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Smart Steam Network in the Industrial Sector

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Contents♪

Industrial Development and Environmental Impacts in Korea♪

The evolution of Korean industrial development policy

	1960s	1970s	1980s	1990s	2000s
Nature of development	• Formation of industrial development base	• Establishment and development of heavy industries	• Modification of industrial structure	• Acceleration of industrial development	• Continual industrial growth and expansion
Policy basis	• Government-led, export-oriented industrial development • Promotion of light industries • Establishment and expansion of infrastructure	• Government-led growth of heavy chemical industries	• Rationalization of heavy chemical industries • Promotion of exports in technology-intensive industries	• Deregulation and private industry-led development • Industrial restructuring under IMF guidance	• Development of knowledge-based and futuristic industries • Transition to innovative economy • Balanced development
Key industries	• Textile, electrical products, footwear	• Petrochemical, steel, shipbuilding, automobile, machinery	• Semiconductor, electronics, automobile	• Service-based software industry, semiconductors, fine chemistry, automation	• Information and communication technology (ICT), Video games, biotechnology, convergence

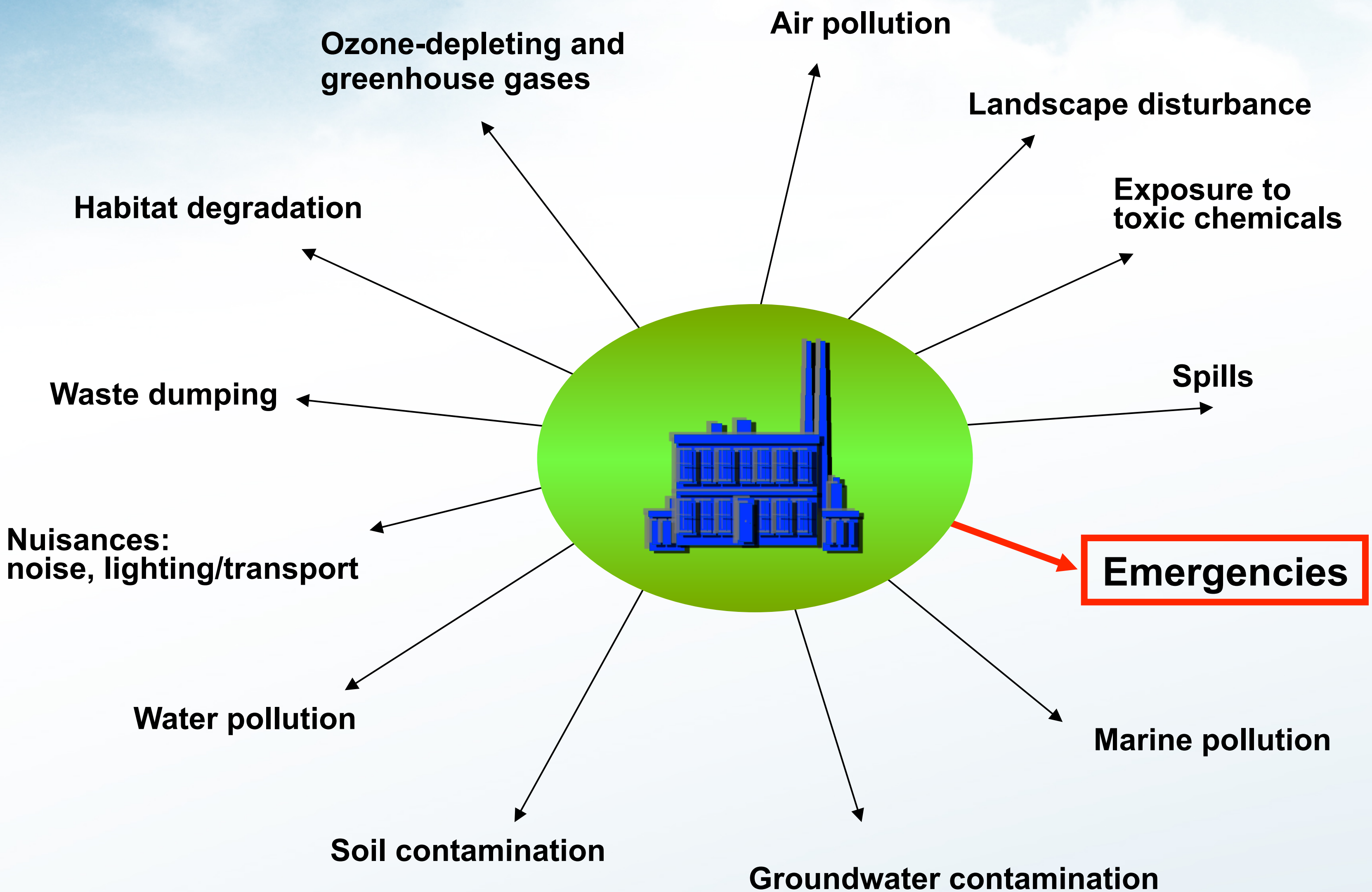
The status of industrial complexes in Korea (by 2014)

Type	Number	Total Land Area (km^2)	Occupied Land Area (km^2)	Number of Companies (in operation)	Employment (10,000 persons)	Production (billion dollars)	Export (billion dollars)
National	41	790.0	537.8	44,741	118.6	665.7	281.5
Regional	560	507.7	500.2	22,582	74.2	339.8	152.1
Urban high-tech	14	2.8	2.8	188	0.2	0.19	0.001
Rural	459	74.2	73.9	5,869	1.4	50.7	12.7
Total	**1,074**	**1,374.8**	**1,114.7**	**73,380**	**207.9**	**1,056.4**	**446.4**

Energy consumption, waste generation, and greenhouse gas emissions from industrial complexes in Korea

Classification	Energy consumption (1,000 toe/yr, by 2013)					Waste generation (ton/day, by 2013)	GHG emissions (Mt CO2-eq, by 2012)
	Coal	Petroleum	Natural gas	Electricity	Other		
National level (A)	32,679	101,809	25,345	40,837	9,578	382,081	668.3
Industrial sector (B)	31,807	60,114	10,470	22,088	6,527	149,815	498.8
B/A	**97%**	**59%**	**41%**	**54%**	**68%**	**39%**	**72.5%**

Environmental and safety issues in industrial park



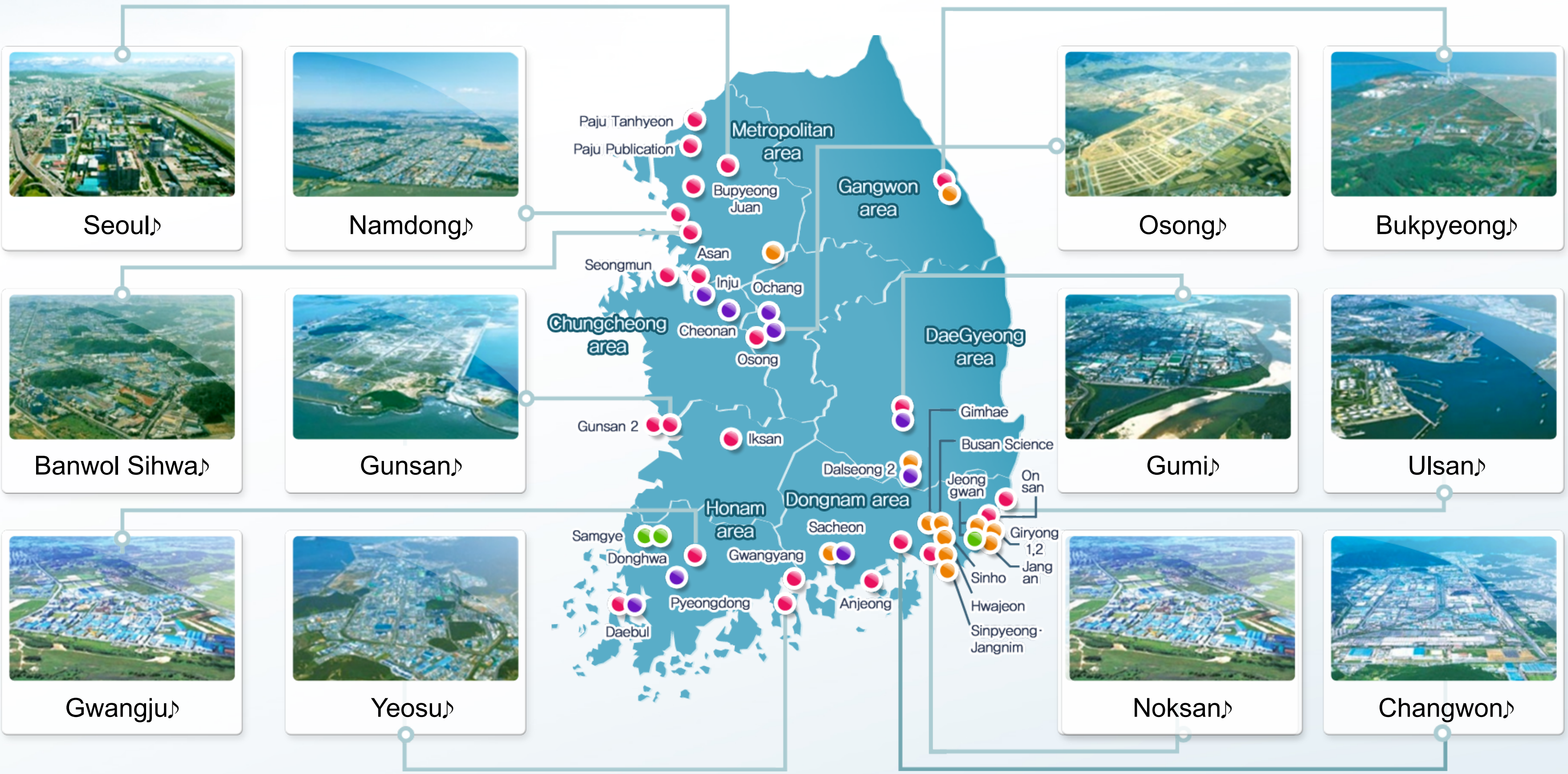
Source : Anthony Chiu (2006)

Korea Industrial Complex Corporation : KICOX
(Established by Korean Ministry of Trade, Industry and Energy)♪

63 Core Industrial Parks(48,000 Co.s) Supported by KICOX♪

Impact in Korea('10): 41% in Production, 43% in Export, 23%(1.07 mil.) Labors♪

National Industrial Complex♪ General Industrial Complex♪ Foreign Investment Zone♪ Rural Industrial Complex♪



What is EIP ? Expansion of RECP to industrial park level

Raw Material

Energy

Segregated Production Cluster

Waste

Heat, Waste, Water, Air etc.

Raw Material

Energy

Optimising Resource & Energy Efficiency Through process integration

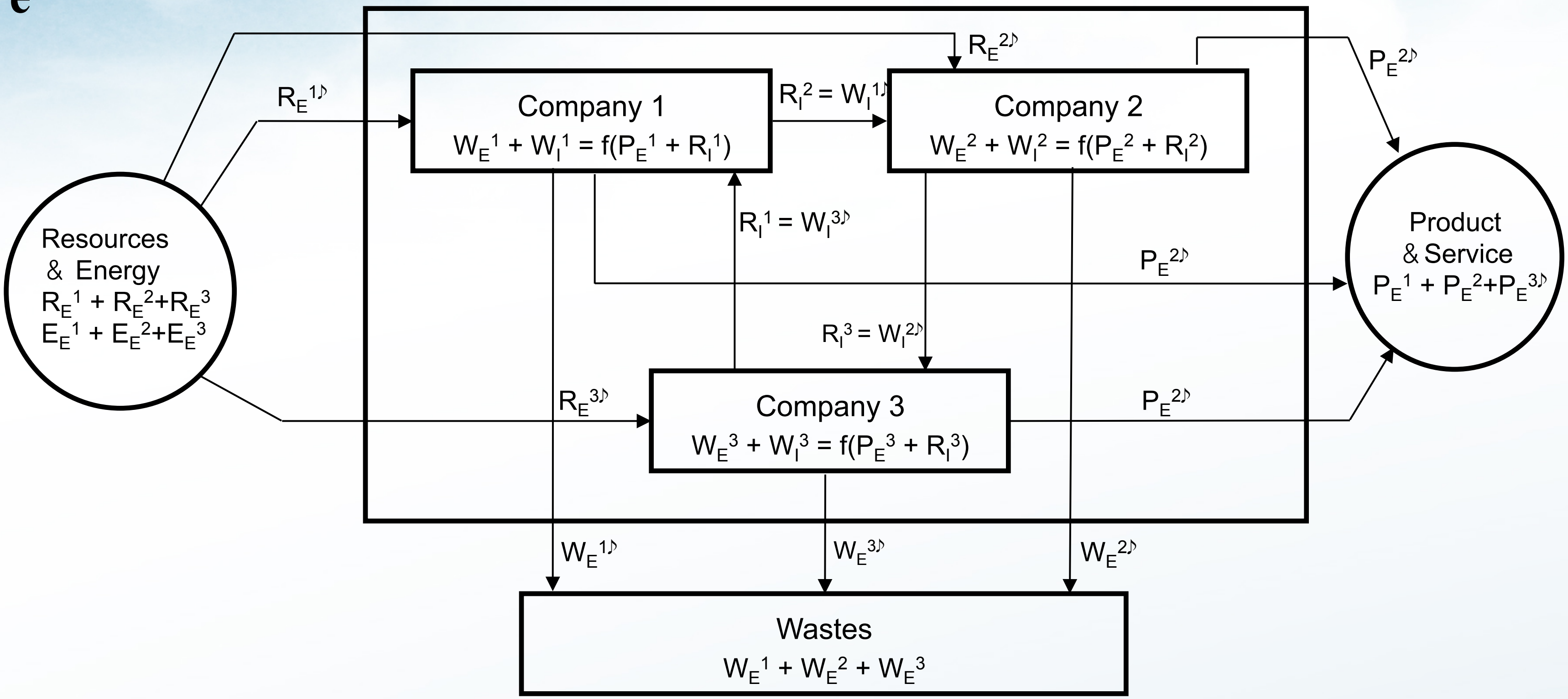
Waste Minimization

RECP in Park level ➔ Zero Emission

Conventional industrial parks		Eco industrial parks
Economic benefit	Targets	Economic, Environmental and Social Benefits
raw material	Resource	raw material, by-products and waste
Disposal by individual or groups	Waste	Reuse and recycle
Large quantity	Waste generation	Minimal/zero quantity
Pollution generators	Social image	Eco-friendly industry
conflict	Relation with Community	harmony

Eco-Industrial Park♪

Max ∑ Product & Service ; Min ∑ Resources & Energy ; Min ∑ Wast e



Synergies identified to exchange resources, energy , by-products etc.

