



**NANYANG
TECHNOLOGICAL
UNIVERSITY**

Eco Industrial Parks for Waste Minimization

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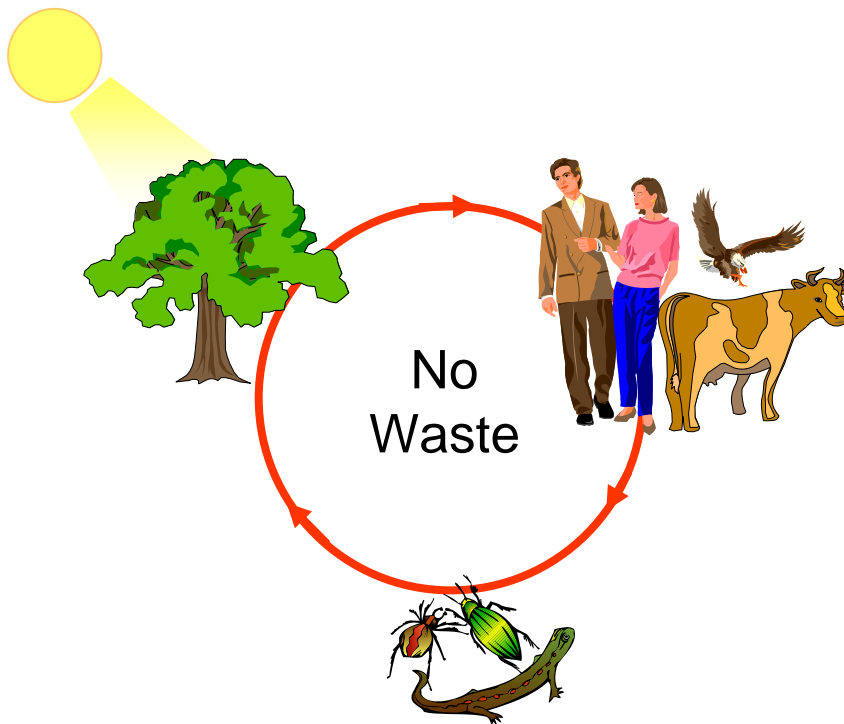
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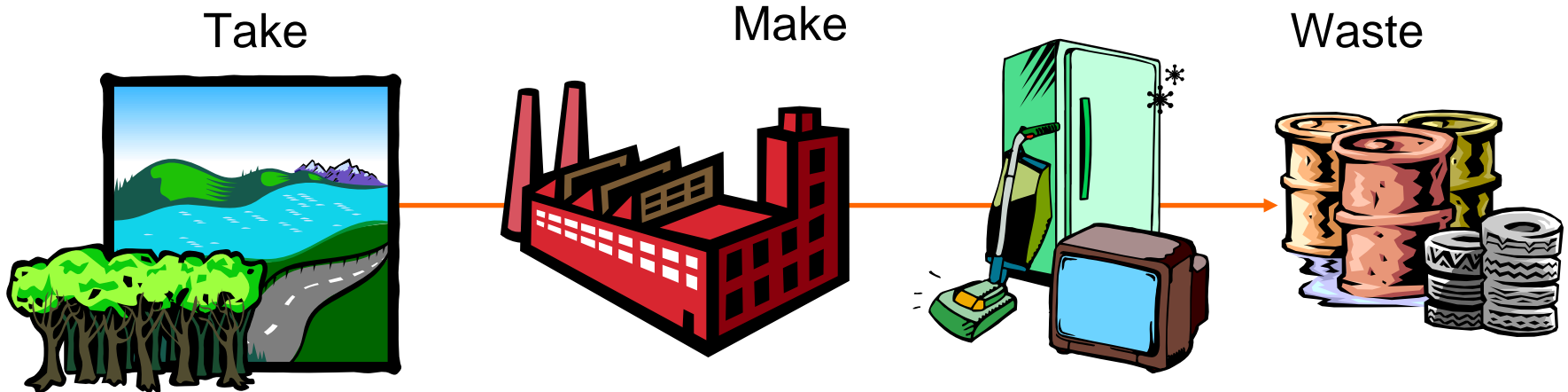
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To maintain the integrity of life, we need to understand how nature works:



- Nature works in cycles
- There is no waste - what is unused by one species becomes nutrients for the next
- The sun's energy drives the process
- Green celled plants using photosynthesis create net concentration and structure

