Building Waste-to-Energy and Resource Supply Chain towards Circular Economy System

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Outlines

I. Introduction

II. Waste Management Plans in Taiwan

III. Waste-to-Energy/Resource Technologies

IV. Successful Experiences

V. Conclusions and Recommendations

I. Introduction

1.1 International Movement on “Green Economy”

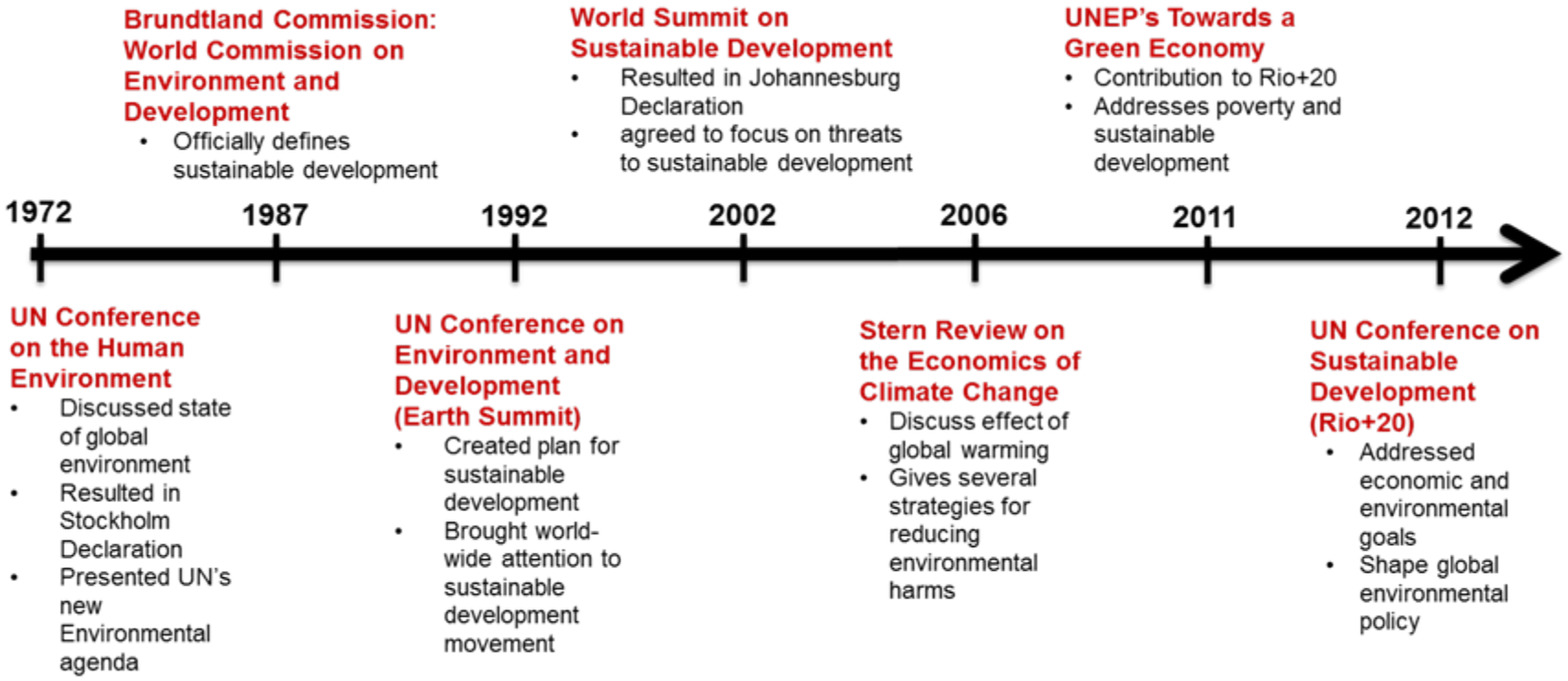
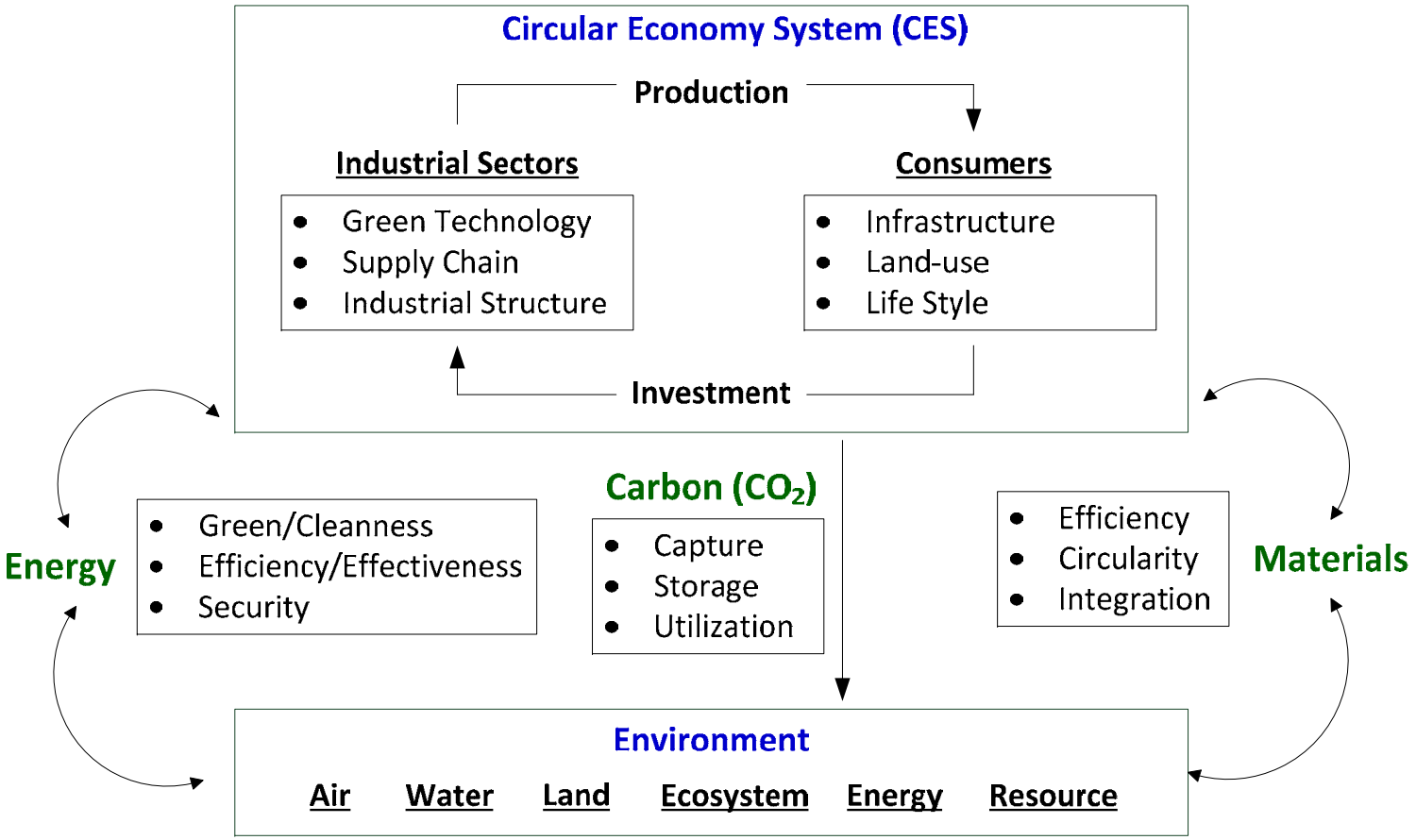


Figure. Important international movement on the sustainable development and green economy

1.2 Building WTE Supply Chain for CES



Conceptual framework of building WTE supply chains for CES

1.3 Biomass Components

- **Biomass: It refers generally to the organic matters originated from organism, such as :**

1) Forestry wastes (matchwood, etc.),

2) Agriculture wastes (pod, cob, bagasse, and rice straw),

3) Domestic wastes (garbage, kitchen waste),

4) Animal husbandry wastes (carcass),

5) Industrial organic wastes

(waste plastics, rubbers, and paper).