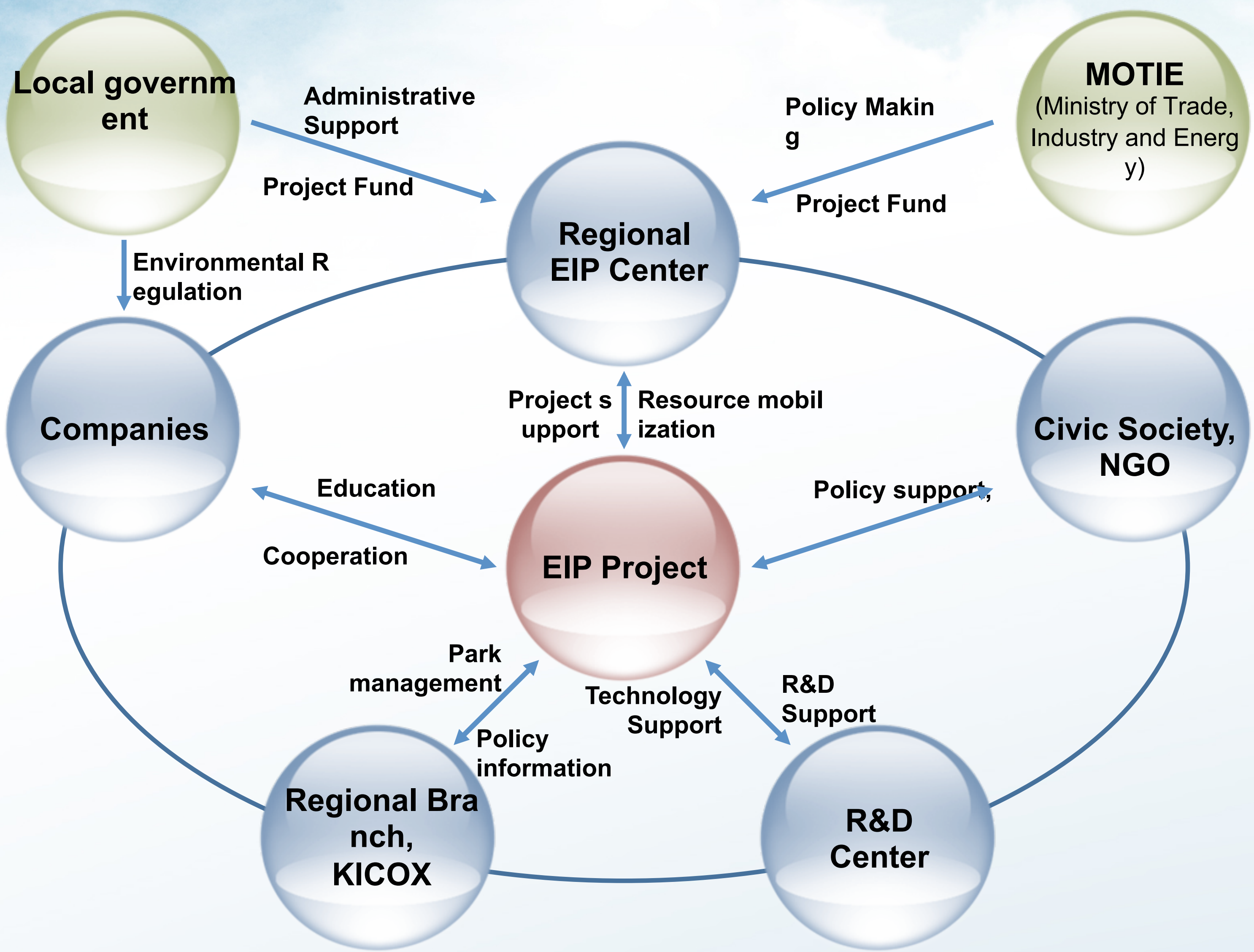
www.rti.org/pubs/case-study.pdf

Ⅱ
Eco-Industrial Park Initiative in Korea♪

SWOT analysis for Korean EIP Initiative

External Environment / Internal Environment		Opportunity (O)	Threat (T)
		• Stricter national and international environmental regulations • Growing governmental interest in and willingness for industrial restructuring • Support from environmental NGOs	• Requirement for resources (finances, time, technology, and human resources) • Lack of business interest • Negative community perceptions of industrial complexes
Strength (S)	• Agglomerated industrial structure • Experience with CP technology development and dissemination • Existing policy for sustainable industrial development • Existing cases of spontaneous IS	**Strategies (SO)** • Pilot experimentation and stage-based EIP program implementation • Dissemination of successful cases • Participation of local governments	**Strategies (ST)** • Business mobilization through government financial support (i.e., research funds) • Capacity building through training • Integration of institutional systems to promote implementation
Weakness (W)	• Lack of experts • Lack of business awareness and motivation • Lack of resource database • Aged infrastructure	**Strategies (WO)** • Establishment of EIP centers • Consultation with international experts (e.g., UNIDO, UNEP, consultants)	**Strategies (WT)** • Evaluation of project proposals based on feasibility • Establishment of eco-forums and coordinator systems • Outreach and training

Regional EIP Initiative – Research Consortium applied by local government



Summary of Korean EIP Project♪

Legal basis♪

Act on the Promotion of the conversion into environmen t-friendly industrial structure (Article21)♪

Responsible authorities♪

- Ministry of Trade, Industry and Energy(MOTIE)
- Korea Industrial Complex Corporation(KICOX)♪

1st phase♪ EIP with 5 industrial complexes♪

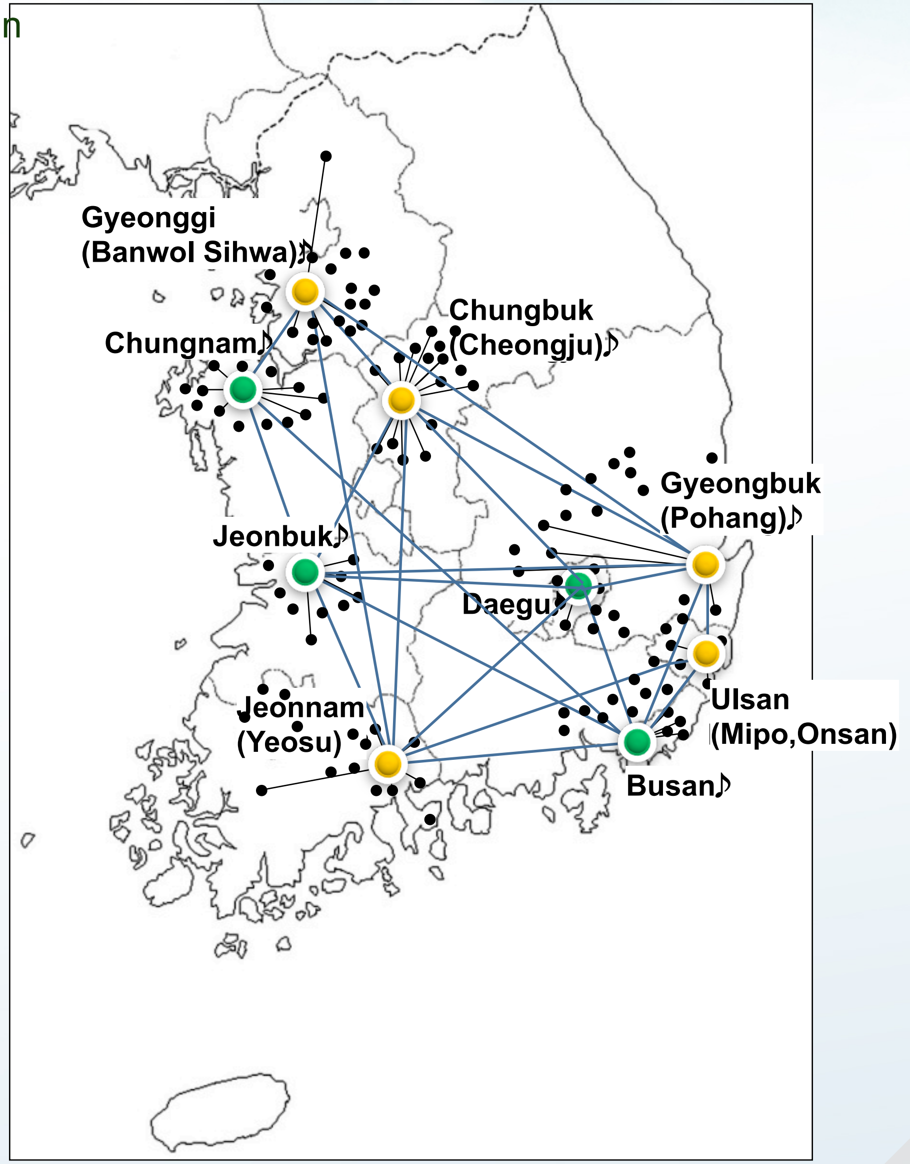
- 2005.11~2010.5
- Pilot on 5 industrial complexes

2nd phase♪ Diffusion on 46 EIP♪

- 2010.6~2014.12
- Diffusion on 46 industrial complexes
- 9 Hub – 49 Spoke IC

3rd phase♪ 150 industrial complexes will be operated♪

- 2015.1~2019.12
- Construction of national EIP network



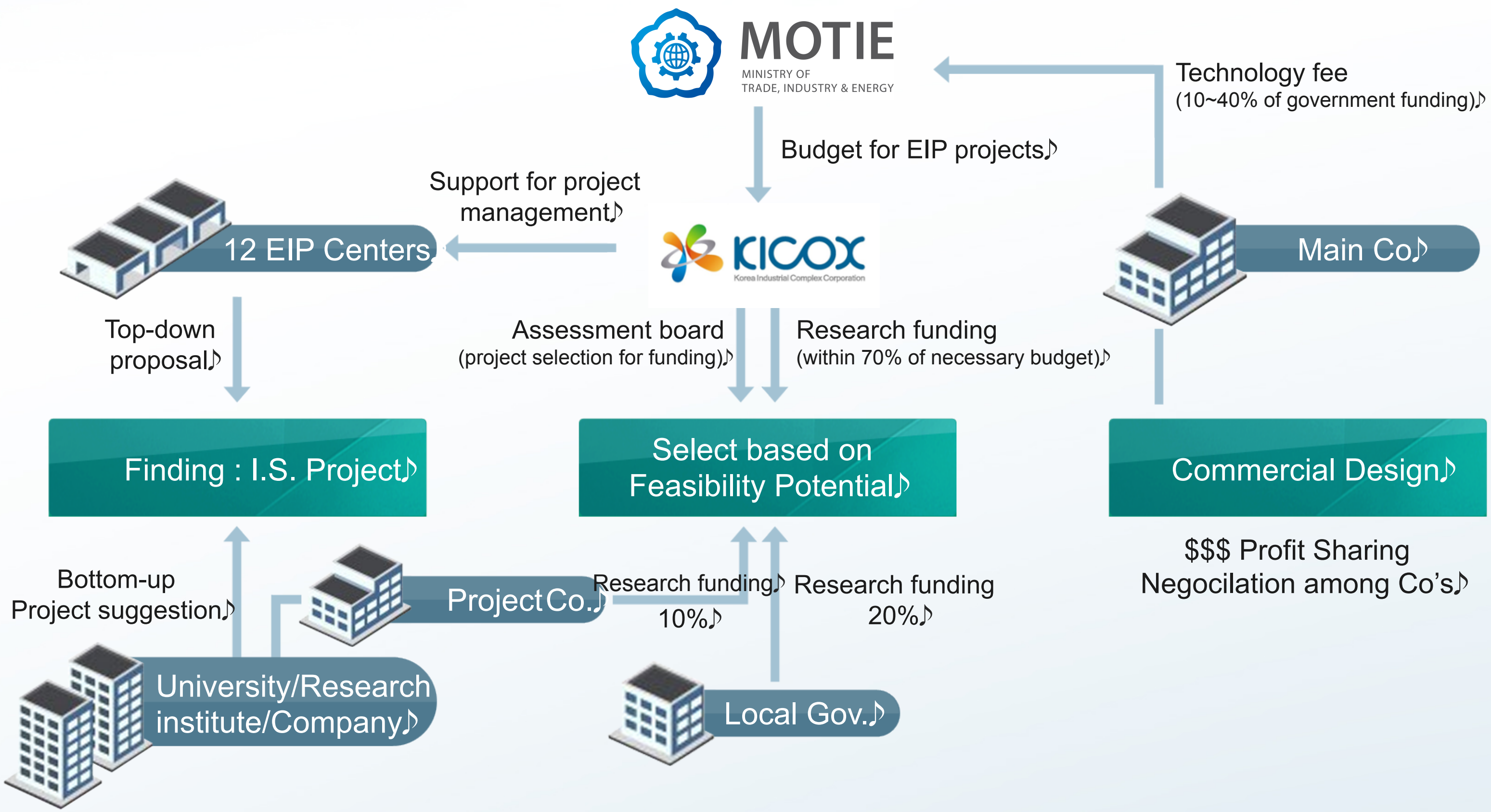
Korean EIP Initiative: Green Business Development through IS Project