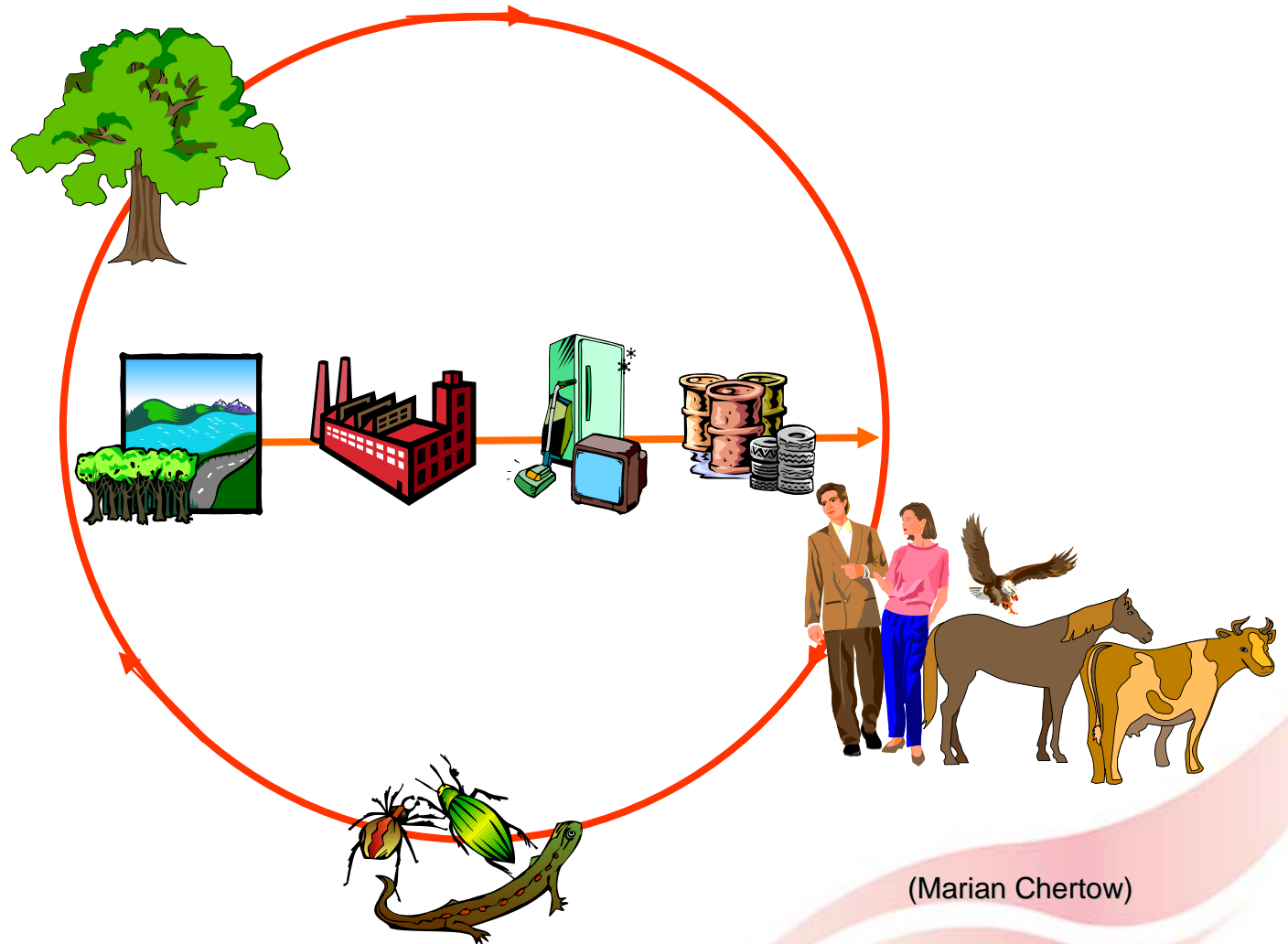
In contrast, our industrial system functions primarily in a linear fashion:



Take “natural capital,” structured valuable material, and process it into unusable waste