Crops

Wood

Alcohol Fuels

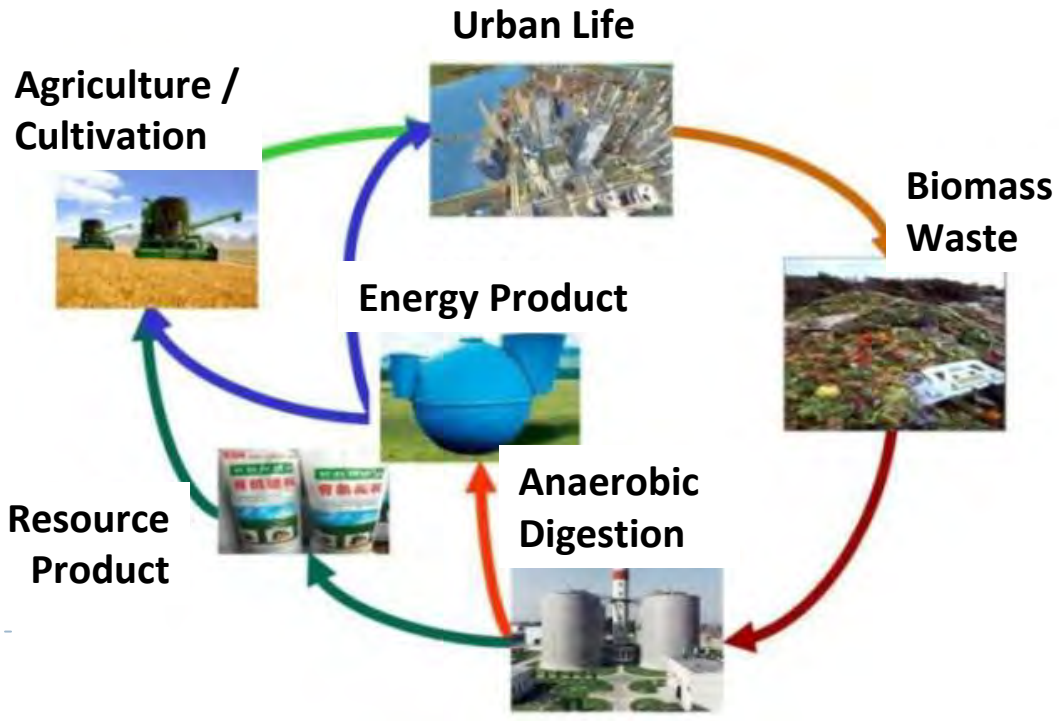
Landfill Gas

Garbage

1.4 Industrial Development of Biomass Energy

- Based on the scientific and technological innovation, the foundation and development of biomass energy industry can be promoted.
- Sustainable development depends on a "**Green** Economy"
- Only be implemented if fundamental changes are made to the current energy supply chains, especially in industrial parks

  - ✓ Improve the solid waste disposal rate
  - ✓ Achieve the harmless treatment
  - ✓ Achieve energy production of biomass waste



II. Waste Management Plans in Taiwan

2.1 Milestone of Municipal Solid Wastes (MSW) Management Plans in Taiwan

Land-fill

Incineration

Decommission of Land-fill

Zero waste Policy

Zero Land-fill

WTE and Resource Supply Chain

Disposal

1989

1997

2002

2005

2012

1984

1990

1998

2003

2010

2014

Resource Recycle Act

Renewable Resource Recycle

General Waste Source Reduction (Plastic bag free)

Mandatory Garbage Sorting Enforcement

Biomass Energy Utilization Plans

2.2 Implementation of Zero Waste Vision Plans in Taiwan

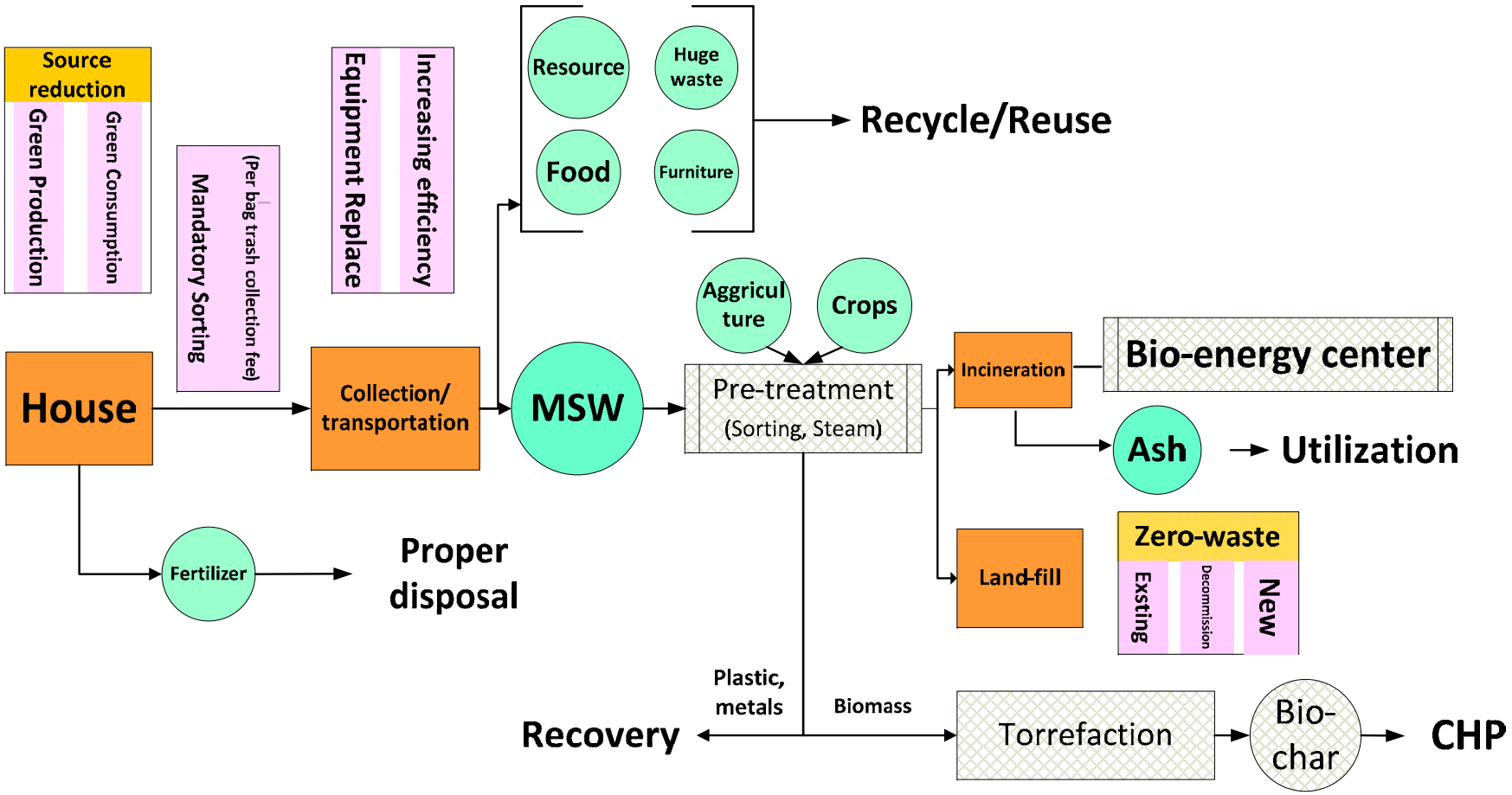


Diagram of Implementation of Zero Waste Vision Plans in Taiwan

2.2 “Per Bag Trash Collection Fee“ in Taipei City

2.2 Collection of Food Waste in Taipei City

2.2 Waste Minimization and Recovery

Food Wastes (Organic)

- Food left, etc. → Livestock raising (pigs, etc.)
- Fruit, Tee leaves, etc. → Land fill, composting

Huge Wastes

- Furniture, bicycle, etc. → For-sale
- Tree, etc. → Alternative Fuel, etc

Others → Plastics, 3C Products, etc.