Project Financing Source

Central Gov.(70%) & Local Gov.(20% : matching), Private Co.(10% : participation fee)

Process

Identification → Feasibility study → IS business Implementation



IS Development - Role of Regional EIP Center♪

Commercialization & network expansion♪

Step 1 Exploring new networks♪

Data collection to explore new synergy networks♪

- Review of data reported by companies♪
- Encouraging participation through seminars & business meetings♪
- Collecting on-site information from companies♪
- Project identification through **Top-down or Bottom-up** approach♪

Step 2 Feasibility Study

Support feasibility study for network establishment♪

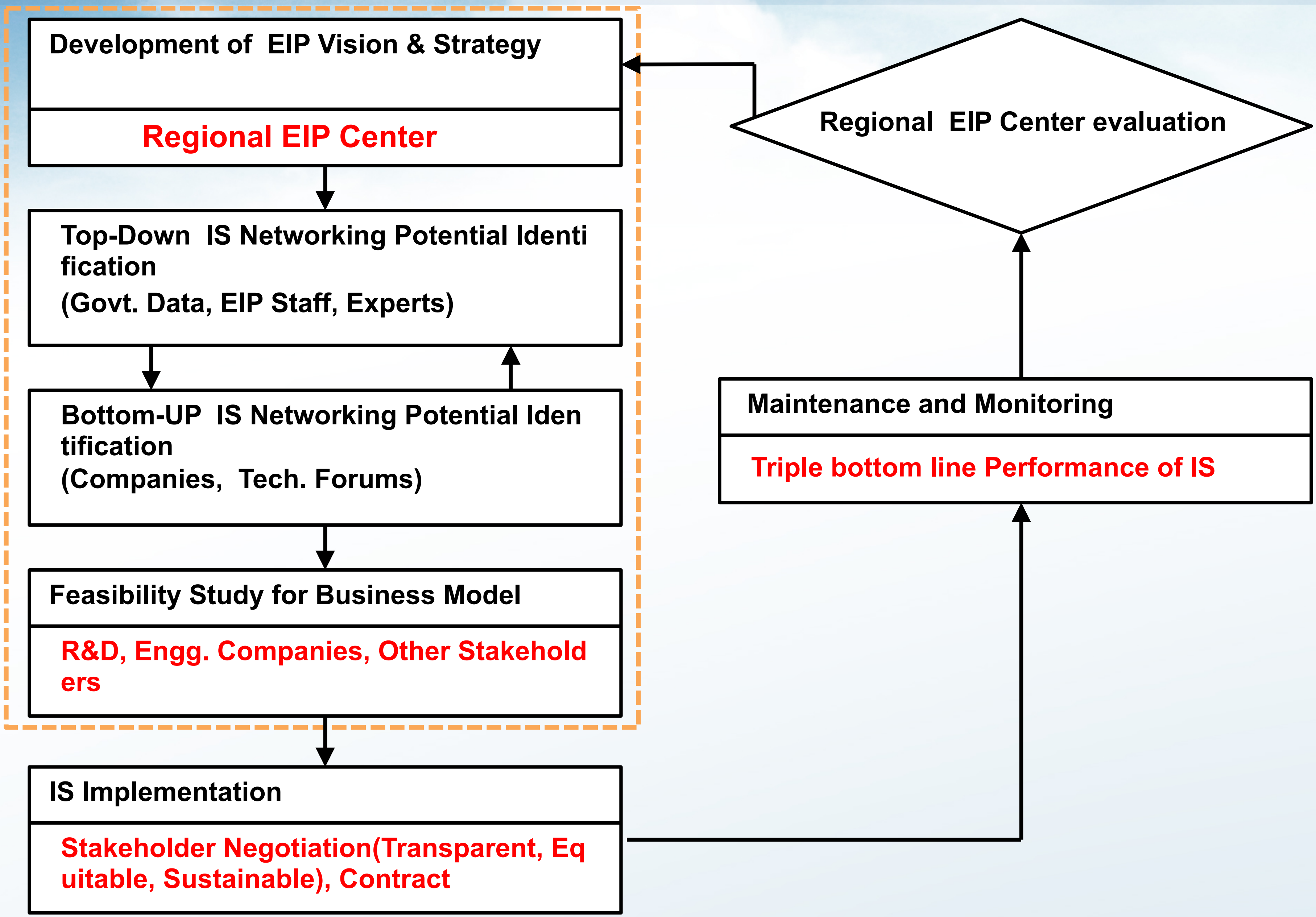
- Supporting feasibility investigation team ♪
- Co-authoring research proposals with stakeholders♪
- Monitoring the progress of the feasibility study ♪
- Final report as a **Business model** that includes the stakeholders requirements

Step 3 Commercialization

Stakeholder participation & overcoming barriers♪

- Coordinating benefit sharing among participants ♪
- Project **financing sources (ESCO, WASCO etc)**♪
- Evaluate potentially linking project with GHG emission reduction projects♪
- Highlight Success story♪

IS Expansion Strategy in Korea EIP Initiative



EIP Outcomes (by 2014)

Project: 521 Found → 337 Supported → 262 Completed → 159 are in Business
(60.7% among completed IS R&D projects are in business)

Economic effects

- Cost cut from Raw Material & Waste Reduction
- Added Revenue from New product Sales

	’14 Outcomes rom New Project (U SD$ Million/yr)	Outcomes (‘07~’14) Including previous projects
Cost cut	160.2	554.3
Revenue	244.5	776.7
Total	404.7	1,331.0

Environmental effects

- Reduction of energy consumption
- Reduction of greenhouse gas emission
- Reduction of solid waste emission
- Reduction of water consumption
- Reduction of SOx, NOx, emission

Energy	258 Ttoe/yr	992 Ttoe
CO_2	1,405 Tton/yr	4,703 Tton
By-product	1,095 Tton/yr	3,635 Tton
Water	36,774 Tton/yr	37,341 Tton
Air pollution	156T ton/yr	930 Tton

Social effects

- Promotion of new investment to recycle facility
- Job creation

Investment	591.3
Job creation	717

* Currency Exchange Rate(\1,000=$1) was applied

EIP Outcomes of Energy project (by 2014) ♪

Project: 114 Found → 80 Supported → 76 Completed → 39 are in Business
(51.3% among completed IS R&D projects are in business)♪

Economic effects♪

- Cost cut from Raw Material & Waste Reduction♪
- Added Revenue from New product Sales♪

	'14 Outcomes rom New Project (USD$ Million/yr)♪	Outcomes ('07~'14) Including previous projects
Cost cut	86.6♪	298.5♪
Revenue♪	92.3♪	313.6♪
Total♪	178.9♪	612.1♪

Environmental effects♪

- Reduction of energy consumption♪
- Reduction of greenhouse gas emission♪
- Reduction of solid waste emission♪
- Reduction of water consumption♪
- Reduction of SOx, NOx, emission♪

Energy♪	244 Ttoe/yr♪	917 Ttoe♪
CO_2♪	759 Tton/yr♪	2,599 Tton♪
By-product♪	18 Tton/yr♪	60 Tton♪
Water♪	178 Tton/yr♪	481 Tton♪
Air pollution♪	151 T ton/yr♪	909 Tton♪

Social effects♪

- Promotion of new investment to recycle facility♪
- Job creation♪

Investment♪	357.0♪
Job creation♪	306♪

* Currency Exchange Rate(\1,000=$1) was applied♪

Heat Network Strategy in Industrial Sector

: Value Creation through Energy Efficiency Program♪

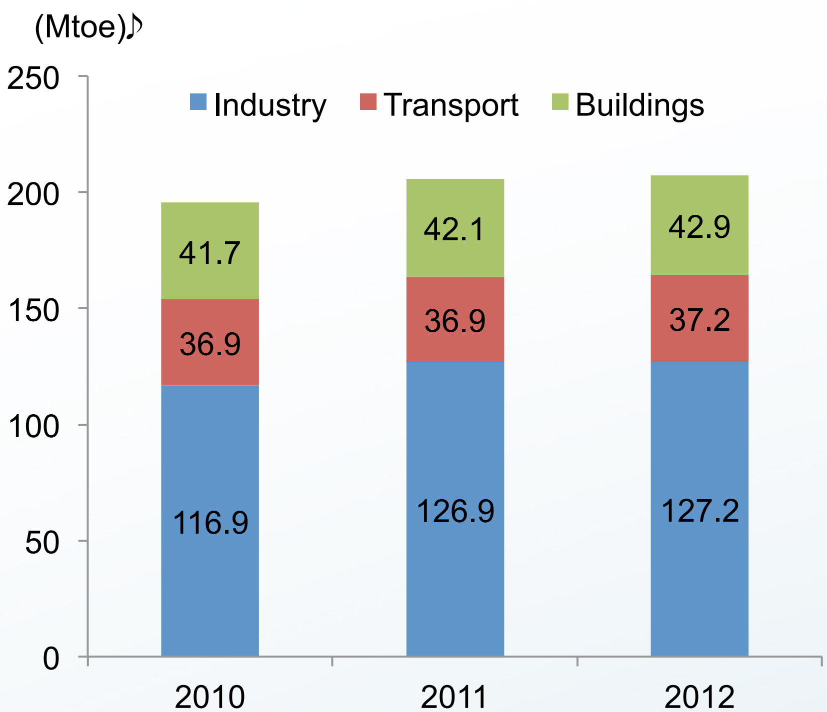
Energy Use Profiles in Industry

Industry energy use accounted for 61.4% of final energy use.

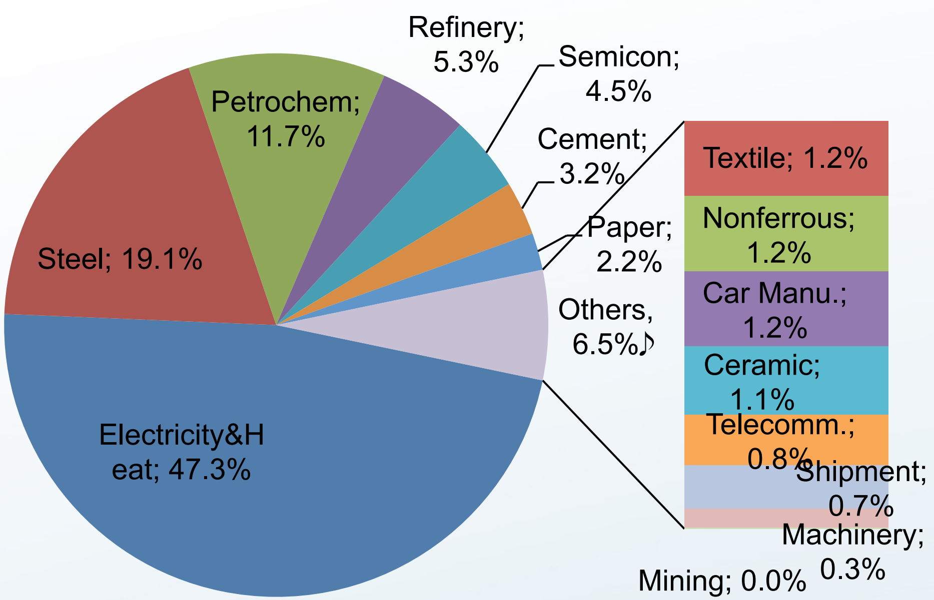
•Industry energy use has increased at 4.3% per annum in recent 3 years, ov erwhelming 2.9% of final energy consumption.

•Target managed companies in 17 sub-sectors took up about 70% of industr ial energy use.♪