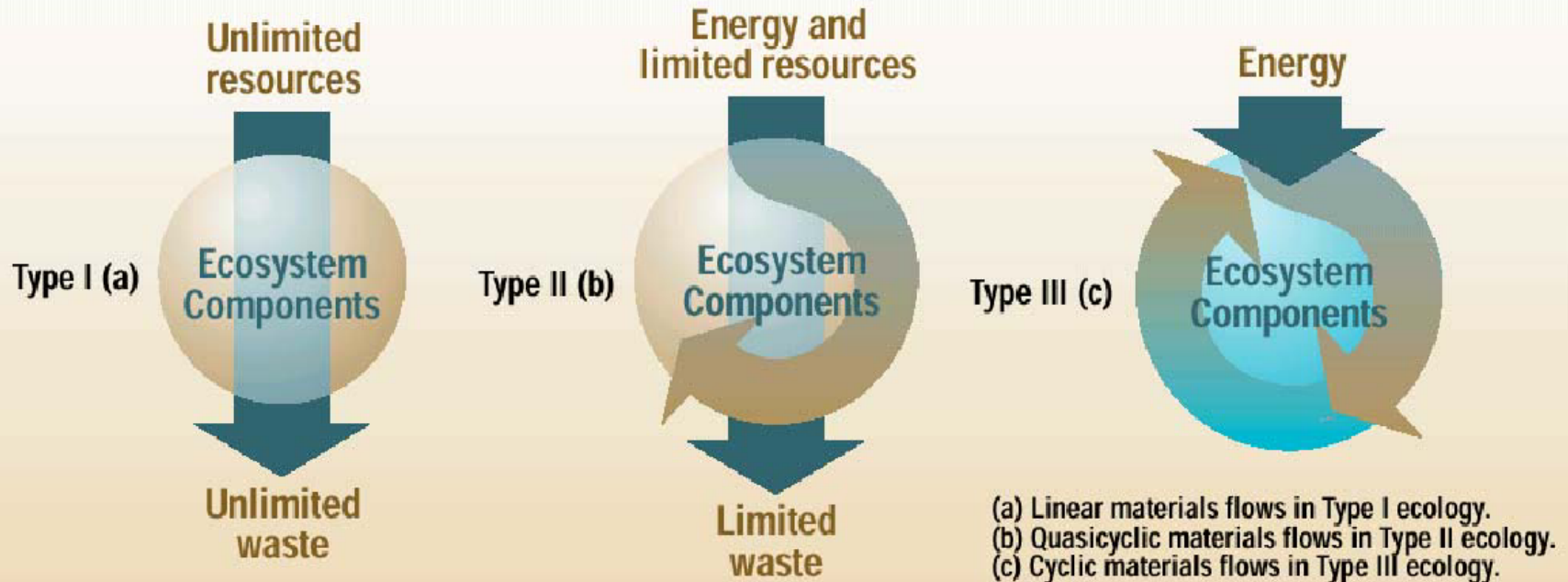
Only 6% of material flow ends up in products

This industrial system, operating on an ever larger scale, is embedded in and affecting nature's cycle:



