanced environmental standard. Without the efforts and investment of business enterprises, it may be almost impossible to improve the environmental quality of Ulsan, where heavy industrial and chemical plants are densely located.

Since the 1992 Earth Summit in Rio de Janeiro, local authorities are generally considered important actors in the transition towards sustainable development. In order to enhance the environmental quality drastically the Ulsan metropolitan city has commissioned "The Environmental Pollution Investigation and Comprehensive Environmental Master Plan" for ' 98 to 2002. , where seven environmental fields were included such as water, air, odors, ecosystem, waste, soil and the Taewha River. The comprehensive action plan for improving environment for '98 to 2002 was made based on the environmental investigation. It was planned to invest a total of 1,200 billion won including a municipal budget of 700 billion won on a 94 projects for the planned period.

In the mean while, to improve the urban infrastructure, environmental quality, educational and cultural conditions, Ulsan citizen and NGO's made a civic movement of the establishment of Ulsan metropolitan city, which resulted in raising metropolitan status June 15, 1997.

Ulsan industrial complexes has been continuously evolving from conventional industrial complexes to eco-industrial parks, based on sustainable development concepts imposed in industries after Rio Earth Summit in 1992. To change the Ulsan more environmentally-friendly ecology city where human and nature coexist, “Ecopolis Ulsan” was declared in 2004 based on “The Master plan of Ulsan”, which include the eco-industrial park as an action plan.

This article introduces the concets of eco-industrial park and describes the existing industrial symbiosis in Ulsan industrial complexes and evaluates the economic and environmental effects. In addition, Ulsan EIP pilot project, which will be implemented for 15 years from 2005, is addressed including regulatory issues and technologies to be required.

2. Eco-industrial parks

Industrial estate may be defined simply as “a tract of land, subdivided and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and the close proximity of firms. Though the industries located in industrial estate are afforded a number of benefits, including external economies of scale, reduced production costs, they also have disadvantages such as the increase of industrial pollution.

With the combined influence of increased awareness of environmental issues and more stringent regulations, estates are being obliged to look for cost-effective ways of improving their environmental performance.

An eco-industrial park or estate, emerging as an alternative of IE, is a community of manufacturing and service business located together on a common property, which seek enhanced environmental, economic, and social performance through collaboration in managing in environmental and resource issues. The goal of an EIP is to improving the economic performance of the participating companies while minimizing environmental impacts. Components of the EIP approach include green design of park infrastructure and plants(new or retrofitted); cleaner production; pollution prevention; energy efficiency; and inter-company partnering. An EIP is also seek benefits for neighboring communities to assure that the net impact of its development is positive.

There are three basic categories of eco-industrial project:

1. Eco-industrial park or estate(EIP) – an industrial park developed and amaged as a real estate development enterprise and seeking high environmental, economic, and social benefits as well as business excellence.
2. By-product exchange(BPX) – a set of companies seeking to utilize each other’s by-products(energy, water, and materials) rather than disposing them as waste.
3. Eco-industrial network(EIN) – a set of companies collaborating to improve their environmental, social, and economic performance in a region.

3. Policies supporting eco-industrial park in Korea

3.1 Sustainable development of industrial policy

The chapter 30 of Agenda 21, in which the role of business for the support of Agenda 21 is defined, states the involvement and cooperation of business are vital factors in achieving the objectives of Agenda 21, sustainable development.

Industrial environmental policy have drastically changed after the Ministry of Commerce, Industry, and Energy(MOCIE) enacted ‘APEFIS, Act to Promote

Environmentally Friendly Industrial Structure, in Dec. 1995.

Based on the APEFIS, MOCIE established institutional system for clean production (CP) and environmental management system(EMS) based on ISO 14001 as implementing tools, and “The first comprehensive master plan for environmental friendly industrial development” was made and operated based on APEFIS.

This plan included streamlining the supporting system, CP transfer and dissemination, promoting environmental industry, and stimulating environmental management.

1) Clean production program

Cleaner production is the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner production can be applied to the processes used in any industry, to products themselves and to various services provided in society. This program supports the development of cleaner production technology that helps industry be eco-efficient.

O Cleaner production technology development

This program supports the development of cleaner production technology that helps industry be eco-efficient. It is classified into three categories; general project, shared project and consolidated project.

O CP Technology transfer and dissemination program

This program supports transfer of domestic and foreign technologies that increase productivity and reduce environmental load for the company. Supporting area are CP Assessment, technology transfer, international joints projects, information service, training and education, supply chain environmental management(SCEM), environmental management system(EMS), regional dissemination center, open laboratory, eco-industrial park(EIP)

2) EIP Project

Korea National Cleaner Production Center(KNCPC), Korea Institute of Industrial Technology(KITECH) started 15 year 3-phase project, 'Eco-industrial park(EIP) construction for infrastructure of cleaner production in Korea' with the support of Ministry of Commerce, Industry, and Energy.