< Final Energy Use (2010-2012) >♪



< Industry Energy Use in 2012 >♪

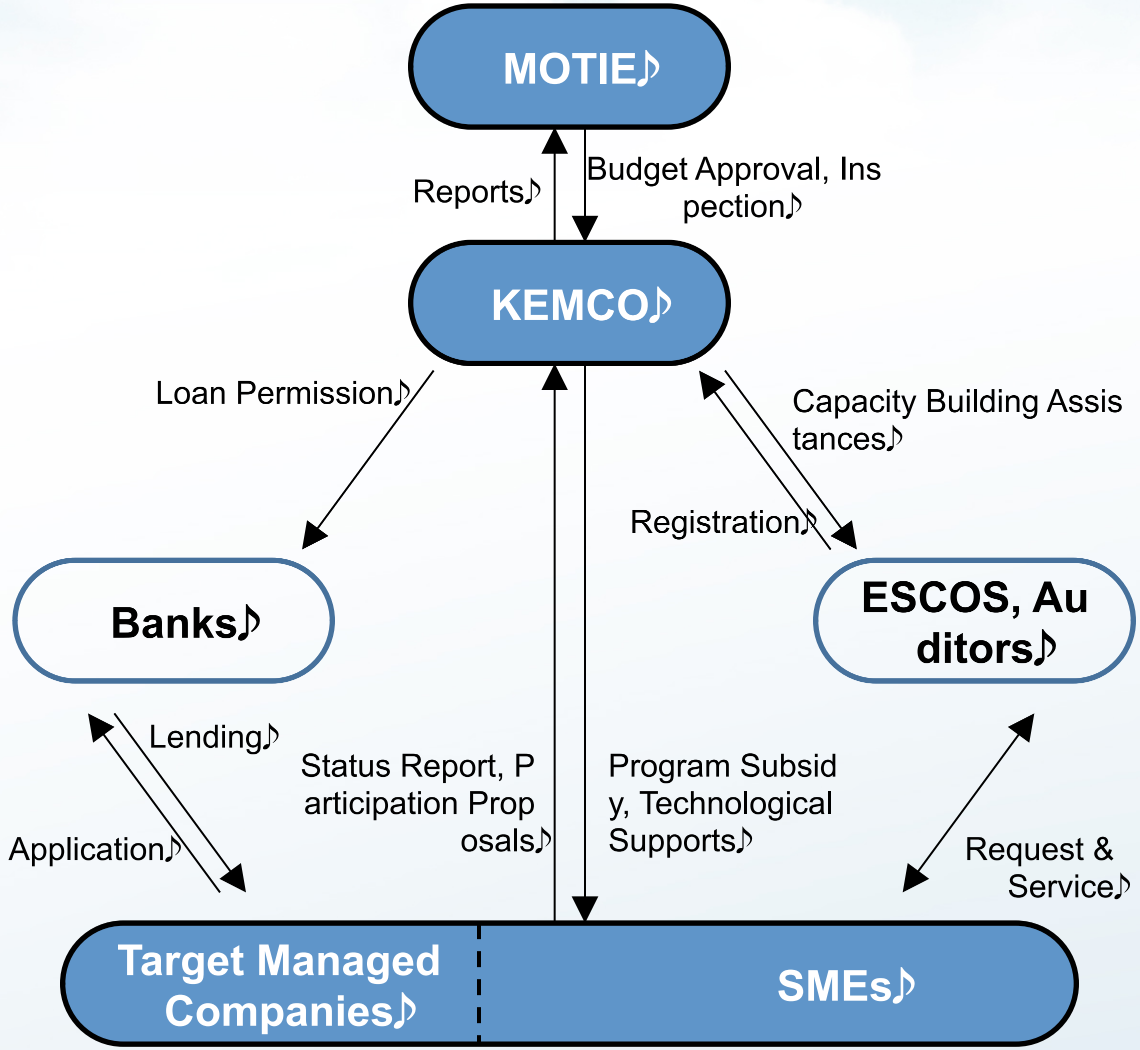


* Energy use in Target Managed Industrial C ompanies♪

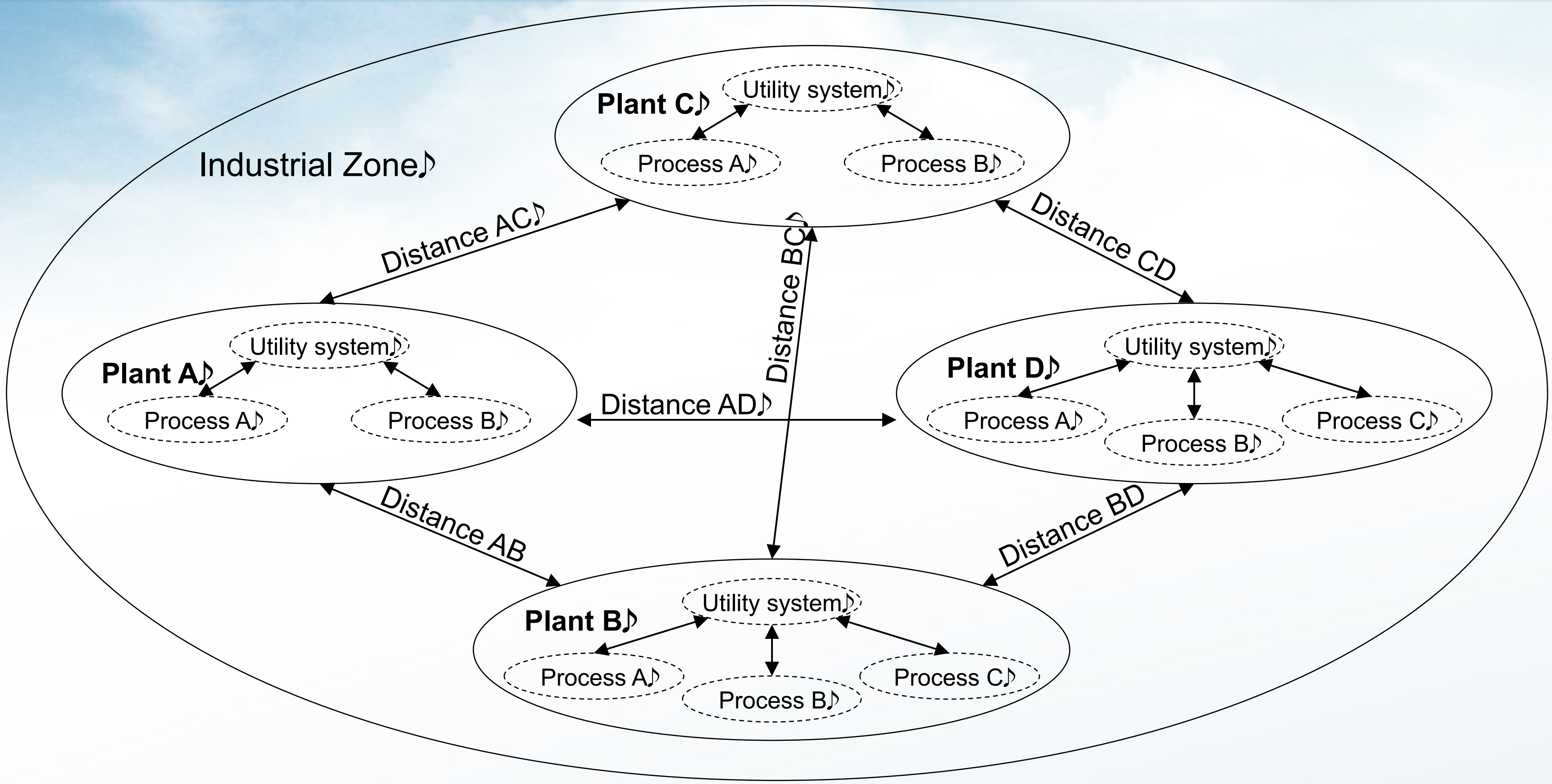
Program Structure for Industry Energy Efficiency(KEMCO)

EE Programs for Industry♪

- **Energy Use Reporting**
- **Energy Audits**
- **ESCO (Energy Service Company)**
- **Preferential Loans**
- **Target Mgmt. Scheme (Mandatory)**
- **EnMS (ISO 50001) (Voluntary)♪**



Definition and Situation



- A process is a sequences of operations that convert raw materials into products
- A plant is an independent production unit which consists of one or more processes serv ed by a utility system
- An Industrial zone is characterized by a set of plants located in a centrally administered area of concentrated industrial activity♪

Source : Mirko Z. Stijepovic, Patrick Linke, Optimal waste heat recovery and reuse in industrial zones, *Energy*, 36, 4019-4013 (2011)♪

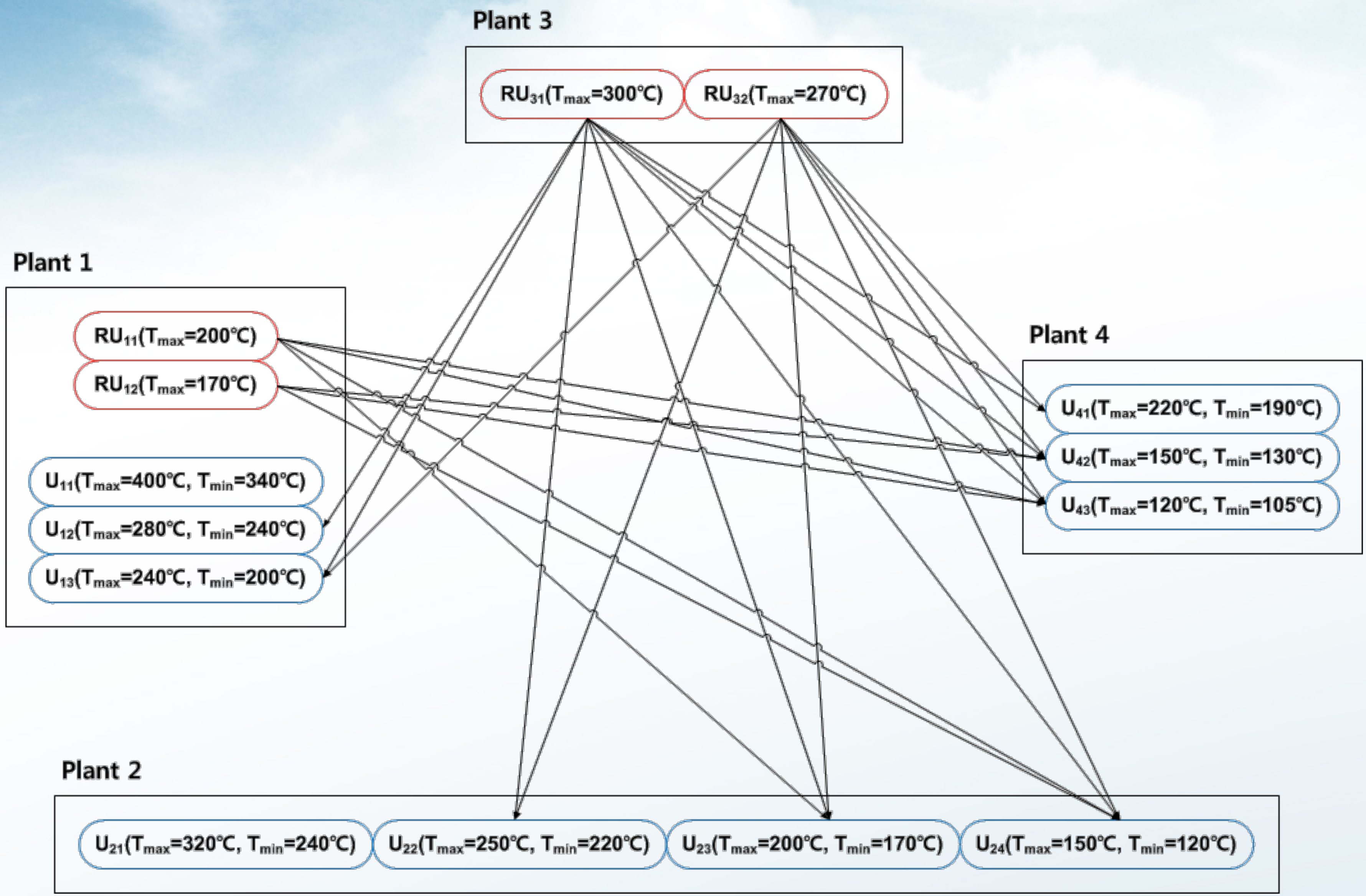
Problems in thermal network in industrial park

1. Different entities and stakeholders
2. Safety and reliability of operations of processes and plants to maximize of the capital investments
3. Significant seasonal changes in production rate
4. Emergency of plant shutdown
5. Heat loss and capital costs
6. Reliability, controllability and flexibility of the plant♪

Temperature and heat recovery potential of industrial process

	Temp. classification sources ♪		Typical recovery methods/technologies♪
High 650℃ -♪	Steel electric arc furnace♪	1370-1650℃♪	Combustion air preheat
	Glass melting furnace♪	1300-1540℃♪	Steam generation for process heating or for mechanical/electrical work
	Aluminum reverberator furnace♪	1100-1200℃♪	Furnace load preheating
	Fume incinerators♪	650-1430℃♪	Transfer to med-low temp. process♪
	Coke oven♪	650-1000℃♪	
Medium 230℃-650℃♪	Heat treating furnace♪	430-650℃♪	Combustion air preheat
	Cement kiln♪	450-620℃♪	Steam/power generation
	Gas turbine exhaust♪	370-540℃♪	Organic Rankine cycle for power generation
	Reciprocating engine exhaust♪	320-590℃♪	Furnace load preheating, feedwater preheating
	Drying & baking ovens♪	230-590℃♪	Transfer to low-temperature processes♪
	Steam boiler exhaust♪	230-480℃♪	
Low 30℃-230℃♪	Drying, baking and curing ovens♪	90-230℃♪	Space heating
	Exhaust gases exiting recovery devices in gas-fired boilers♪	70-230℃♪	Domestic water heating
	Cooling water (annealing furnaces, internal combustion)♪	70-230℃♪	Upgrading via a heat pump to increase temp. for end use
	Process steam condensate♪	50-90℃♪	Organic Rankine cycle
	Hot processed liquids/solids♪	30-230℃♪	
	Cooling water (air compressors)♪	30-50℃♪	

Feasible thermal links within the industrial park



Source : Mirko Z. Stijepovic, Patrick Linke, Optimal waste heat recovery and reuse in industrial zones, *Energy*, 36, 4019-4013 (2011)♪

Systematic methodology of thermal network in industrial park

1. Data acquisition
2. Screening for waste/underutilized heat recovery potential
3. Feasible integration options for waste/underutilized heat recovery and reuse
4. Targeting the maximum waste/underutilized heat recovery and use potential
5. Design optimal waste/underutilized heat recovery and reuse networks (Economic, environmental and social benefit analysis)

Economic and Environmental Benefits of Energy Network

Economic value

$$\pi = \sum_{i=1}^{n} p_i - \sum_{i=1}^{n} (R_i + E_i + W_i + O_i)$$

$$\Delta\pi = \pi_a - \pi_b = \left(\sum_{i=1}^{n} p_{i,a} - \sum_{i=1}^{n} (R_{i,a} + E_{i,a} + W_{i,a} + O_{i,a})\right) - \left(\sum_{j=1}^{n} p_{i,b} - \sum_{j=1}^{n} (R_{i,b} + E_{i,b} + W_{i,b} + O_{i,b})\right)$$

π : Economic value, π_a : Economic value of EIP project, π_b : Economic value of Baseline project

P_i : Product 'I' value, R_i : Resource cost, E_i : Energy cost, W_i : Environmental cost, O_i : Operation cost

Environment effect(separate calculation)

$$EE = \sum_{i=1}^{n} (W_i + A_i + w_i)$$

$$\Delta EE = EE_a - EE_b = \left(\sum_{i=1}^{n} W_{i,a} + \sum_{i=1}^{n} A_{i,a} + \sum_{i=1}^{n} w_{i,a}\right) - \left(\sum_{i=1}^{n} W_{i,b} + \sum_{i=1}^{n} A_{i,b} + \sum_{i=1}^{n} w_{i,b}\right)$$