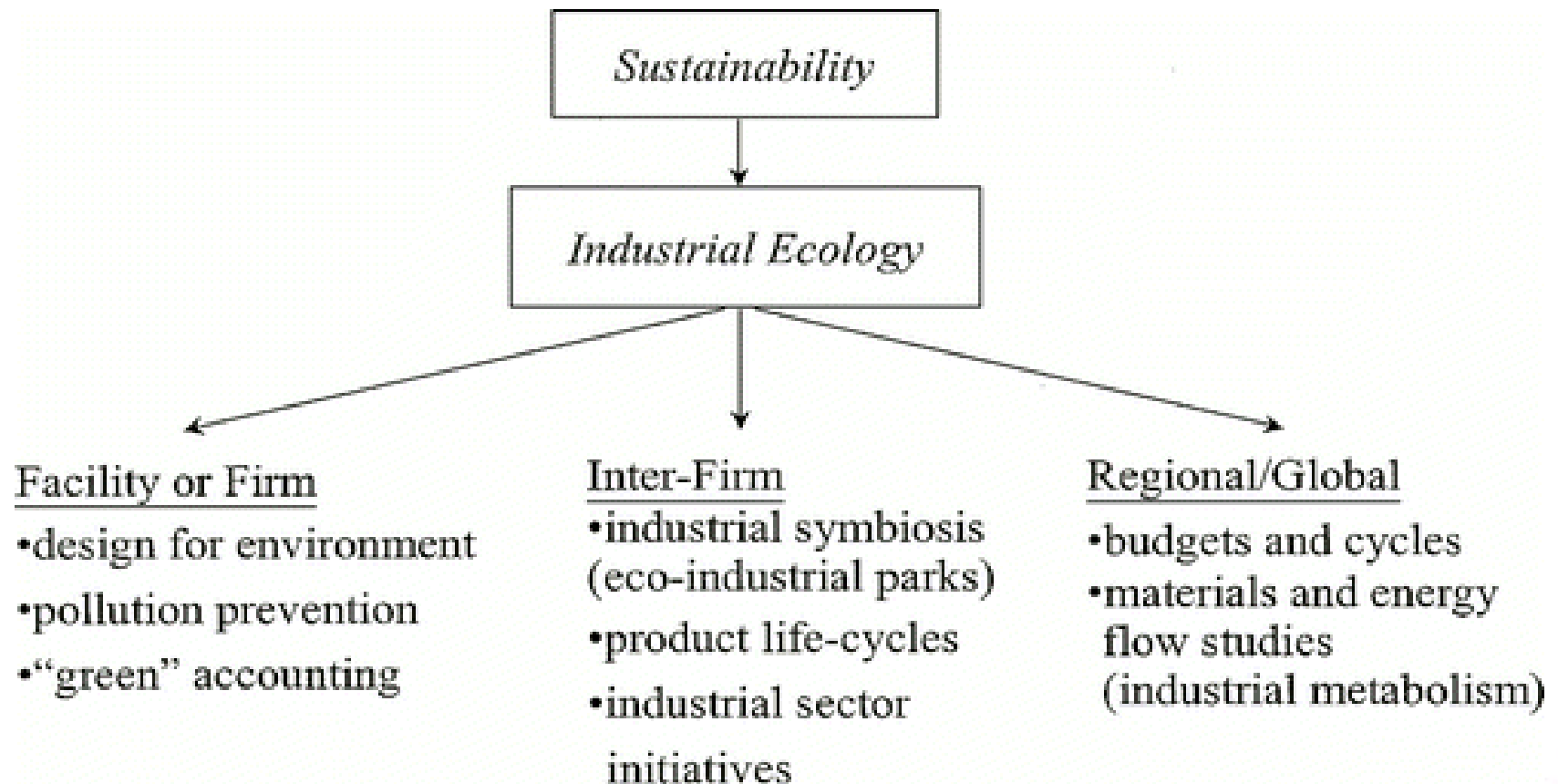
Industrial Ecology (IE)

INDUSTRIAL ECOLOGY



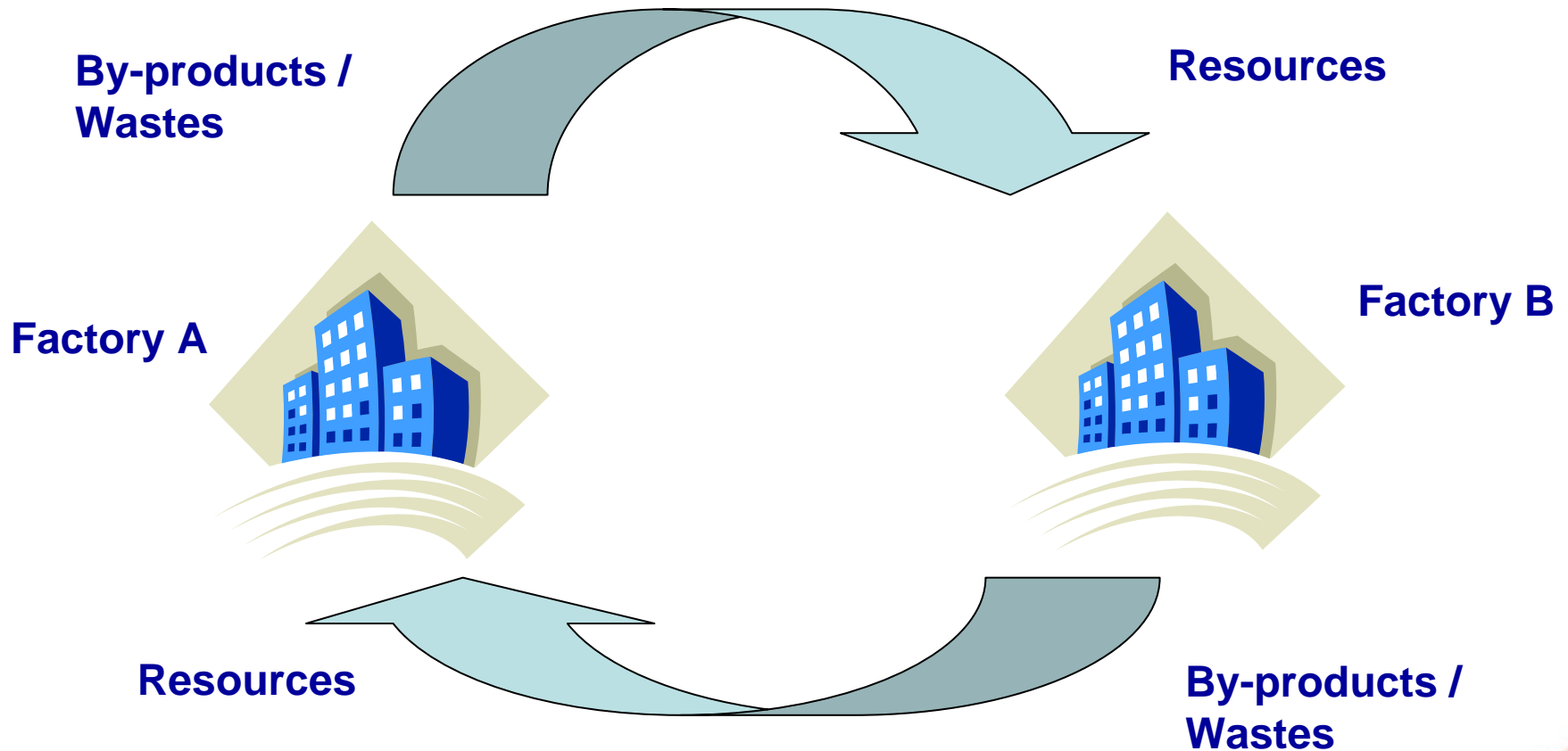
(Brad Allenby)