In 2004, trial projects are performed for 6 industrial parks including Ulsan

industrial complexes to find the feasibility of applying industrial ecology to existing industrial parks. For inter-networking businesses, cleaner production assessment will be done before making by-products exchange network, that will characterize so called 'Korean Eco-Industrial Park Model' with the introduction of environmental management system. KNCPC and Korea Industrial Complex Corp. will be the main actors in implementing phase 1. In phase 2, the success stories in phase 1 will be transferred and disseminated to other industrial parks. This requires the active participation of institutes, colleges, and consultants. In phase 3, industrial parks will be designed on the basis of industrial ecology at the first stage and EIP construction model will be also applied.

Table 1. Korean EIP Construction Plan

Categories		1yr	2yr	3yr	4yr	5yr	Total
Technology Development	By-product exchange	174	348	348	348	435	**1652**
	Process analysis and optimization	87	174	130			**391**
	Alternative raw material	174	348	435	435	435	**1,826**
	Material cycle modeling	43	43	43			**130**
Technology Transfer	Waterpinch expansion	43	43	43			**130**
	Process diagnosis analysis	234	348	348			**930**
	Integrated EMS				87	261	**348**
	Inter – industry CMS				43	157	**200**
Infrastructure	By-product and waste recycle DB		87	87	87	87	**348**
	EIP professional education		87	87	43	43	**260**
	Integrated Recycling Pilot Plant		174	867	867	1,739	**3,652**
	Integrated resource recycling system			130	870	1,739	**2,739**
	Comprehensive Water reuse Network				870	1,304	**2,174**
Total		**757**	**1,652**	**2,521**	**3,652**	**6,200**	**14,783**

(unit : 10,000 $, $=1,150\)

3.2 Environmental policies stimulating sustainable development

The government has discarded the growth-driven policies of the past strengthening the environmental preservation and standards. It now strives to achieve sustainable development that pursues environmental preservation and economic development simultaneously. There are several environmental policies, which stimulate the sustainable development of industry such as environmental impact assessment(EIA), prior environmental review systems(PERS) and environment-friendly business management policies.

1) Environmental impact assessment system

The EIA has been focused on aims to promote or enforce environment-friendly development because it most deal with large-scale development project during the execution stage, after plans have been approved and confirmed. It also mainly reviews pollution reduction measures.

2) The prior environmental review system(PERS)

The PERS aims to balance development and preservation by identifying possible environmental impacts of development plans or projects in the early stages of planning. The system includes considerations of ways to carry out development plans while harmonizing the built and natural environments in an aesthetically pleasing manner.

3) Environment-friendly business management policy

Throughout the world, environment-friendly products and management structure of corporations are becoming overriding determinants of their competitiveness. Against this backdrop, first rate are endeavoring to raise their real corporate value through increased sales, cost reduction and investment efficiency via means of environmental management.

In parallel with this trend, Korea is implementing and environment-friendly business designation system to foster sound environmental management. The government designated businesses that practice prevention-oriented environmental management as “environment-friendly.”

The system promotes preventive solutions to environmental pollution that arises during production processes. The businesses handle pollutants in a responsible manner and make tangible contributions to environmental improvement.

Also, a corporate environmental information disclosure system and An eco-

labeling system has been introduced and implemented to stimulate the environment-friendly production and consumption.

4. The pilot project for eco-industrial parks in Ulsan., Korea

4.1 Status of industrial complexes.

There are two national industrial complexes, Ulsan/Mipo and Onsan industrial complexes, and 4 agricultural and industrial estates in Ulsan. Ulsan industrial complex, the core site for automobile, shipbuilding and petrochemical industries, and Onsan complex come together to form a horizontally integrated industrial system, leading Korea's economic development.(Fig. 2, Table 2 and 3).

Fig. 2 Map of Ulsan Industrial Complexes

Table 2. Status of Ulsan. Mipo and Onsan National industrial Estates

Item		Ulsan Mipo	Onsan
Area(1000㎡)	Total(km^2)	40,340	15,237
	Factory area(km^2)	34,567	13,422
Construction		1975. 6. 23	1974. 4. 1
No. of Companies	Moved in	558	212
	In operation	485	158
Water Supply capacity		641,000/day	340,000 /day
Wsate water		250,000/day	150,000 /day
Production(100 million $)		443	99
employ(person)		87,494	9,716

data) KICOX(2002)

Table 3. Classification of industries in Ulsan/Mipo and Osan national industrial park

Category	Ulsan	Onsan	Total
Food Products	9	-	9
Textile Products	5	1	6
Wood Papers	13	3	16
Petrochemical	105	52	157
Nonmetallic	24	9	33
Steel	8	13	21
Machinery	149	43	192
Electric, Electronic	45	4	49
Transport Equipment	97	28	125
Others	13	2	15
Services	54	23	77
Total	522	178	700

(April 2004)

4.2 Pollutants generated from Ulsan industrial complexes

Table 4 is summary of the pollutants generated from Ulsan industrial complexes, which are accounted for high percentage of total generation in Korea. Though

significant efforts have been made in many fields to improve the environmental quality, Ulsan is still suffering from environmental issues.