EE : Environmental effect, EE_a : EE of EIP project, EE_b : EE of Baseline project

W_i : Waste generation, A_i : Air emission, w_i : Waste water generation

Business opportunity of Energy Network

B/C : Benefit Cost ratio

$$\frac{B}{C} = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} / \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

NPV : Net present Value

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

IRR : Internal Rate of Return

$$IRR = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

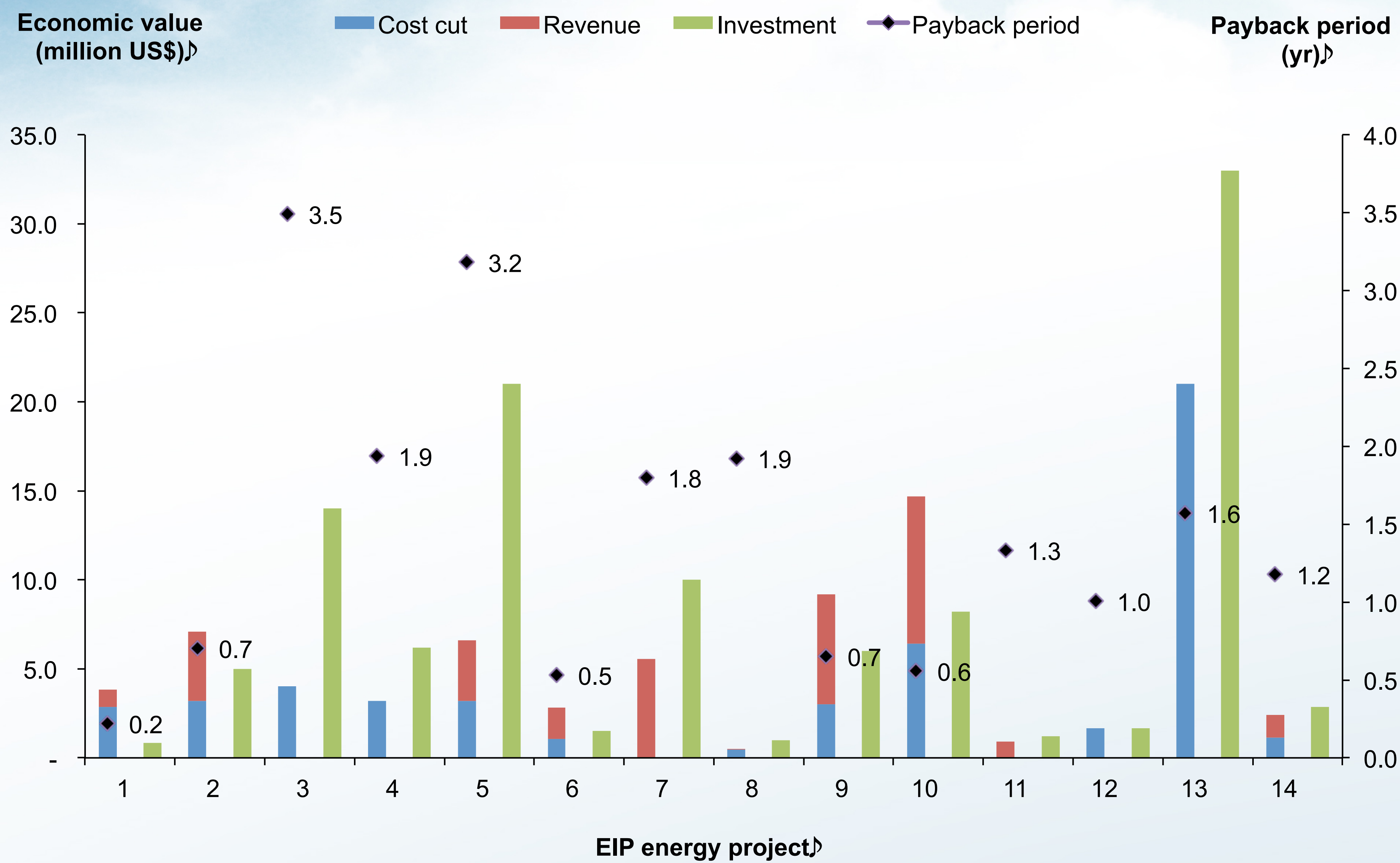
B_t : benefit of time t , r : depreciation , n : time, C_t : cost of time t

Triple Bottom Line Benefits of Energy Network in Ulsan IP

	Commercialization Time (month)	Gov. research fund (million US$)	Economic benefit (million US$)			Environmental benefit				Social benefit
			Investment	Cost cut	Revenue	By-product (ton/yr)	Water (ton/yr)	Energy (toe/yr)	CO_2 reduction (ton/yr)	Job creation (person)
Total EIP		3.59	126.4	73.8	44.5	38,544	72,875	189,206	487,626	184
Energy project		1.46	112.5	51.2	32.3	-	36,500	177,086	486,362	154
1	-	0.037♪	0.9	2.9	1.0	- ♪	- ♪	3,893	12,491	-
2	3	0.010	5.0	3.2	3.9	-	- ♪	18,850	60,476	140
3	-	0.100♪	14.0	4.0	0.0	- ♪	- ♪	10,880	34,907	-
4	10	0.084♪	6.2	3.2	0.0	- ♪	- ♪	6,024	10,188	-
5	10	0.116♪	21.0	3.2	3.4	- ♪	- ♪	26,849	63,643	-
6	2	0.07♪	1.5	1.1	1.7	- ♪	- ♪	8,881	33,094	-
7	1	0.085♪	10.0	0.0	5.6	- ♪	- ♪	8,278	25,084	-
8	-	0.21♪	1.0	0.5	0.1	- ♪	36,500.0	146	-	-
9	25	0.15♪	6.0	3.0	6.2	- ♪	- ♪	16,716	50,396	-
10	2	0.007♪	8.2	6.4	8.3	- ♪	- ♪	18,960	39,427	-
11	7	0.050♪	1.2	0.0	0.9	- ♪	- ♪	2,037	4,757	14
12	-	0.04♪	1.7	1.7	0.0	- ♪	- ♪	♪	14,572	-
13	35	0.473♪	33.0	21.0	0.0	- ♪	- ♪	46,317	100,000	-
14	11	0.04♪	2.9	1.1	1.3	- ♪	- ♪	9,254	37,327	-

* Currency Exchange Rate(\1,000=$1) was applied♪

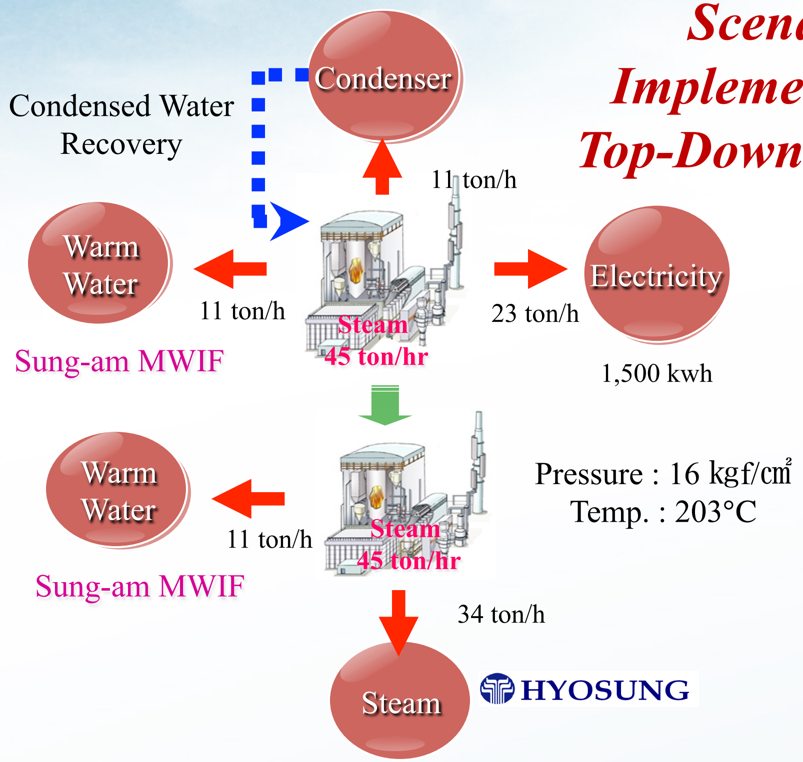
Payback Period of Developed Steam Network in Ulsan IP

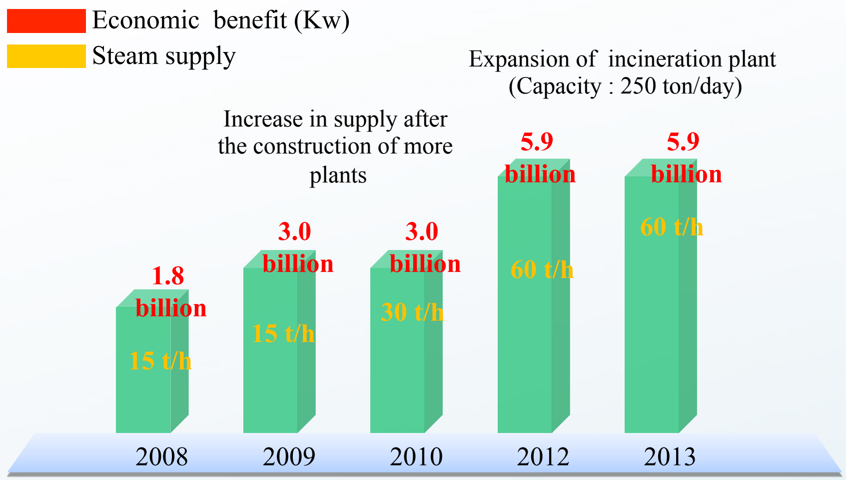


Energy Network in Practice-Example 1

Sungam MWIF – Hyosung Company steam network (2008)

Scenario 1: Implementation of Top-Down IS Network



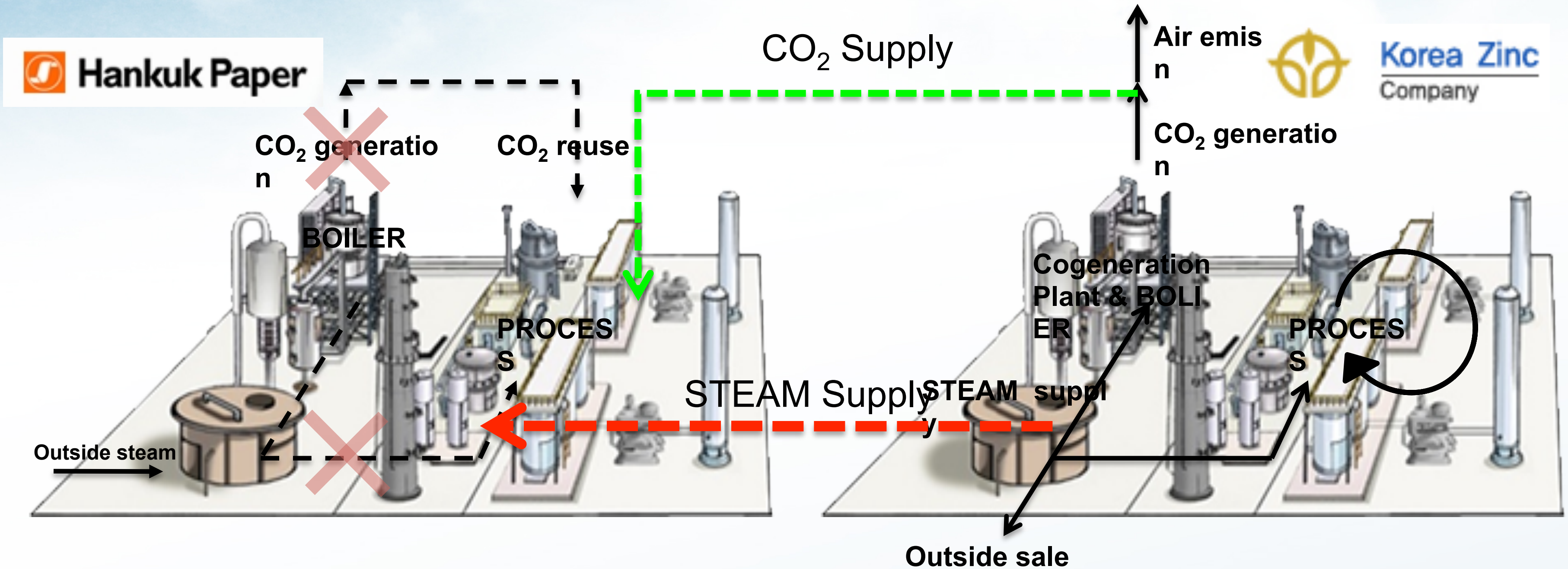


Output

- **Economic benefit: 7.1 million US$/yr (steam selling and B-C replacement)**
- **Environmental benefit: 55,500 ton CO_2/yr, 176.8 ton air pollutants/yr**
- **Establishment of new factories (Employment for 140 people)**

Energy Networks in Practice-Example 2

Top-down IS network : Carbon dioxide and steam network (2010)