3 Levels of Operation of IE



Source: Marian Chertow, “Industrial Symbiosis: Literature and Taxonomy”, Annual Reviews of Energy Environment 2000

Industrial Symbiosis/EIP



EXCHANGE OF RESOURCES

Advantages of EIP

- **Recycling of by-products; the by-product of one company becomes an important resource for another company**
- **Reduced consumption of resources, e.g. water, coal, oil, gypsum, fertilizer**
- **Reduced environmental strain, e.g. reduced CO₂ and SO₂ emissions**
- **Improved utilization of energy resources; e.g. waste gases are used in the energy production**
- **Minimization of waste materials to be treated and disposed of in these industrial estates**
- **Greatly reduce operational costs**

Examples of Established Eco Industrial Parks around the World

Eco Industrial Park Initiatives in Asia Pacific Region

China	Dalian, Tianjin, Suzhou, Yantai, Guigang, Nanhai
Philippines	Laguna International Industrial Park, Light Industry & Science Park, Carmelray Industrial Park, LIMA, Laguna Technopark, Philippine National Oil Company Petrochem Industrial Park; Clean City Center project (USAID)
Indonesia	Lingkungan (LIK), Tangerang; Semarang; Industri Sona Maris
India	Naroda; Tirupur Textile sector; Tamil Nadu tanneries; Calcutta foundries; Tamil Nadu Paper / Sugar; Bagelore Water project; Ankleshwari, Nandeseri, Thane-Belapur
Malaysia	LHT Resources Linkage
Japan	12 ecotowns (e.g. Kitakyushu, Itabashi), Fujisawa, Toyota City
Taiwan	Tainan Technology & Industrial Park, Changhua Coastal Industrial Park; Corporate Synergy System (CSS II) projects
Vietnam	Amata (envi mgt), Hanoi Sai Dong II (feasibility study)
Thailand	Industrial Estate Authority of Thailand plans (Map Ta Phut, Northern Region, Amata Nakorn, Eastern Sea Board, Bang Poo); Samut Prakarn Province CPIE project (ADB funded); Bangkok (Panapanaan)
Sri Lanka	Ministry of Economic and Industrial Development plans

Source: Anthony S.F. Chui, "Eco-Industrial Network in Asia", International Conference on Cleaner Products 2001

Kitakyushu Ecotown, Japan

- Energy generated by combustion of some wastes is supplied to the facilities of the Complex.
- Plastic PET bottle recycling project by Nishi-Nippon PET-Bottle Recycle
- Office equipment recycling project by Recycle Tech Co., Ltd.
- Automobile recycling project by West Japan Auto Recycling Co. where not only automobiles were disassembled but oil and gas were also treated.
- Home appliance such as TVs, refrigerators, and washing machines are disassembled and their parts recycled for remanufacturing.
- Fluorescent tube recycling project
- Medical waste recycling project