2.2 Reuse and Recycle of MSW Incinerator Ashes

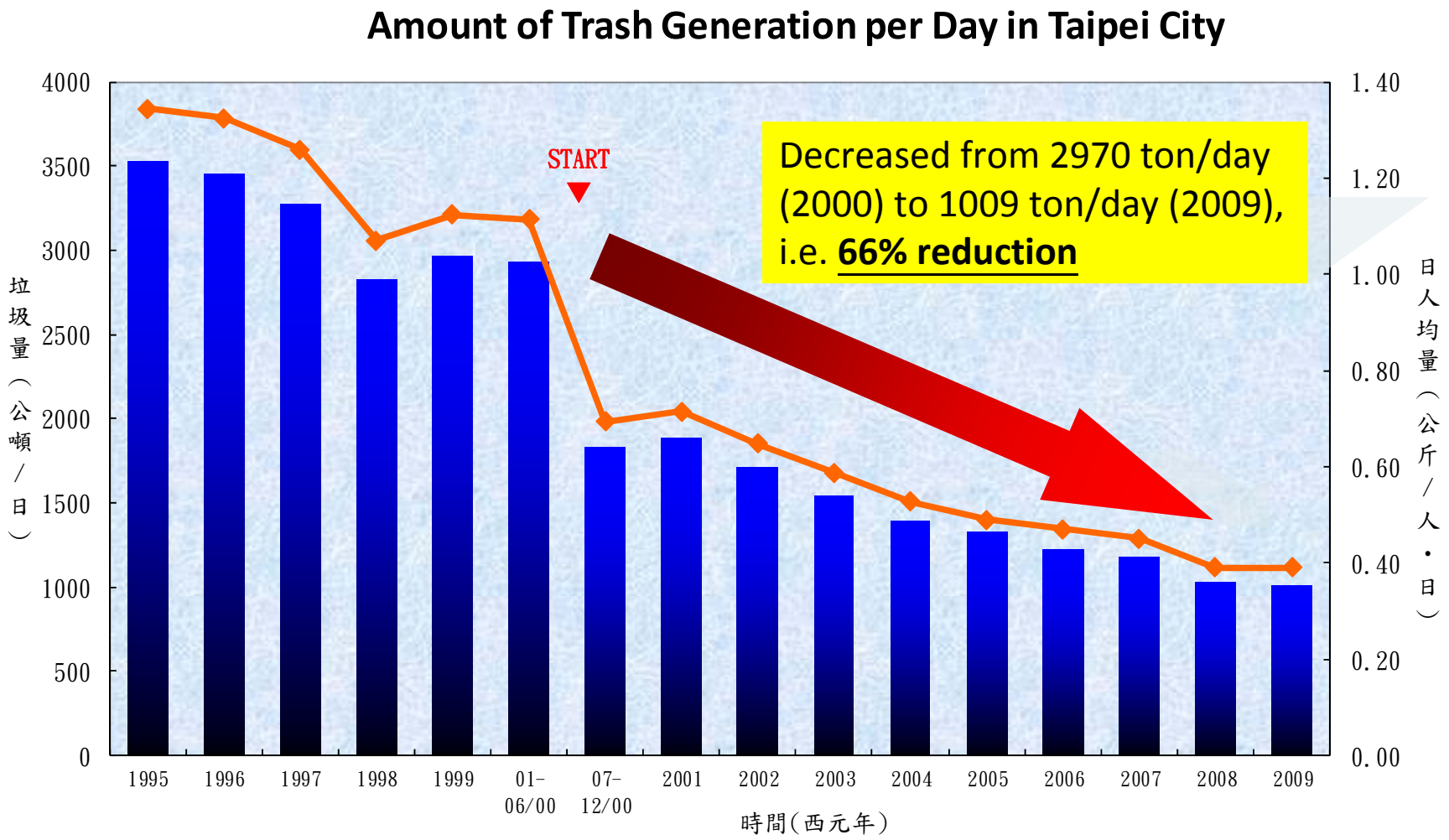
Sewage sludge → Mixed with aggregate or agricultural applications

MSWI Bottom Ash → Aggregate of road-based and construction materials

Totally recycle since 2005.9

MSWI Fly Ash → Cement Industries, etc.

2.2 Performance of “Per Bag Trash Collection Fee” Policy



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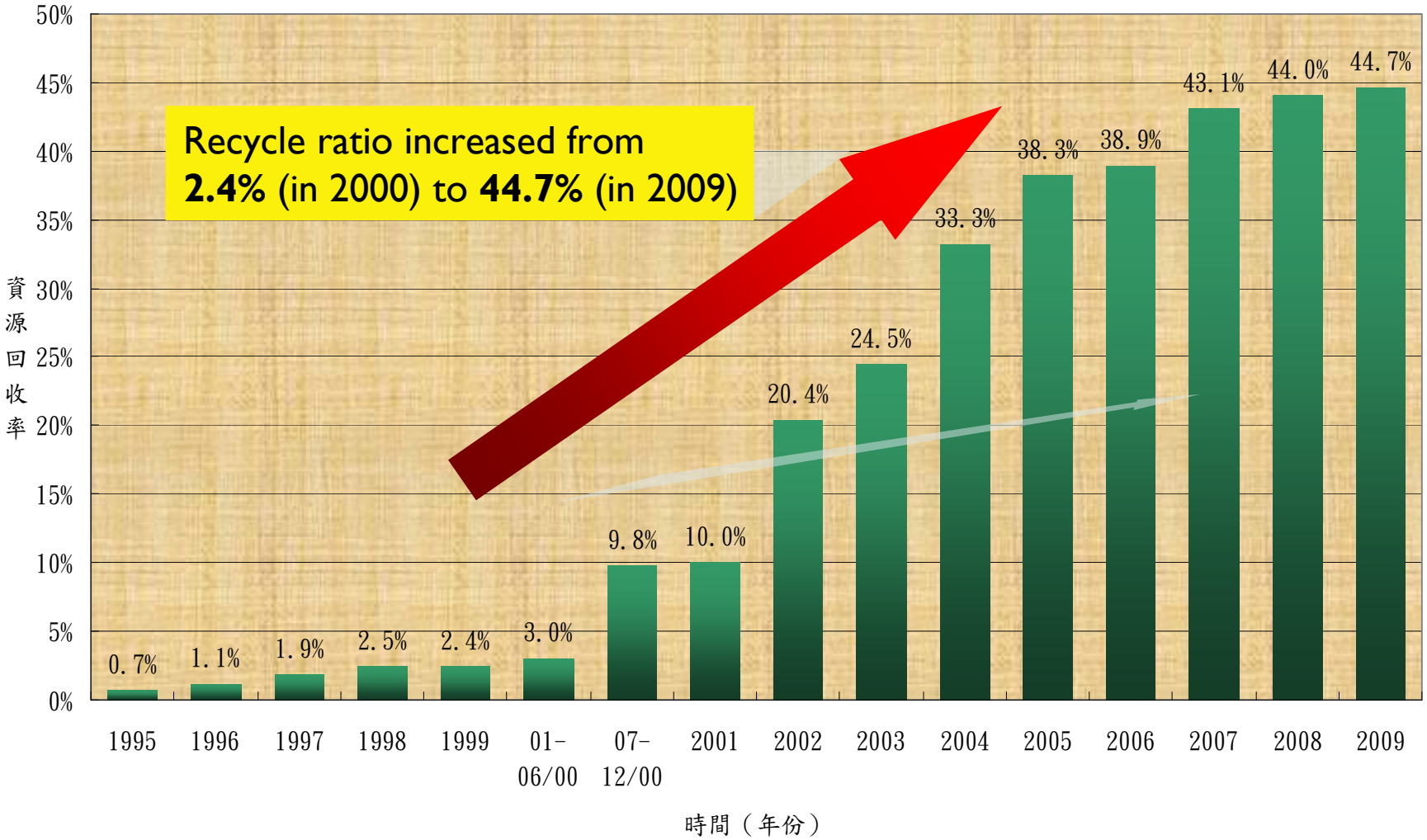
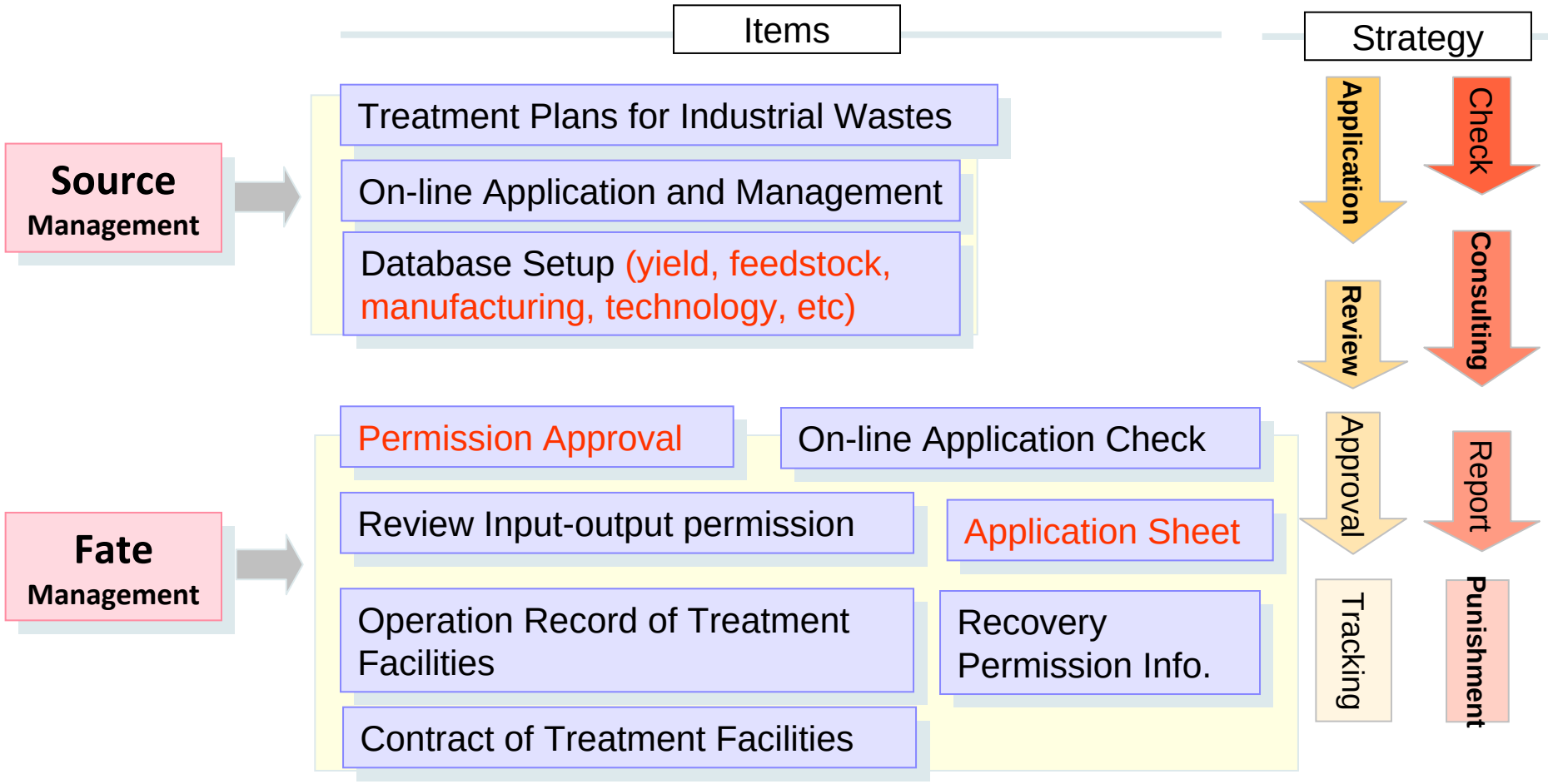