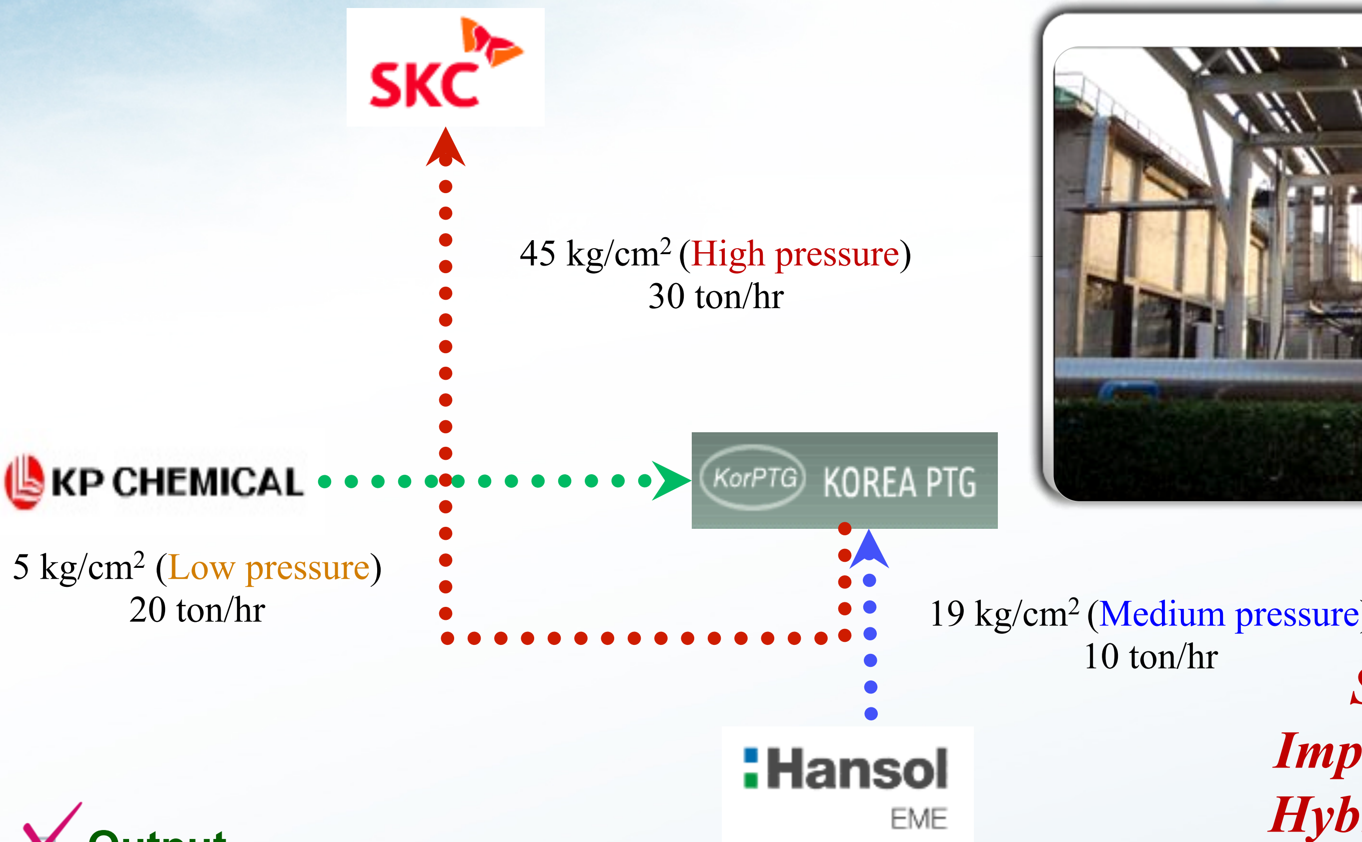


Output

- **Economic benefit : 6.6 million US$/yr (Steam selling and B-C replacement)**
- **Environmental benefit: Reduction of 63,643 ton CO_2/yr, 1691.5 ton /yr air pollutants**

Energy Networks in Practice-Example 3

Steam Network project (2009)



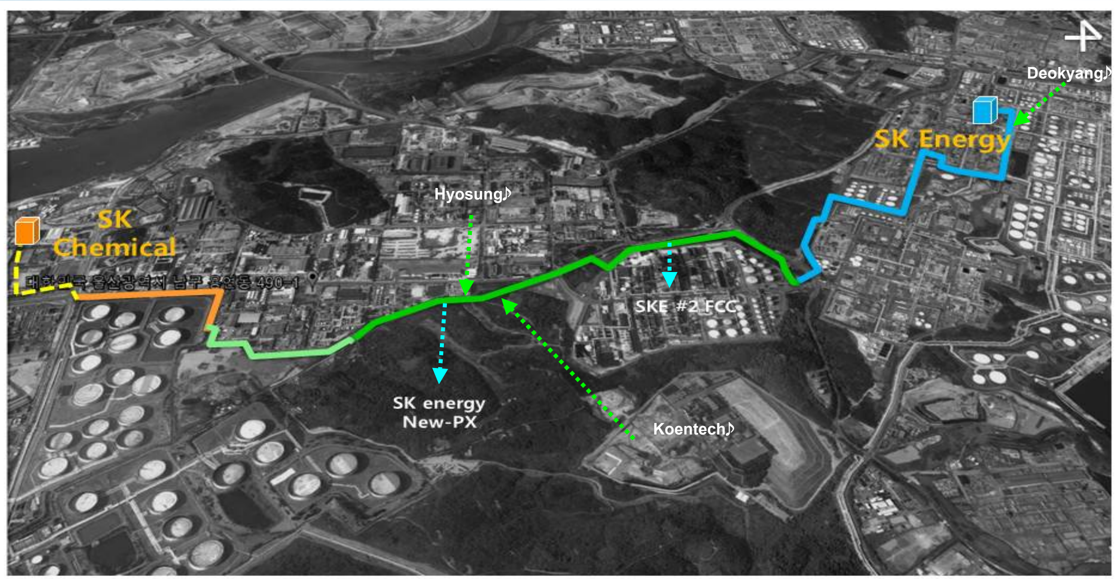
Scenario 3: Implementation of Hybrid IS Network

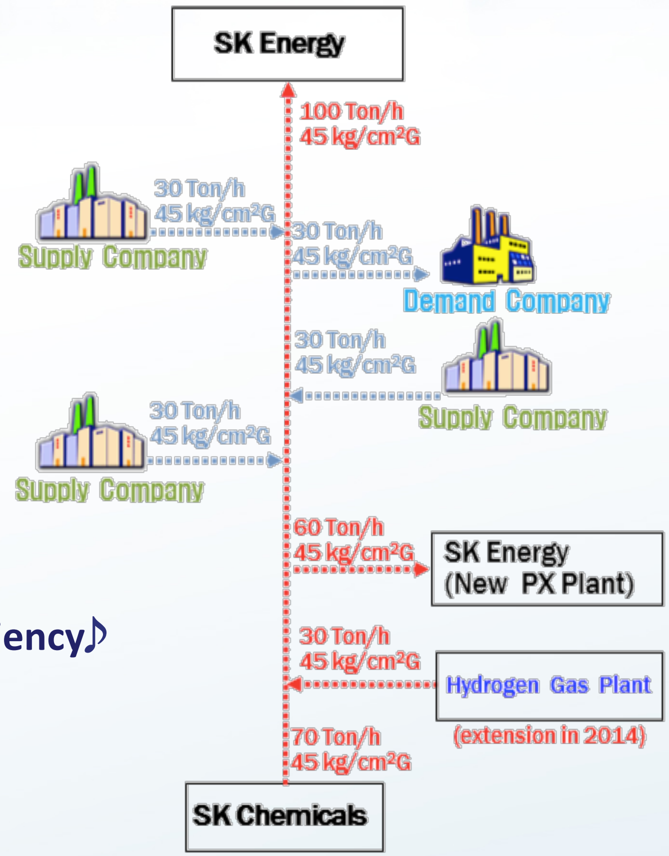
Output

- **Economic benefit : 6.4 million US$/yr (Steam selling and B-C replacement)**
- **Environmental benefit: Reduction of 44468 ton CO_2/yr, 314.1 ton /yr air pollutants**

Energy Networks in Practice-Example 4

Steam Networks by Public-Private Partnership ♪

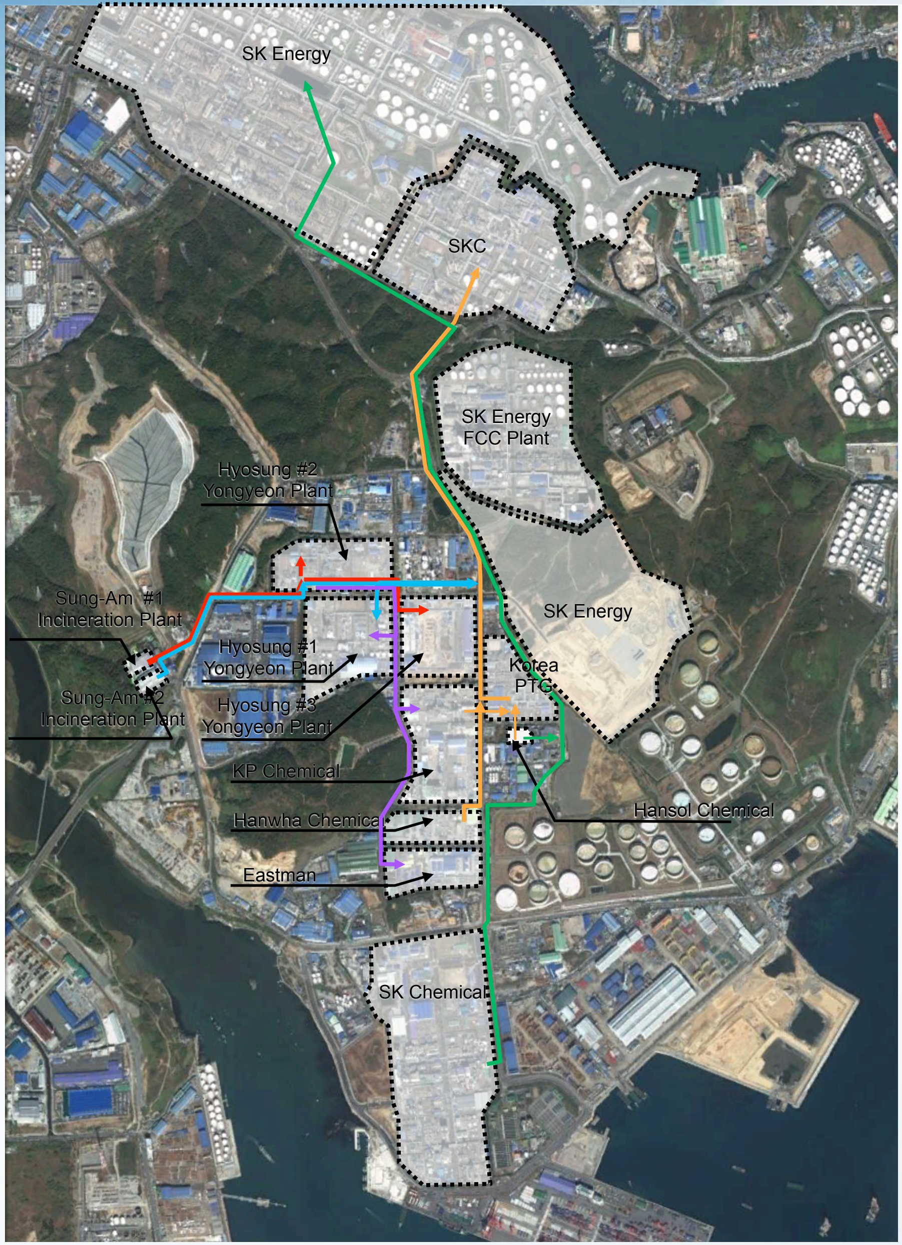


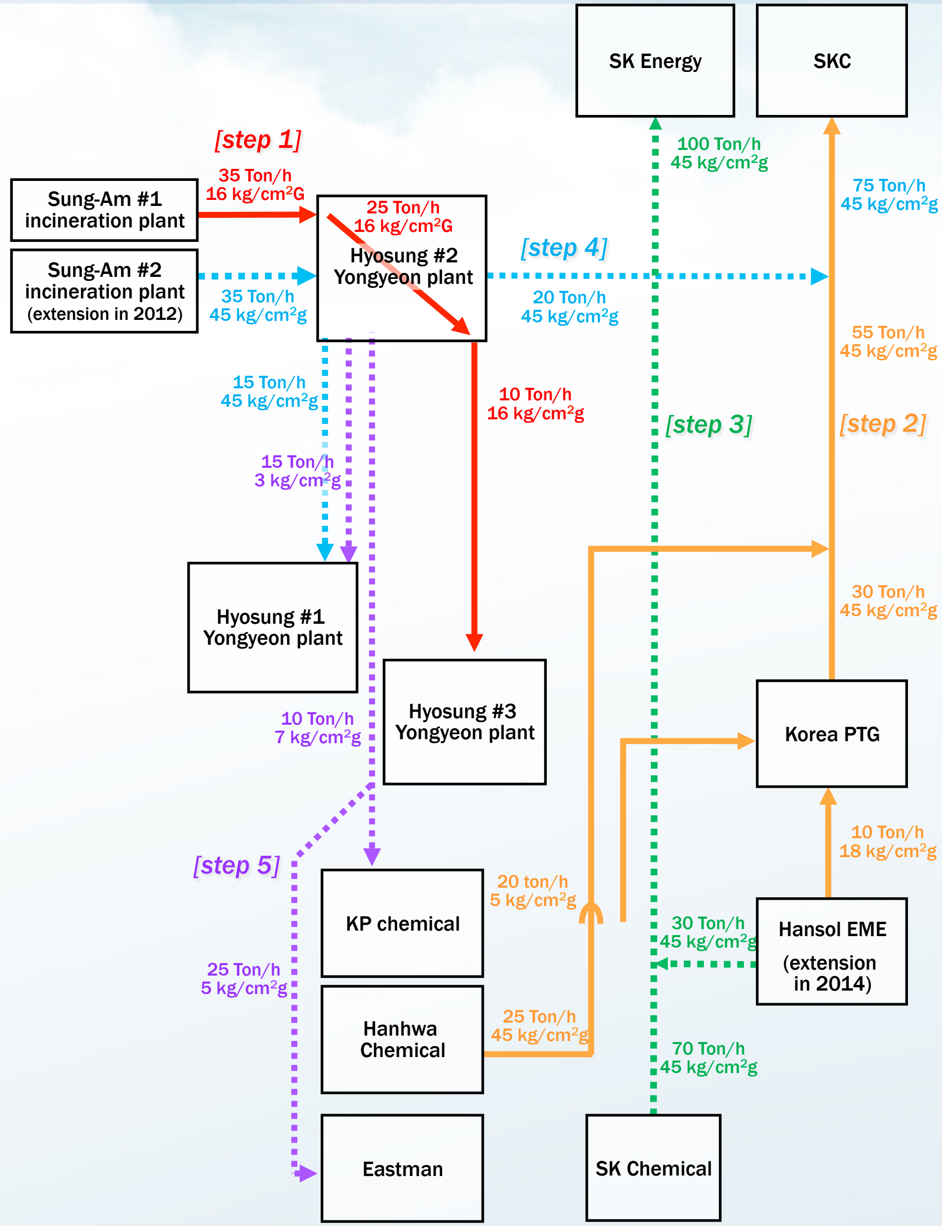


Steam Highway for industrial competitiveness and energy efficiency♪

- **Expectation:** ♪
  - **(Economy)** \$19.7million/year energy supply & cost cut♪
  - **(Environment)** 48,470 ton GHG (CO_2) Reduction /year
- **IS PPP:**
  - **(Public sector)** invested a steam pipeline(highway) with several entrances and exists, to facilitate steam ne tworking among companies in the area
  - **(Private sector)** participated in the network development to reach their own facility♪