Source: Anthony S.F. Chui, "Eco-Industrial Network in Asia", International Conference on Cleaner Products 2001

Establishing the Tuas/Jurong Industrial Estate as a Model Eco Industrial Park (EIP) through Integrated Waste Minimization

Introduction

- Tuas/Jurong Industrial Estate is home to most important industries in Singapore
- Huge amount of liquid and solid waste generated, e.g.
100,000 tonnes of oil sludge and 26,000 tonnes of lubricating oil
- Most of the waste is sent for disposal or incineration; huge amount of money spent on disposal and treatment of these waste
- Environmental problems such as land and water pollution emerge due to these waste treatment methods

Objective

- To evaluate the feasibility of developing an EIP in the Greater Tuas/Jurong Industrial Estate
- To develop all the industrial estates into a comprehensive EIP




EIP Master Plan

1st step of EIP development

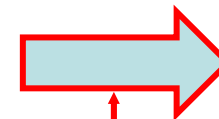
 *Identify EIP potentials*

JTC-NEA-NTU
waste minimization
study-phase 1

 *Master plan of EIP in Jurong conceived more integrated links*

JTC-NEA-NTU
waste
minimization
study-phase 2

Develop EIP

 *Systematic management system of EIP developed EIP maturing and taking shape*

EIP network
monitoring system
implemented

 **2012**

The Proposed Schedule

Proposed Revised Project Schedules:

Serial No	Task List	Duration (May - August 2006)																
		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	
	Task 1. Gather waste material data and information																	
1	1.1 Identifying and prioritizing industrial clusters of interest ^a	XXXX	XXXX															
2	1.2 Planning and scheduling of project works	XXXX	XXXX															
3	1.3 Preparation and reviewing of survey questionnaire	XXXX	XXXX															
4	1.4 Identify and Selection of potential industrial facilities		XXXX	XXXX														
5	1.5 Invitation of selected industrial facilities to EIP survey ^b			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX							
6	1.6 Followup calls to confirm participations and sending survey forms.			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX							
7	1.7 Start survey and interviews			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
	Task 2. Determine usability of target waste materials																	
8	2.1 Developed survey results database				XXXX	XXXX	XXXX	XXXX	XXXX									
9	2.2 Identify and categorize the different types of industrial waste materials				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
10	2.3 Evaluating the usability of target waste materials				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
11	2.4 Evaluate the consistency, quantity and available of the identified industrial waste				XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
	Task3. Identify existing and potential partnership																	
12	3.1 Identifying to existing industrial scraps and waste collectors and partnership								XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
13	3.2 Do matching and proposed industrial partnership								XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
	Task4. Evaluate feasibility of establishing a model EIP study area																	
14	4.1 Setting up an evaluation system for appraisal of potential and existing partnership								XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
15	4.2 Evaluating economics cost benefits of implementation of EIP such as on transportation, pre-treatments and disposal, setting new plants, training cost, material cost... etc.								XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
16	Task5. Report preparation												XXXX	XXXX			XXXX	XXXX

a: JTC would provide information on the different industrial cluster

b: JTC would contact top managements of the targeted companies to invite them to participate in the EIP project.

Meetings will be arranged with these companies and NTU to brief these companies about the survey and also to clarify their doubts.

XXXX - dd schedule, XXXX - overlap period, XXXX - extension time

Questionnaire

- The survey questionnaire was prepared to collect the data/information on the inputs and outputs of energy, water and material of a generic industrial facility. It was designed as an initial screening of industrial facilities.
- The questionnaire consisted 2 main parts, i.e. OUTPUT and INPUT
- **OUTPUT:**
 - Part A: Materials (Quantity produced, treatment processes, specification, etc.)
 - Part B: Water (Amt. of wastewater generated, types of treatment, etc.)
- **INPUT:**
 - Part A: Materials (Quantity required, sources, description of material, etc.)
 - Part B: Water (Sources and purposes of water, amt. daily requirement, etc.)
 - Part C: Fuels and Alternatives (Total amt. of electricity used in previous year, highest peak demand value, etc.)