臺北市歷年資源回收率統計

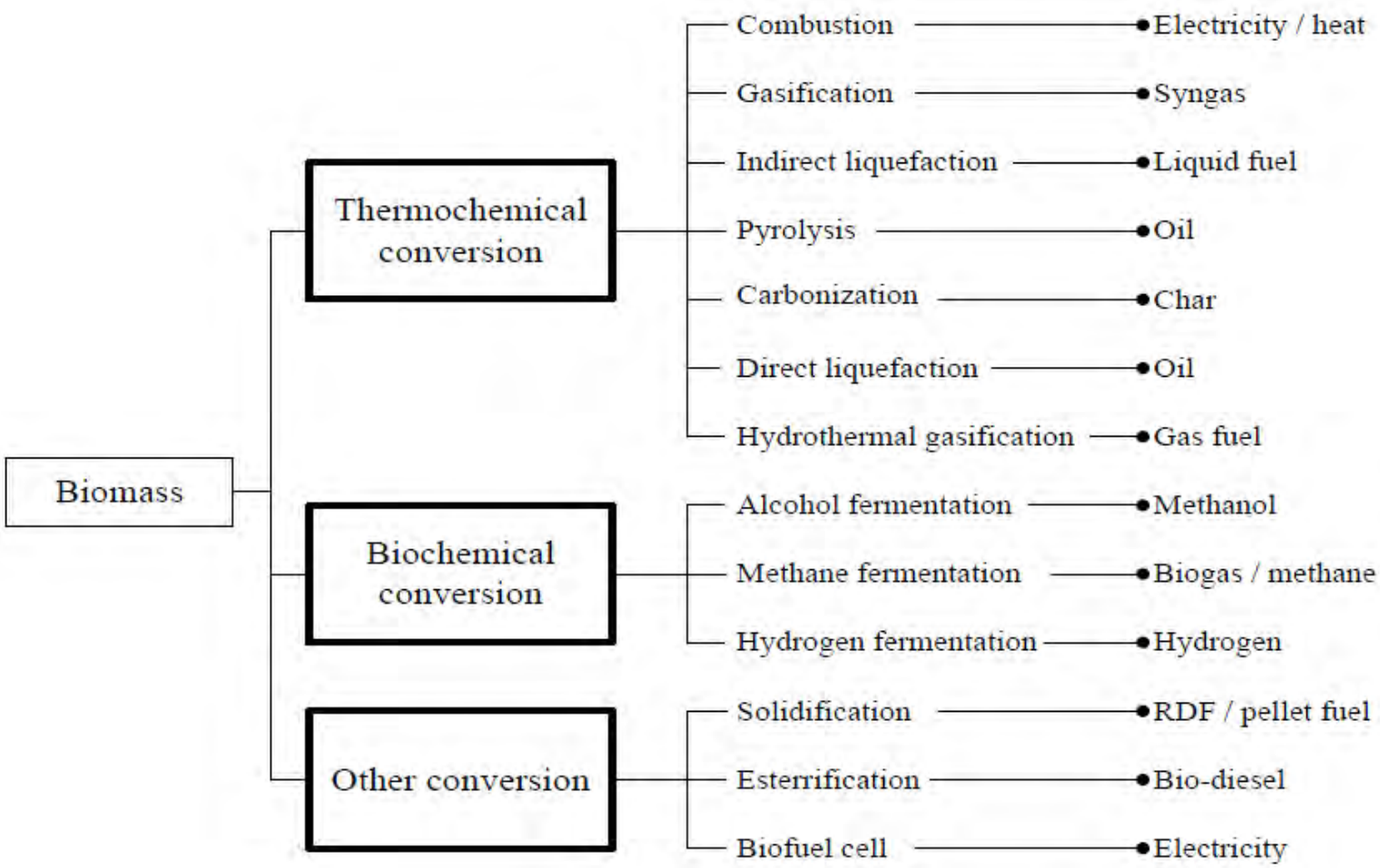
2.3 Industrial Waste Management Plans



2.3 Industrial Wastes Enforcement Programs

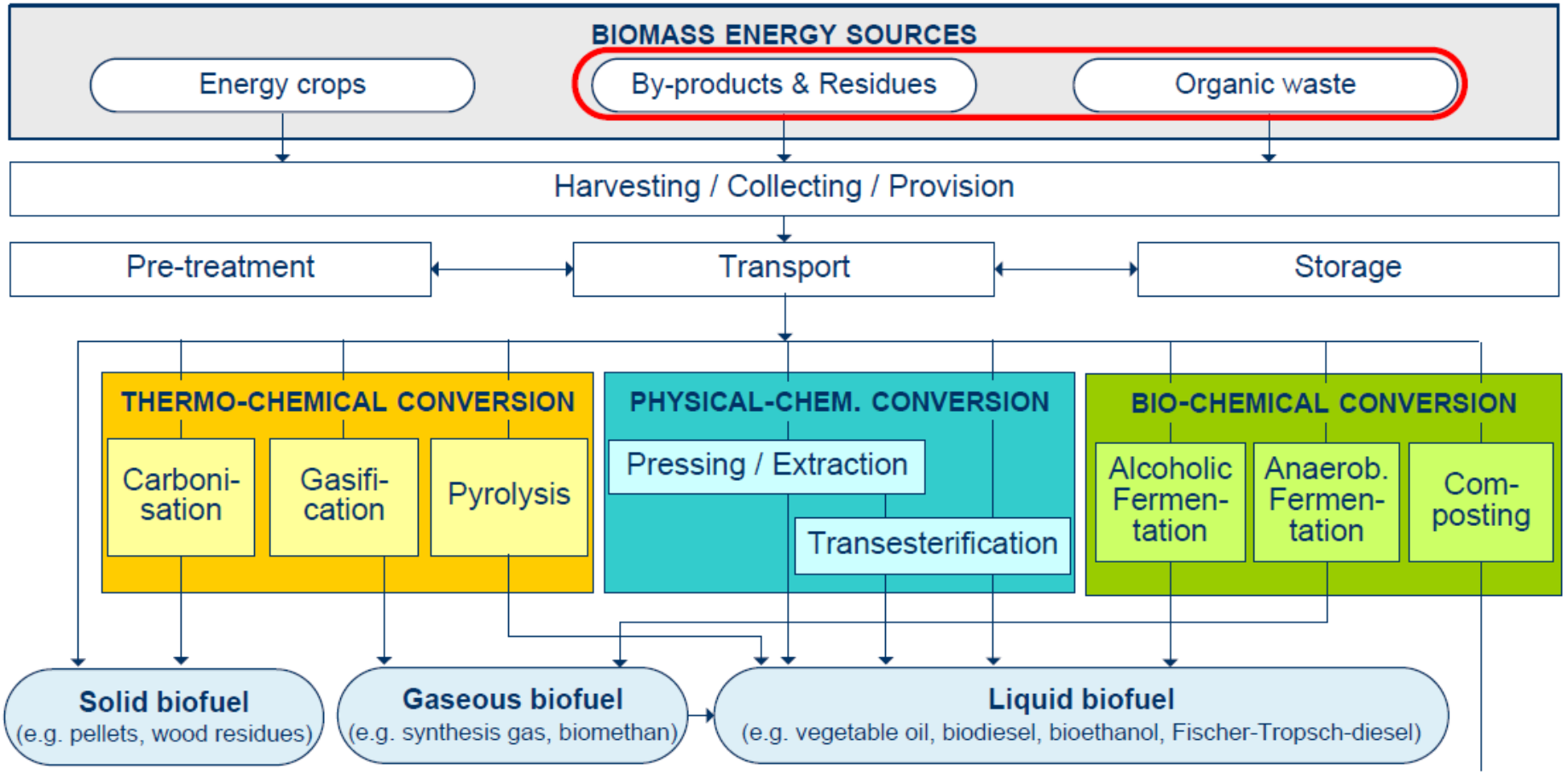
III. Waste-to-Energy/Resource Technologies

3.1 Utilization technology of biomass



(Fan, 2009).