Due to the strengthening environmental regulations imposed on the stack industries, movement and shutdown of company are becoming another social problems in Ulsan. Thus, innovation of industrial complexes to eco-industrial park is urgently required for sustainable development of industrial parks.

Table 4. Pollutants generated from Ulsan industrial complexes(2002)

	Air[1)]				Waste Water		Solid Waste	
	SO_2	NO_2	TSP	VOC	Generation	Discharge	General[1)]	Hazardous
Ulsan	82,971	63,569	22,849	82,666	367,216	345,234	6,672	296,611
(ratio)	(15.8)	(6.1)	(24.6)	(11.8)	(8.7)*	(23.4)*	(3.3)	(10.2)
Korea	526,599	1,045,332	92,720	699,214	4,226,321*	1,477,166*	204,428	2,914,546

Data: MOE(2003)

note: 1) Data for air and general solid waste are from 2001

* Neglecting generation ratio of Kwangyang complexes, accounting for over 50% of total and discharge ratio 3.4%, generation and discharge of waste water from Ulsan industrial complexes are accounting for 27.0% and 24.2% of the total, respectively.

4.3 Industrial symbiosis at Ulsan industrial parks.

Ulsan industrial complexes were originally developed as conventional industrial estate, with a collective energy provider such as electricity, steam and water. The industrial collaborations in Ulsan complexes were spontaneously occurred by meeting the stringent environmental regulations and economic benefits.

As the concept of EIP has just introduced in Korea, the municipality and managers and citizen are gradually interested in by-product exchanges already operated in Ulsan complexes.

The Ulsan industrial collaboration now includes six partners:

Koentec Ltd. – Industrial waste treatment and disposal company with incinerator capacity of 300 ton/day and landfills

SK Corp. – Leading petrochemical industry in Korea, production capacity

of 4,500,000 tons of petrochemicals/yr (aromatics, olefins, PE, PP, solvent, etc). Total annual sale of 220 million barrels in 2003, grasping 34% of the domestic market share

SK Chemicals Corp. - SK Chemicals was the leader to develop high-performance PETG resin (SKYGREEN ®), and is making rapid and steady progress in the polyurethane business.

LG-Nikko Corp. - Leading Cu smelting industry with production capacity of Cu 200,000 ton/yr, Sulfuric acid 1,170,000 ton/yr, Au 100 ton/yr, Ag 230 ton/yr, Pt 60 kg/yr, Pd 500 kg/yr, Se 230 ton/yr

Koreazinc Corp. - Korea Zinc founded in 1974 and is the world No. 1 manufacturer of non-ferrous metals. Korea Zinc and its overseas subsidiaries are together producing 10% of the global zinc production.

The Ulsan metropolitan city – Operate the Ulsan Municipal Wastewater Treatment Plants (350,000 m3/day)

Table 5. Industrial symbiosis in Ulsan industrial complexes in 2004

Material	From	To	Sold/Free	Investment (10000$)	Revenue (10000$/year)
Pure Water	SK Corp.	COENTECH	Sold	209	411
Stream	KOENTECH	SK Corp.			
Stream	SK Corp.	ULSAN PACIFIC TAEYOUNG IND. TS Corp.			
Recovery Zn	LG-NIKKO	KOREAZINC	Sold		461
Recovery Cu	KOREAZINC	LG-NIKKO	Sold		1,739
Steam	LG-NIKKO	HANKUK PAPER	Sold	696	261~348
Biogas	Y WWT	SK CHEMICAL	Sold		26
Waste MeOH	SAMSUNG	O WWT	Free		130

Over very short periods of time, these partner spontaneously developed a series of bilateral exchanges, which also include a number of other companies. It simply evolved as a collection of one-to –one deals that made environmental and economic benefits for pairs of participant in each.

4.4 Feasible industrial symbiosis to be implemented in pilot study

The pilot project is to investigate the feasible industrial symbiosis by intra-plant innovations and approaches, and inter-plant collaboration in improving environmental and economic performance, both of individual companies and collective industrial system.

Fig. 2 is the the proposed EIP based on industrial symbiosis at Ulsan Industrial Complexes including existing industrial symbiosis. SK Corp, Y municipal wastewater treatment plant and LG-Nikko Corp are anchor businesses.