Stepwise Development of Energy Network





Energy Networks in Practice-Example 6

Waste-to-Energy and Fertilizer Networks among Rural, Urban and Industrial Sectors♪

Input

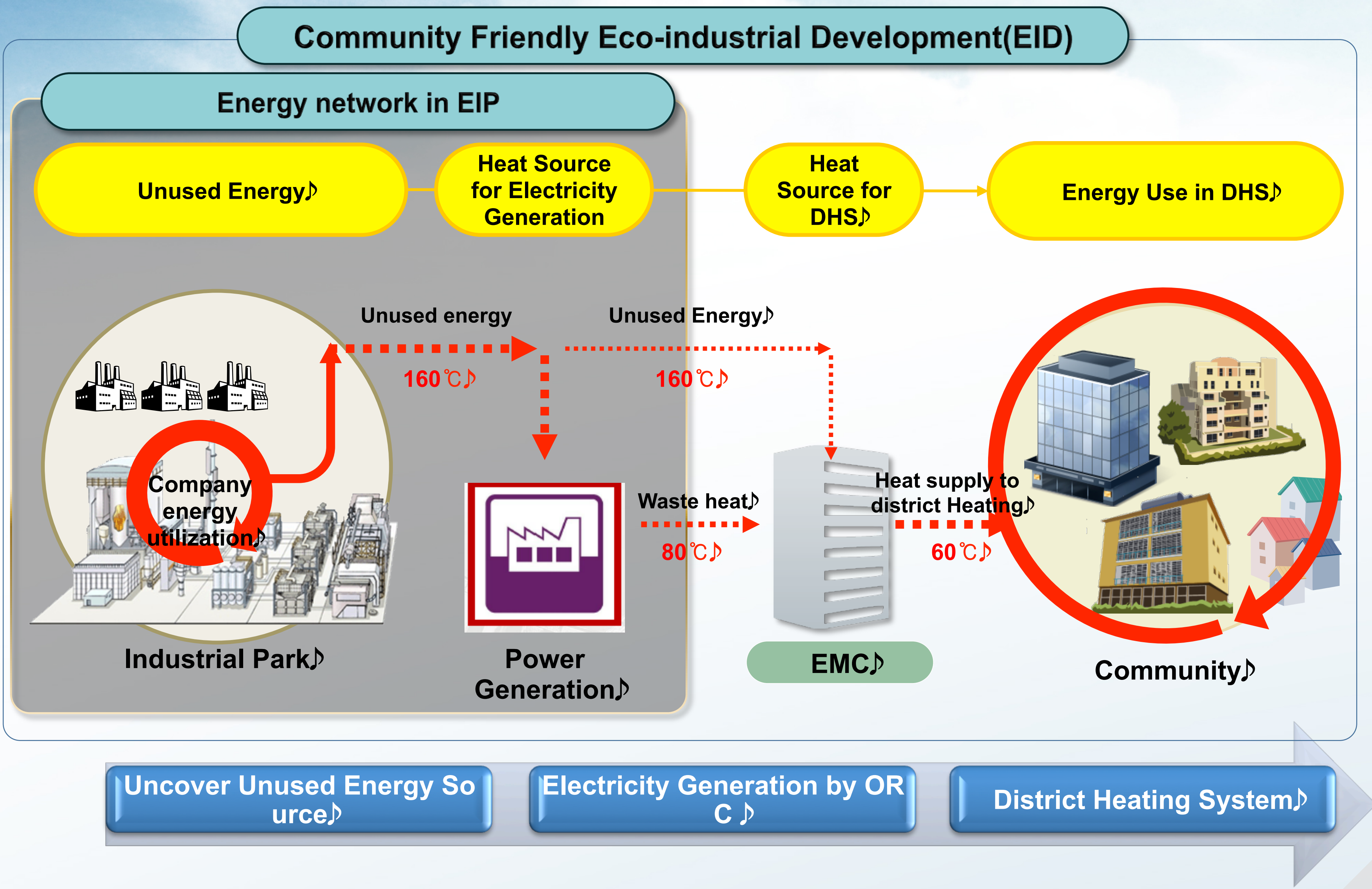
- **Facility investment : $1.2 million♪**

Output

- **Reduced greenhouse gas emission : 4,757ton/yr**
- **Energy saving : 2,037TOE/yr**
- **Steam sale and cost cut from energy saving : $1.8 million/yr♪**

36

Thermal Networks of Community and Industrial Park♪



Chittagong EPZ in Bangladesh (IS project)♪

Low-Carbon Green SEZ Framework Project

- Place : Chittagong SEZ, Bangladesh (168 Manufacturers : Mainly Garment & Textile 90%)♪
- Support Org. : World Bank (Sourcing from Korean ODA)♪
- Biz Terms : 2012. 5 ~ 10♪

Low Carbon Policy♪

- Free Trade & Invest
- Legislation System
- Regulation
- Incentives
- Organization system♪

Sustainable Society Infra.♪

- New Generation Energy
- Program for Energy Efficiency
- Industrial Symbiosis
- Green Building♪

Low - carbon/Green SEZ♪

Carbon Finance♪

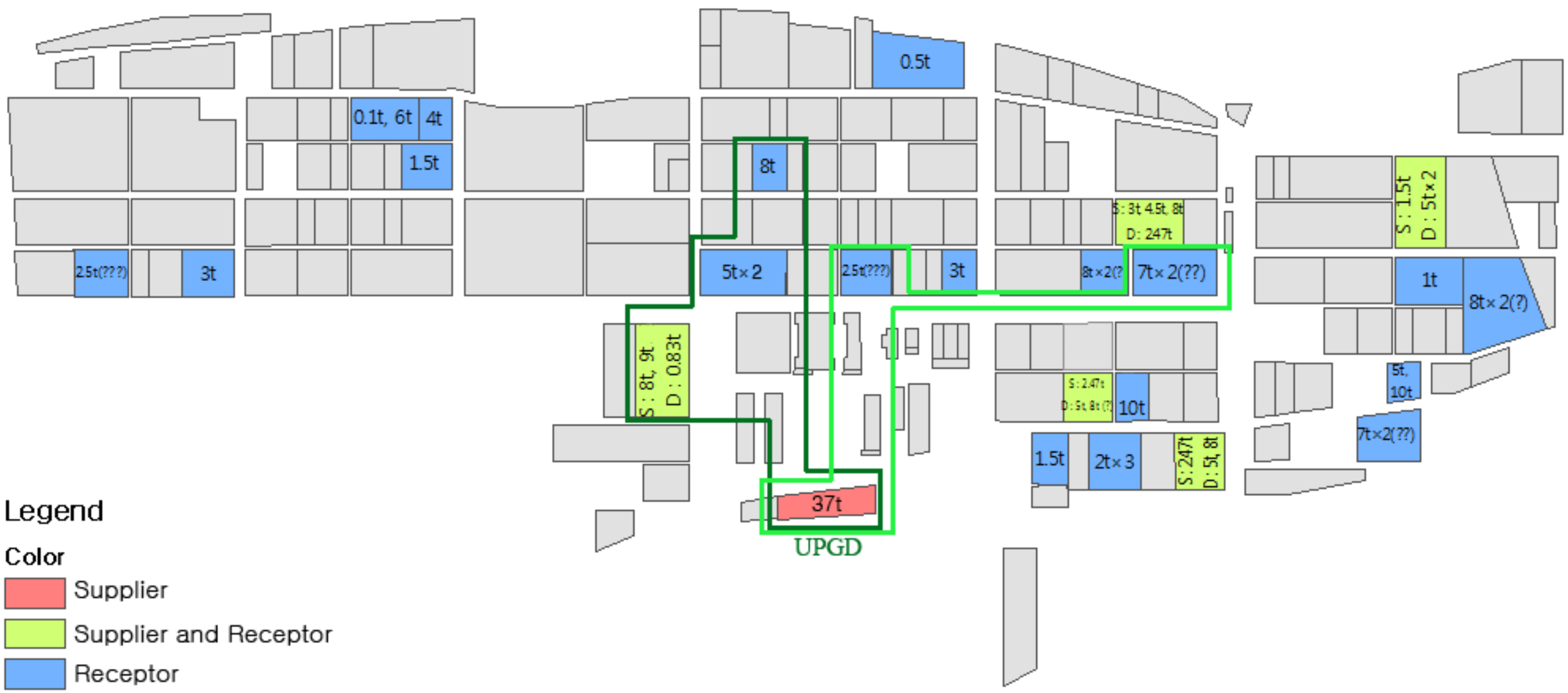
- New Financial Market through CDM
- Automatic Carbon Trading Market
- Synergy between FDI&CDM♪

Set the Reduced Target♪

- Setting Target for GHG
- Inventory system for GHG
- Carbon Foot-Print of
- Production value chain♪

UPGD Power Plant to Company Energy Network♪

UPGD-to-Company steam network project



Scenario: Supplier → Receptor

Scenario: United power generaion & distribution (37 t) → Crown mills (8t, 9t), Qualitex (5 t × 2), Al-hamidi (8 t)
Premier towel (8 t × 2), Siam's superior (2.5 t)

Scenarios of Company to Company Networks

Company-to-company steam network project

Existing symbiosis
Karnaphuli sportswear → Youngone shoe accessory
(Steam and electricity)

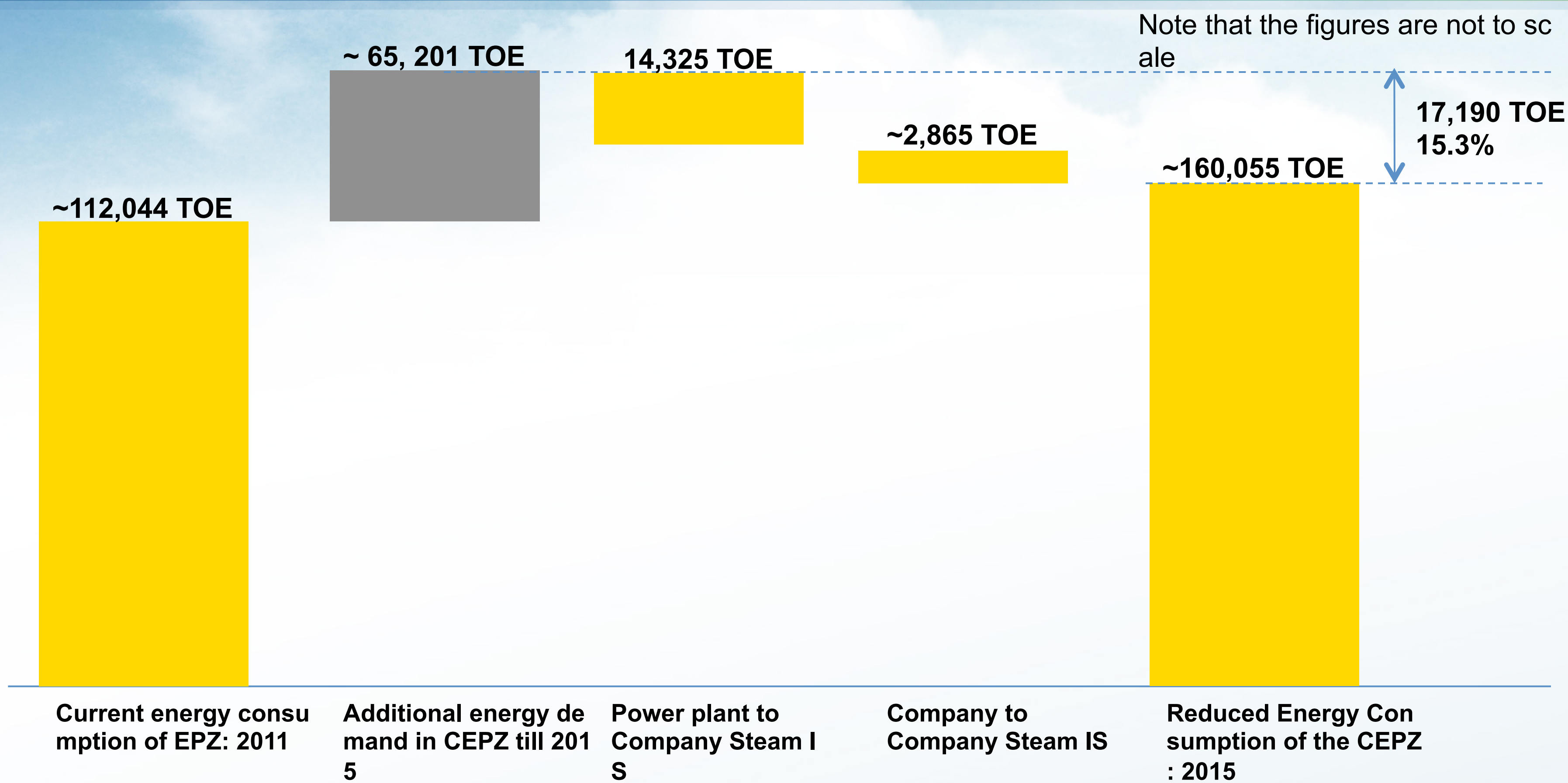
Scenario 1: Siam's superior_unit 2 (2.0 t) → DAF accessory (3.0 t)

Scenario 2: Universal jeans (1.5 t) → Section seven apparels (1.5 t, Diesel boiler)

Scenario 3: Karnaphuli sportswear (1.0 t) → Regency garments_unit 3 (1.0 t)

Scenario 4: Pacific jeans (1.5 t) → Univogue garments_unit 2 (3.0 t)

Expected Carbon Emission Reduction by IS in CEPZ



- Increase in energy demand is due to the operation of new units. It has been considered only from the p rojected electrical energy demand of UPGD (50 MW capacity needed by 2015).
- The Energy IS opportunity includes the steam generation by waste heat recovery from the power plant and the captive generation companies in CEPZ.