3.2-1 Biomass Energy Technology Overview



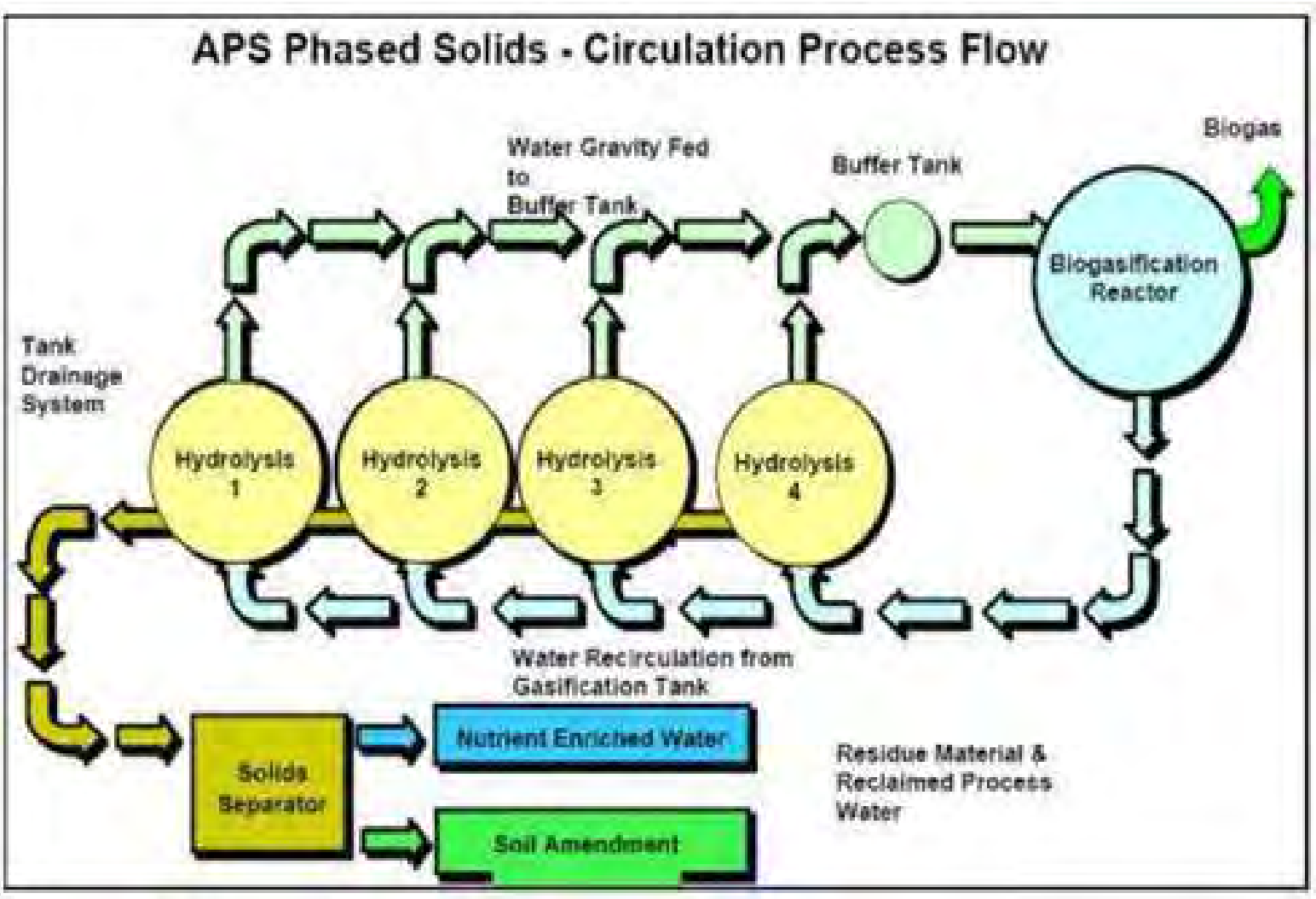
Source: IE-Leipzig, 2007

3.2-2 Biomass Energy Technology Overview

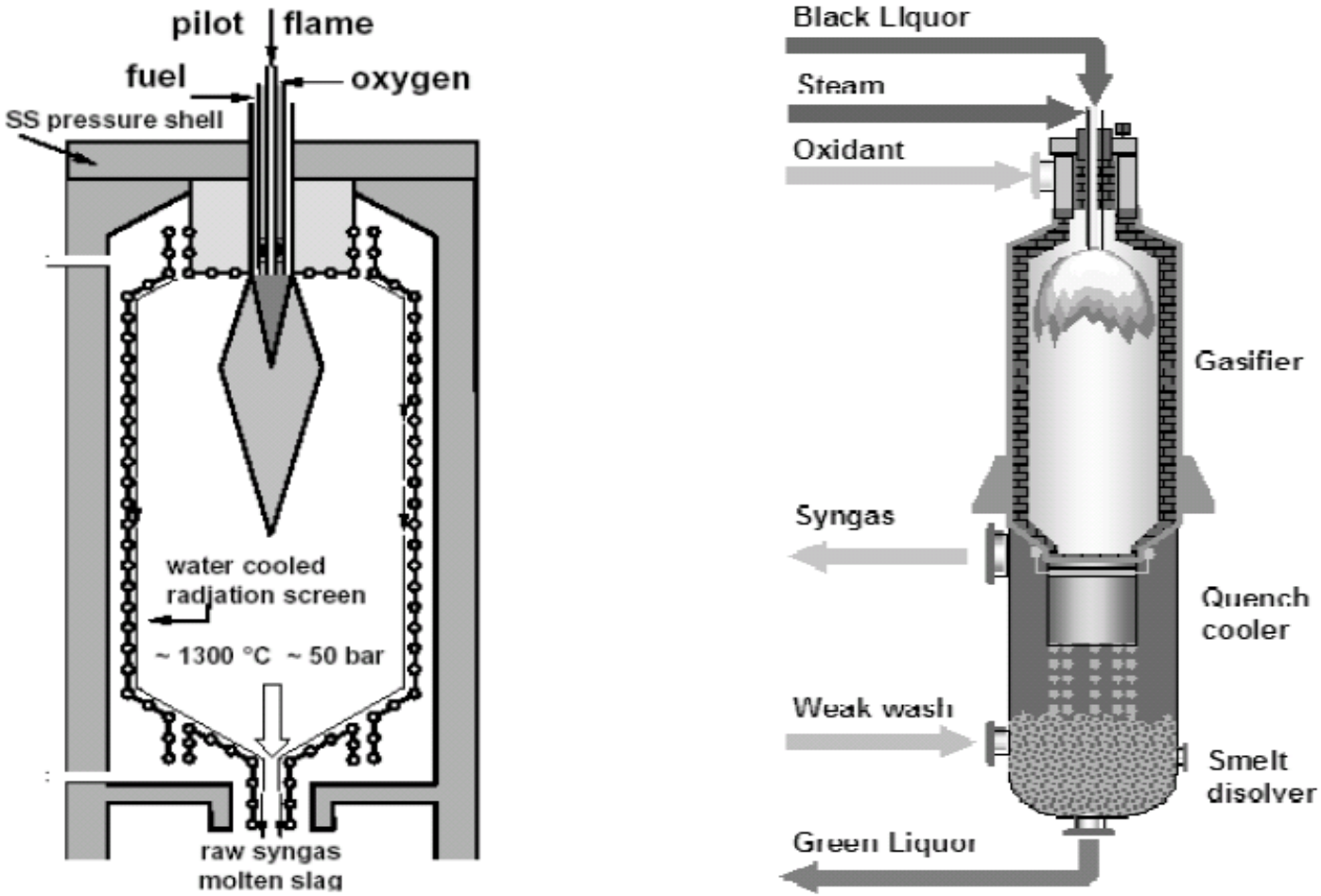
Feedstocks	Conversion Technologies	Products	Case Studies
Type I (Agriculture Wastes)	Drying/Pressing/Granulation (Physical) Torrefaction/Gasification (Chemical) Carbonization (Chemical)	Green Fuel Pellet Bio-char Bio-gas	Utilized for heating supply (Denmark/Taiwan)
Type 2 (Industrial Wastes)	Gasification/Combustion (chemical) Pyrolysis/Combustion (chemical) Bio-refinery (biological)	Heats (heating/cooling) Electricity Bio-gas (DME/methanol)	Utilized for CHP Plant (Taiwan)
Type 3 (Animal Wastes)	Gasification/Combustion (chemical) Anaerobic Digestion (biological) Fermentation (biological)	Bio-gas (H_2/syngas/methanol) Electricity Heats (heating/cooling)	Utilized for Biogas (Germany/Sweden)
Type 4 (Municipal Solid Wastes)	Co-combustion (chemical) Co-digestion (biological) Fermentation/Compost (biological)	Bio-gas (H_2/syngas/methanol) Heats (heating/cooling) Refuse Derived Fuel (RDF)	Utilized as DES Center (USA/Taiwan)