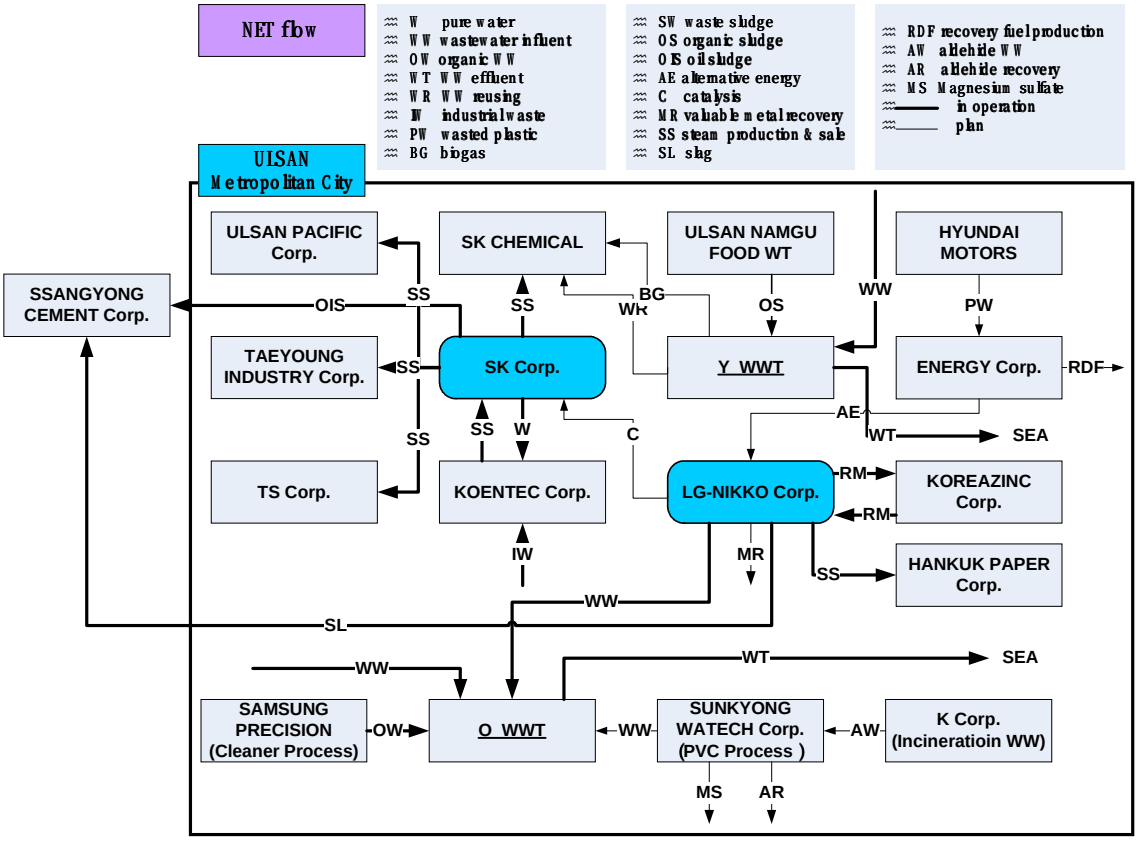

Fig. 2. The proposed EIP based on industrial symbiosis at Ulsan Industrial Complexes

Some technologies of interest to the Ulsan EIP pilot project are

1) plastic separation
2) solvent recycling and recovery
3) recovery of by products
4) RDF production and utilization
5) Wastewater treatment and reuse

5. Conclusions

An eco-industrial park or estate, emerging as an alternative of IE, is a community of manufacturing and service business located together on a common property, which seek enhanced environmental, economic, and social performance through collaboration in managing in environmental and resource issues.

Though Ulsan industrial complexes were originally developed as conventional industrial estates, with a collective energy provider such as electricity, steam and water, the concept of industrial ecology have been already applied due to the stringent environmental regulations and economic benefits.

In 2004, “Eco-polis Ulsan” was declared first in Korea based on “The Master plan of Ulsan”, in which Ulsan EIP Pilot project is included as an action plan. So, success of Ulsan EIP pilot project is key factor to be sustainable Eco-polis Ulsan. .

Ulsan eco-industrial development can be achieved by expanding existing by-product exchange(BPX) and eco-industrial network(EIN). However, system analysis including industrial metabolism, input-output analysis, environmental evaluation, flexibility analysis must be conducted in detail. In addition, Ulsan EIP project must be associated with the regional strategic environmental technologies and businesses to upgrade environmental technologies. To get the public support, education, publicity and leadership for Ulsan EIP are also highly required.

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