INVESTMENT CLIMATE

Investment Climate I World Bank Group

IFC International Finance Corporation World Bank Group

THE WORLD BANK

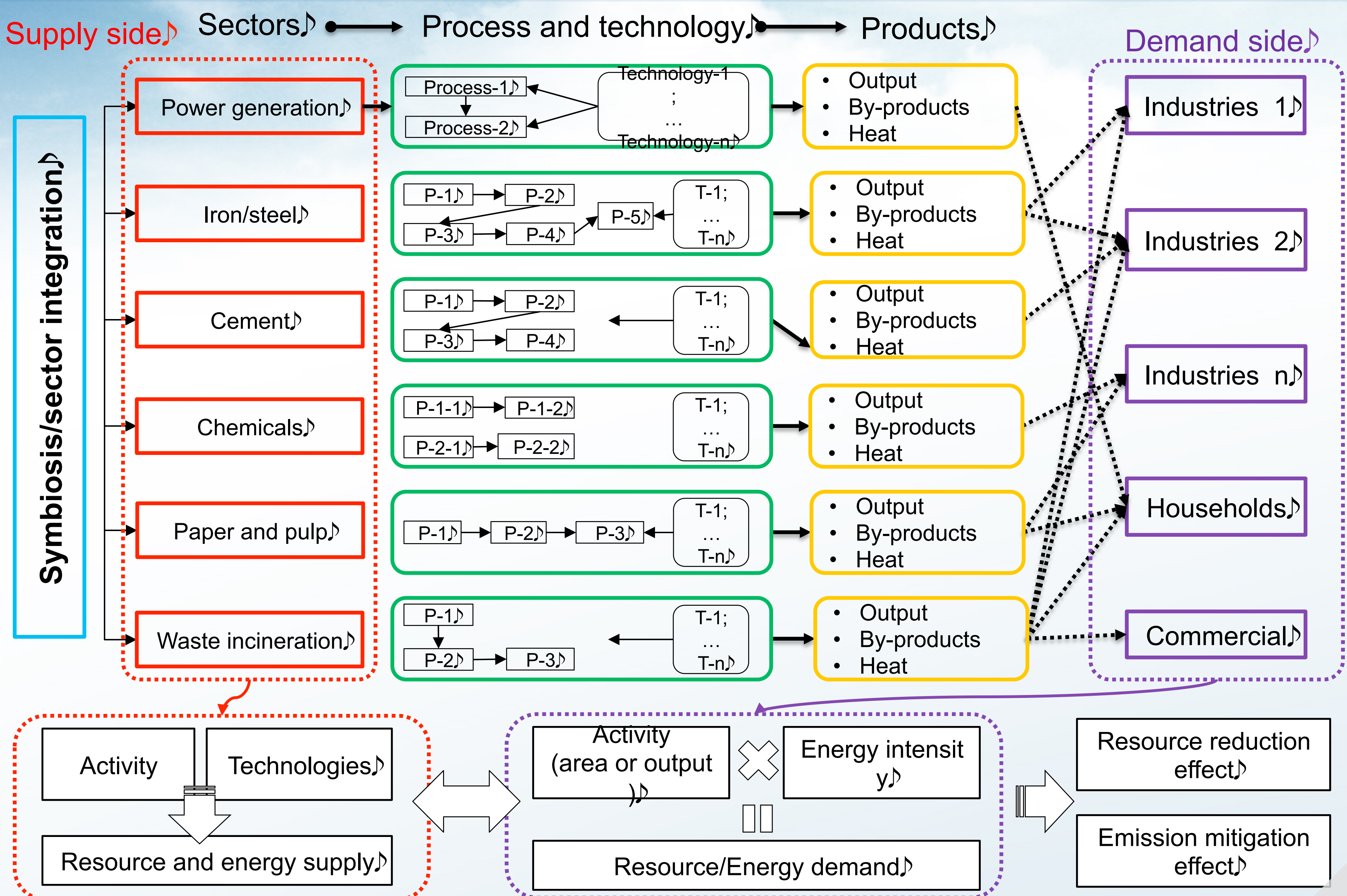
MIGA Multilateral Investment Guarantee Agency World Bank Group

With support from:

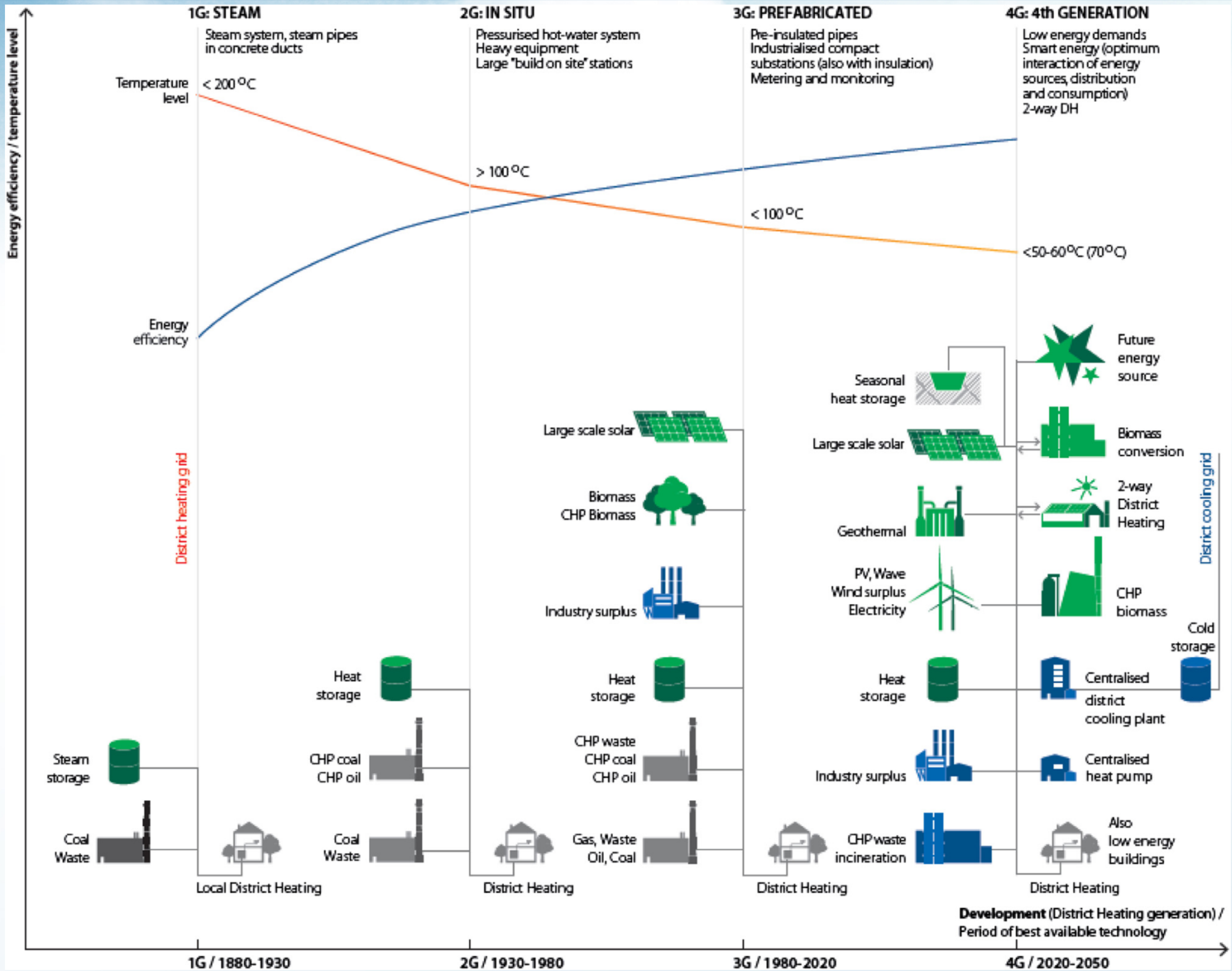
IV

Conclusions and Lessons Learned♪

High Potential of Heat Network in Industrial Park(dong, 2015)

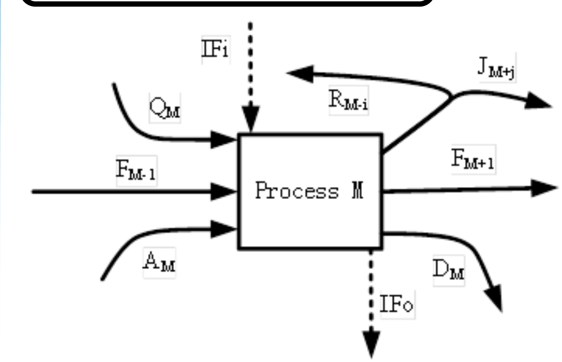


High Potential of integrating 4th Generation of DHS



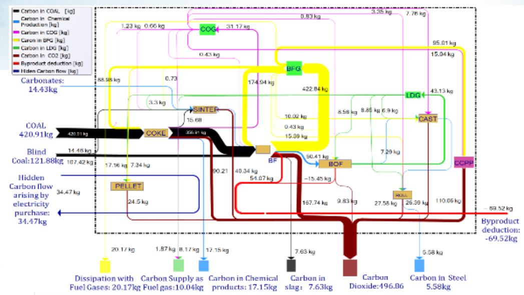
Regional SMART Heat Network by ICT and GIS (Dong, 2015)♪

Process model♪



$$A_M + Q_M + F_{M-1} = R_M + F_M + J_M + P_M + D_M$$

Dong, et al., 2013. Journal of Cleaner Production.♪

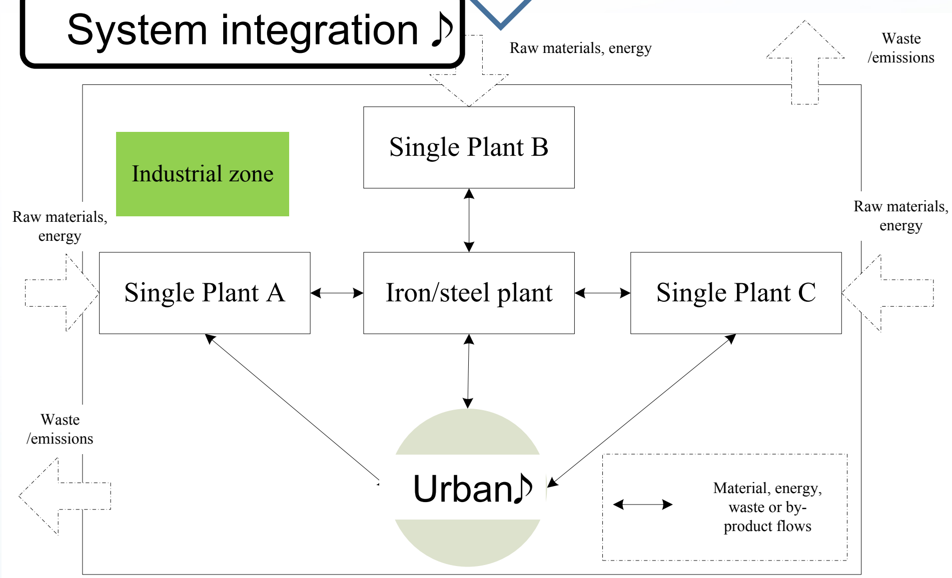


Avoided emission♪

$$R_{ij}=S_j \times M_{ij} \qquad W_{ij}=r_j \times TW_{ij}$$
$$CR_{ij}=Cof_j \times R_{ij}\ or\ W_{ij}$$

- A two-step analytical process is conducted.
- The basic material/energy analysis model is a typical process balance model.

System integration♪



<MEFA procedure>

- Based on the process analysis, system integration could be made.
- The material flow (Energy) flows between companies or sectors could be quantified.

Lessons Learned

1. Consistent Energy and Climate Policy (interdepartment and inter-ministerial cooperation)
2. Regional Consensus on Low Carbon Development (Cooperation with local governemnt)
3. Scientific and Flexible Institutional System
4. Technological Innovations
5. Creative Business Model
6. Customized Stakeholder Management Strategies
7. International Collaboration♪

Ulsan

welcomes you

to

2016 Green Industry Conference

(jointly organized by UNIDO, MOTIE and Ulsan City)

Thank you

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