Technology tree of waste-to-energy (WTE) supply chain for bioenergy utilization

3.3-1 Anaerobic Digestion Process



3.3-2 Gasification Process



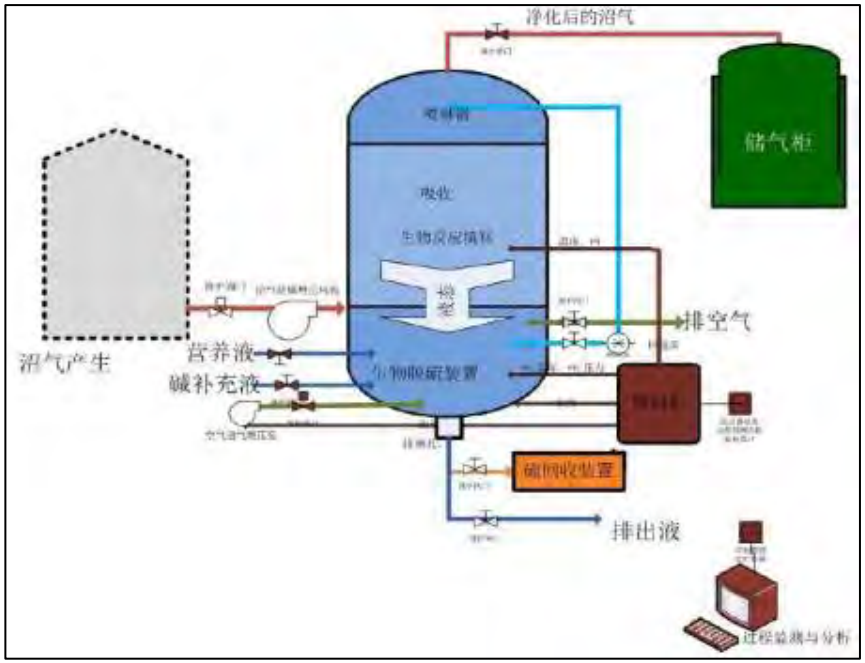
Sagging entrained flow gasifier for biomass & pyrolysis slurry (left hand side) and for black liquor23 (right hand side)

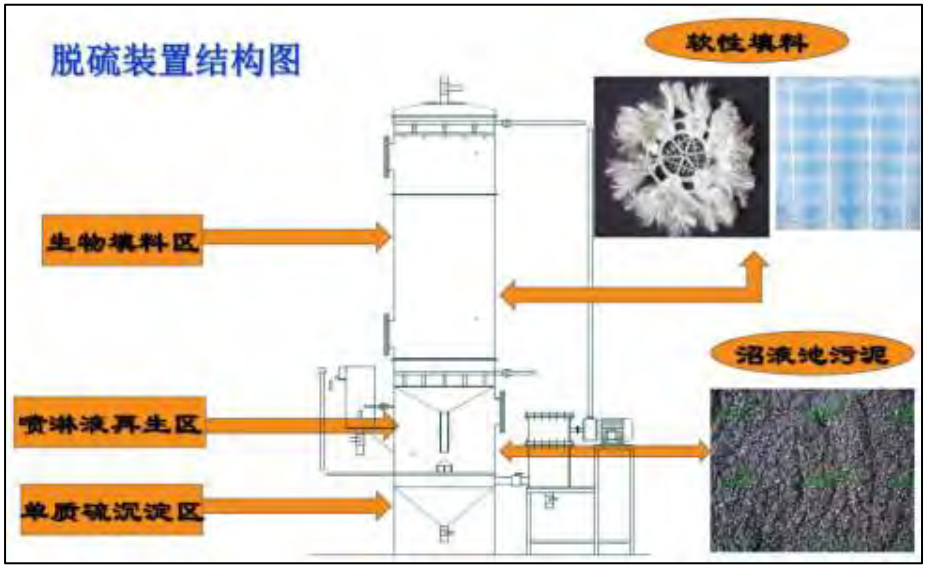
Source: Chemrec, www.chemrec.se (2009)

Source: Henrich and Weirich (2002)