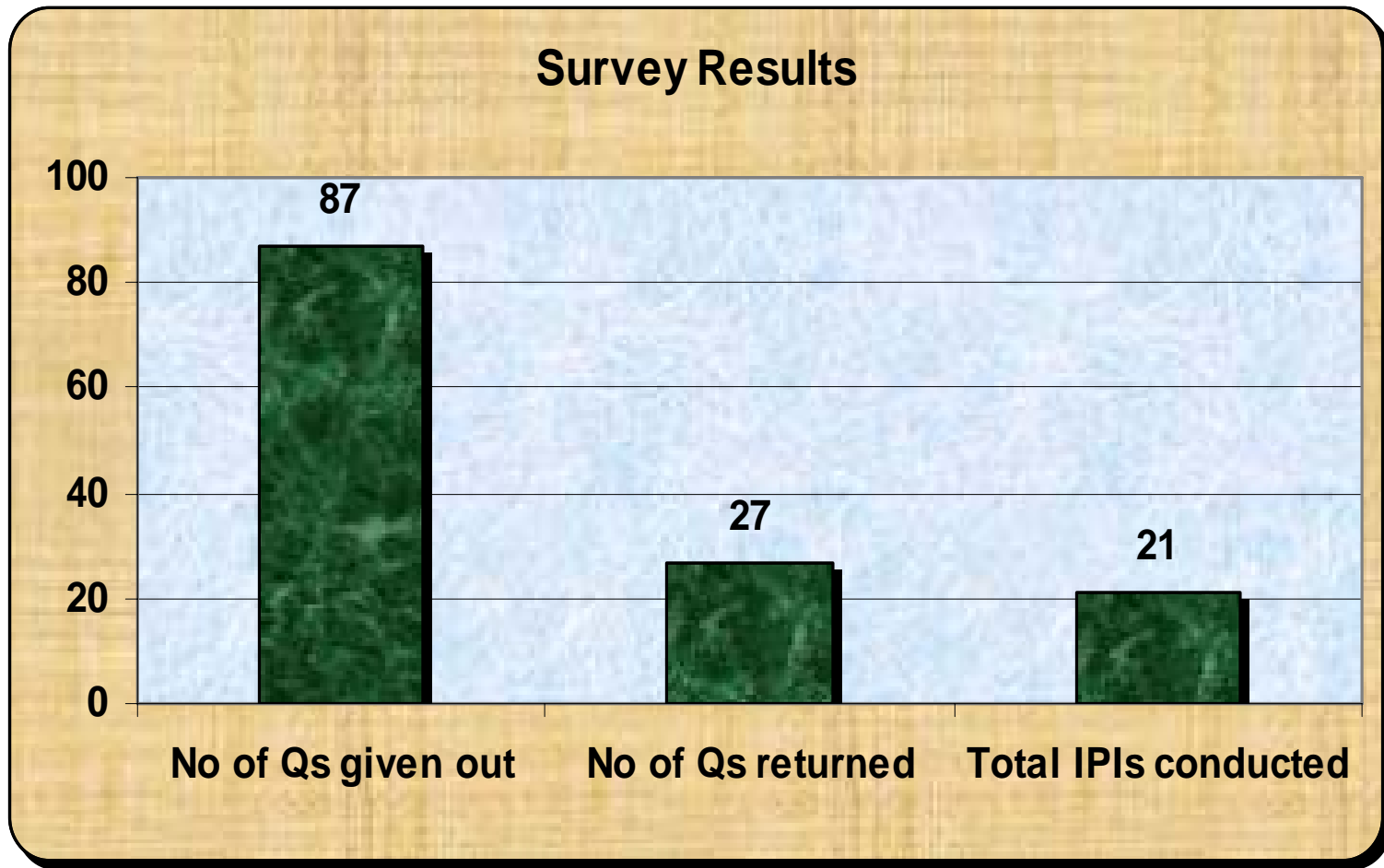
Industries of Concern

The priorities of industries and clusters are shown below:

- 1 Petroleum
- 2 Petrochemicals
- 3 Chemicals
- 4 Pharmaceuticals
- 5 Biochemical
- 6 Shipyard
- 7 Power Plants
- 8 Food & Beverage
- 9 Semiconductor and other E-wastes
- 10 Constructions
- 11 Plastics
- 12 Other Recyclable Municipal Solid Wastes

Industries 1 through 7 were considered as EIP Cluster 1 that would be surveyed first, followed by EIP Cluster 2 (Food and Beverage), EIP Cluster 3 (Semiconductor), and EIP Cluster 4 (industries 10, 11, and 12)

Survey



SSIC Codes of the Participants

2 Digit SSIC Code	Industrial Classification	Number of Companies Participating in Project
25	Manufacture of chemicals and chemical products	9
26	Manufacture of pharmaceutical and biological products	2
27	Manufacture of rubber and plastic products	1
29	Manufacture of basic metals	1
31	Manufacture of machinery and equipment	1
33	Manufacture of Electronic products and components	2
34	Manufacture of medical precision and optical instruments, watches and clocks	1
40	Electricity and Gas Supply	2
45	Mixed Construction Activities	1

Waste Minimization experience of the interviewed 21 Industrial Facilities

Experience with reuse	Number of facilities	Percentage of facilities
No experience	2	9.52
No experience, but interested	3	14.28
Few examples implemented	8	38.09
Large examples implemented	7	33.33
Totally self contained and few additional options remain	1	4.76
Total	21	100

Database Structure

SSIC Code	Description of Item	I/O?	Quantity (mnth)	Facility Code	Additional Information	Current practice	Technology/ strategy needed to market	Potential Industries which could use this	Partnership Type	Name of Facility
2510	Manufacture of Petroleum and Petroleum Products									
	Waste polyvinyl alcohol	O	8 -10 tons	A	biodegradable, 2 kinds - wet(30%) dry granular slabs (70%) higher potential for reuse, water soluble - trace methanol and solvents like methyl acetate may be present (due to batch process consistency may not be maintained)	sent for incineration	Batching out different consistencies (feasible as per owner)	Paper , Adhesives, Textiles as high strength glue	IV	A
	Paper bags (torn contaminated)	O	600 pcs	A	may be contaminated with PVA - sent to recycler at a cost	sent to recycler	Resource Recovery Facility		II	A
	Wooden Pallets	O	Random	A	Waste wood can be used as mulch, compost. Rest can be made into compressed wood if cannot be restructured	sent to recycler	Resource Recovery Facility	Compost Industries, furniture industries	IV	A
	Wastewater	O	8610 cu.m	A	traces of methyl acetate, methanol and acetic acid but total impurities less than 200 ppm -	sent to SUT	Water Pinch Technology – use less contaminated streams for lower grade jobs	internally reused for jobs demanding lower grade water,	IV	A

Partnership Categories

- Type I - Partnerships appeared possible in the long term (1)
- Type II - Partnerships seemed unlikely (13)
- Type III - Partnerships probable in the short term (one time exchange or contract period linkage due to production pattern) (1)
- Type IV - Open channels that had an immense potential to be reused; however companies which could use this byproduct have not yet been involved in the project (42)

Type I – Probable Partnership

- Methanol
Firm J to Firm D

Type II – Unlikely Partner Byproducts

1. Paper bags (torn /contaminated)
2. Spent T catalyst (a form of metal chelate)
3. Chemical esters
4. Purified isophthalic acid (PIA) waste from washing
5. Organic waste stream
6. Sludge cake
7. Dye spray
8. Glass frit
9. Paint sludge

Type III – Short Term/Contract Partnership

- Metal Scrap
Between Firm B and Firm V

Type IV – Open Channels

- Waste polyvinyl alcohol
- Wooden pallets/ crates
- Spent alumina catalyst
- Bio sludge
- Oil and fat from ester production
- Waste drums/ steel /aluminum chips
- Chemical sludge cake
- Polypropylene bag waste
- Tar
- Dichloromethane
- Ethanol
- Waste oil
- Dust/Sand
- Copper slag
- Magnesium oxide
- Defective contact lenses
- Poly vinyl acetate
- Clorox
- Saline

Partnership Details

- Each partnership was detailed as follows:

Material Description

1. *Information of the material from generators*
2. *Requirements of the material by acceptors*
3. *Evaluation of partnership potential*
4. *Analysis of the partnership based on the*
 - *Pre-partnership situation of the buyer/seller*
 - *Post-partnership situation of the buyer/seller and transportation*

(in terms of annual cost savings, total energy/carbon reduction from transportation, value and amount of material reused)

Experience learned

- Participation rate
- Survey and interview
- Collaboration with waste collection and treatment facilities (contractor/broker)
- Necessary development of infrastructure (with government support) to enhance waste exchange
- Creative innovations for reusing materials

Future Plan (Phase II)

- **Facilitation:** Continue facilitating connections among potential partners identified and new partners to be identified (include testing, matching, and exchange of waste materials)
- **Promotion:** Promote EIP awareness via newsletters, newspaper, and other media
- **Centralized MRF:** Establish a centralized material recovery facility (MRF) to promote recovery and reuse of waste materials
- **Web site:** Establish an interactive website that can be used by the potential waste generators and acceptors (info sharing)
- **More estates:** Involve all other industrial estates in Singapore





Thank You