3.4 Biogas Purification Process

Bio-desulfurization equipment for biogas





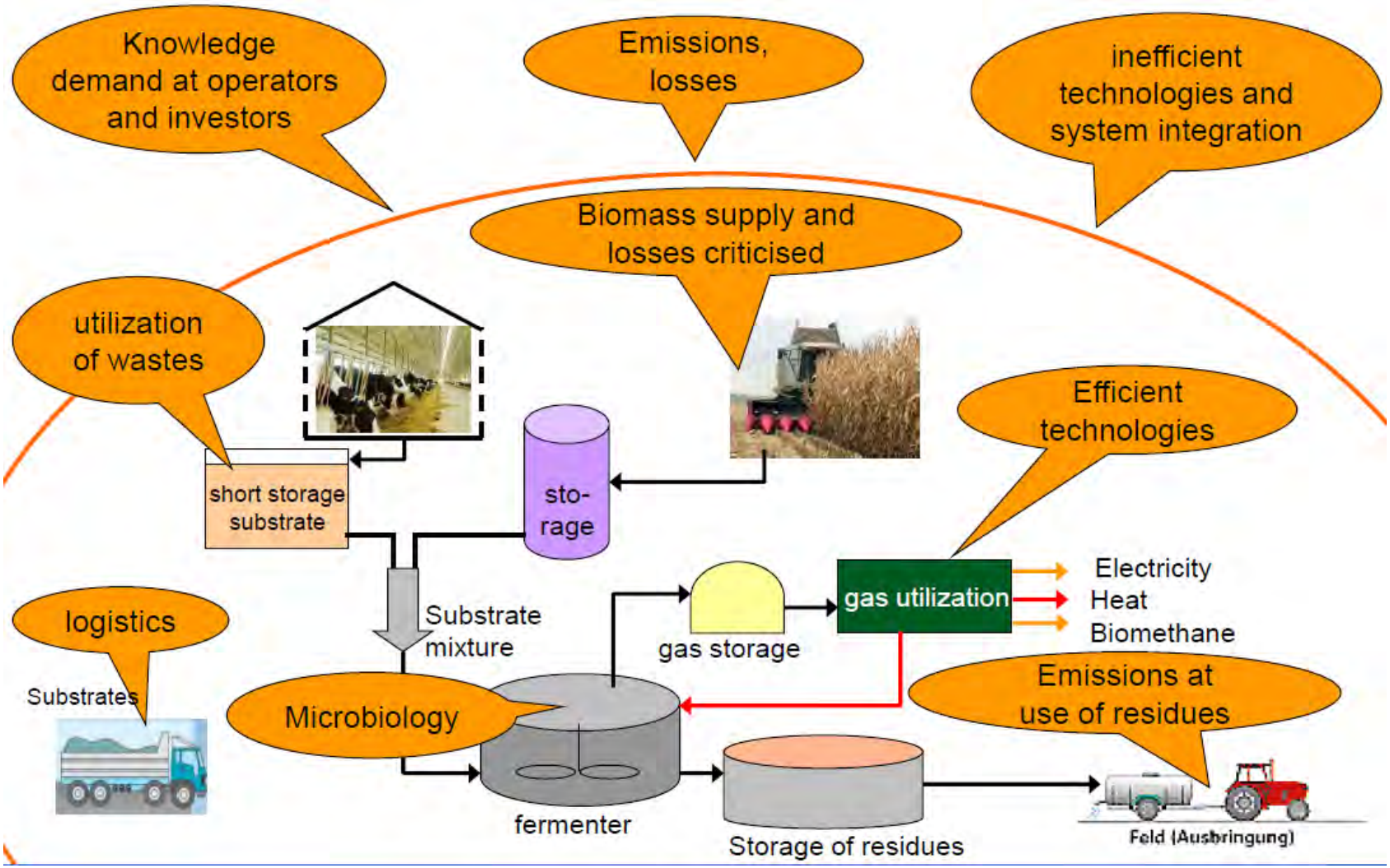








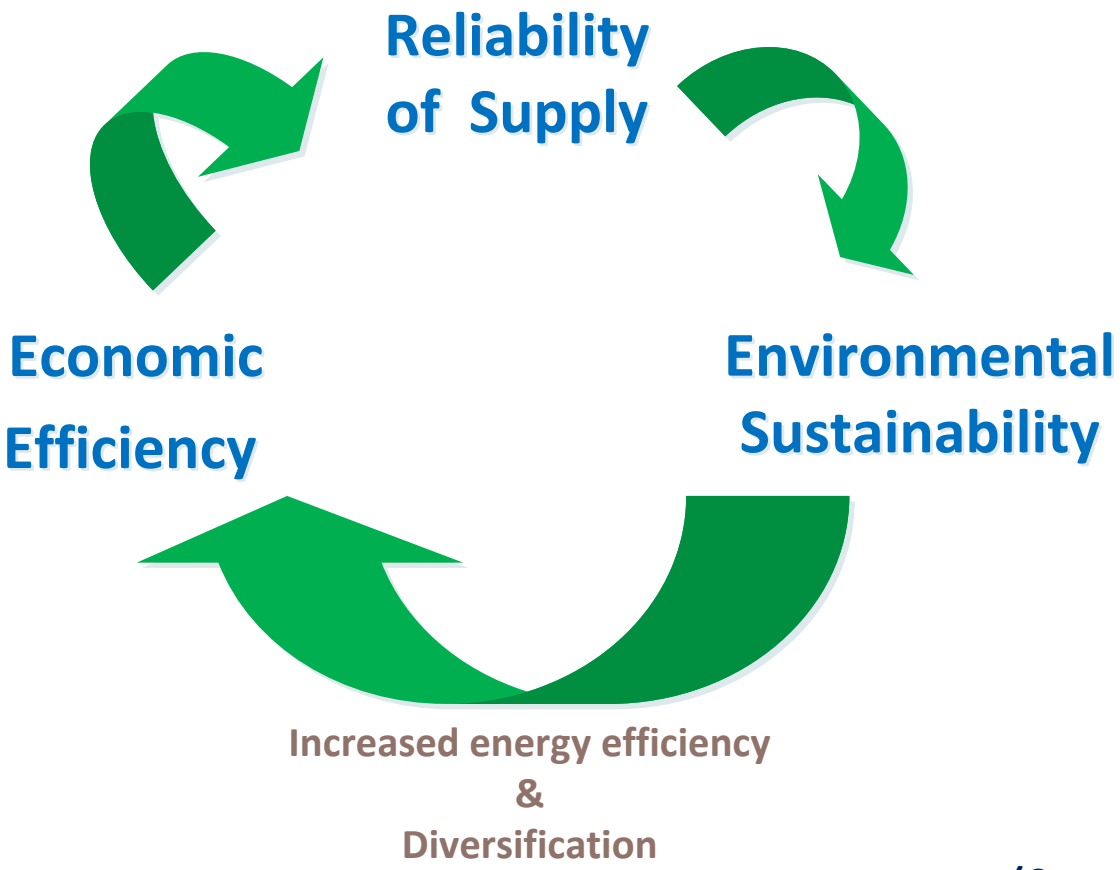

3.5 System Optimization



IV. Successful Experiences

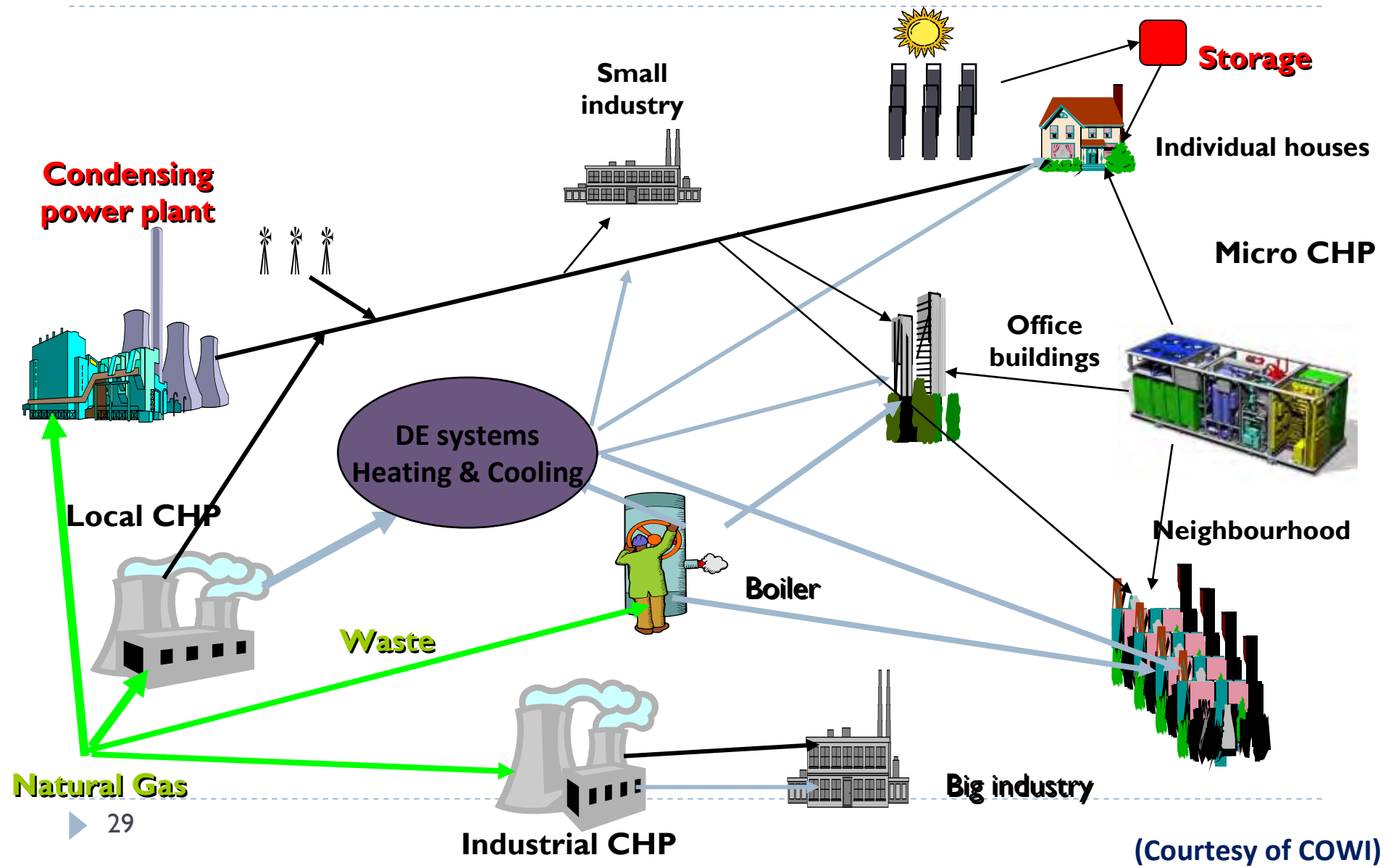
4.1-1 Sustainable Energy Development (Danish)

- Balancing of Goals at Short Term and Long Term



(Courtesy of COWI)

4.1-2 Energy supply structures: Competition or Synergies



(Courtesy of COWI)

4.1-3 Denmark: Multi-fuel Boiler Technologies

Avedøre II (2001) / DONG Energy A/S
CHP / 485 MWe & 545 MJ/s heat

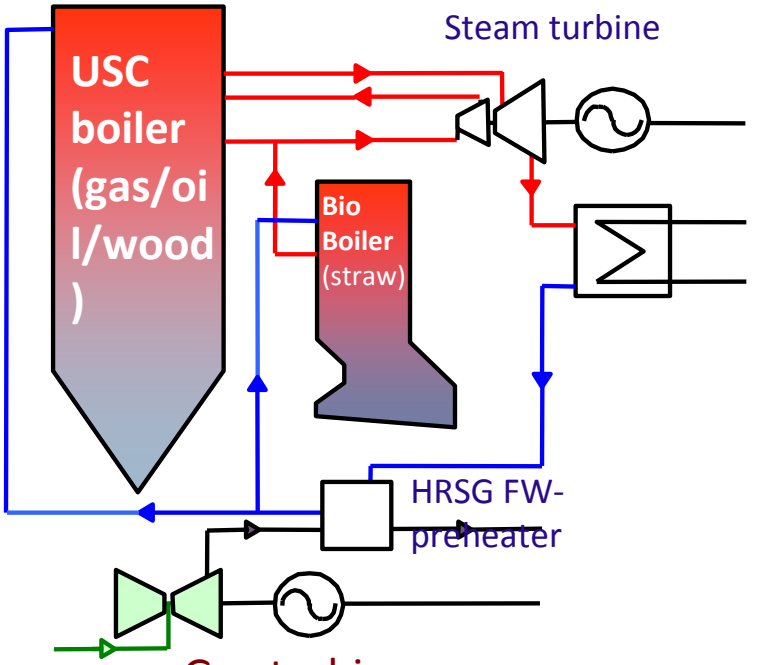
Avedøre Power Station unit 2 design:

- 100% on coal and natural gas
- 100% on heavy fuel oil (HFO)
- 70% on biomass (wood pellets)

USC combined with 2 x 50MW gas turbine

Increased output: 150MWe

Total plant efficiency: 51%

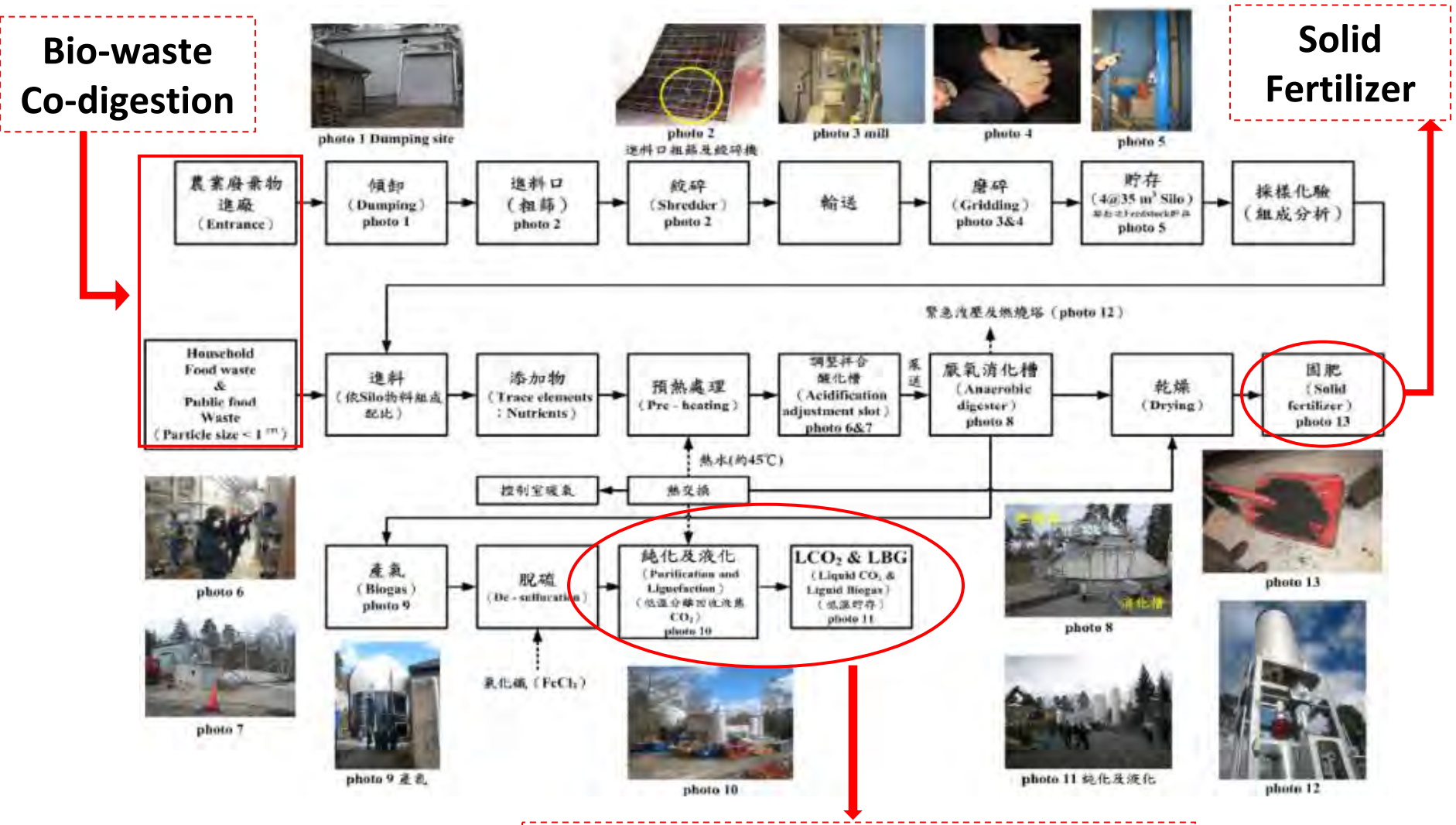


Plant concept by DONG Energy, visited by delegations during COP15

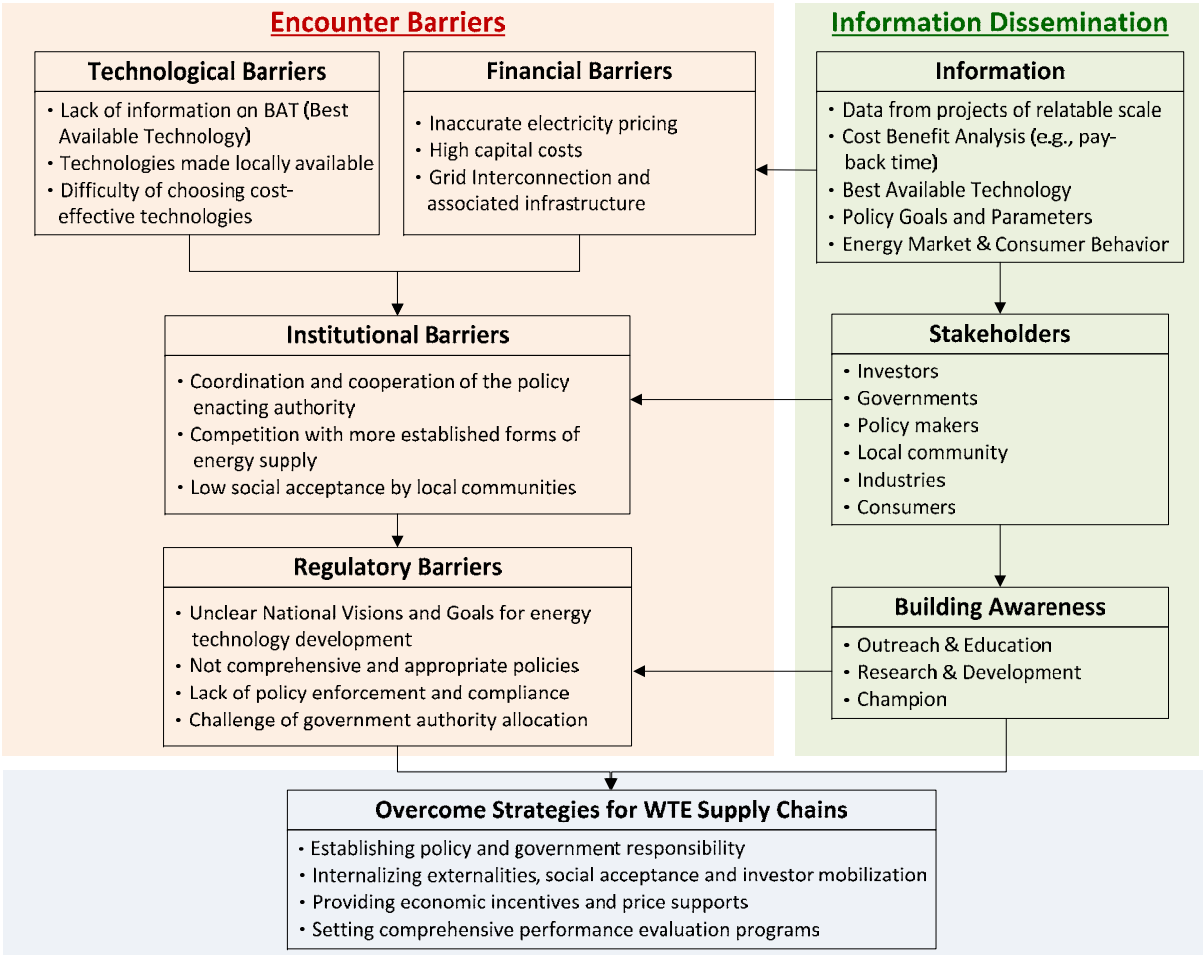
(Courtesy of STF Group)

Using "Green Fuel Pellets"

4.2 Sweden: Bio-waste Treatment Flowchart



4.3-1 Barriers and Strategies in Taiwan

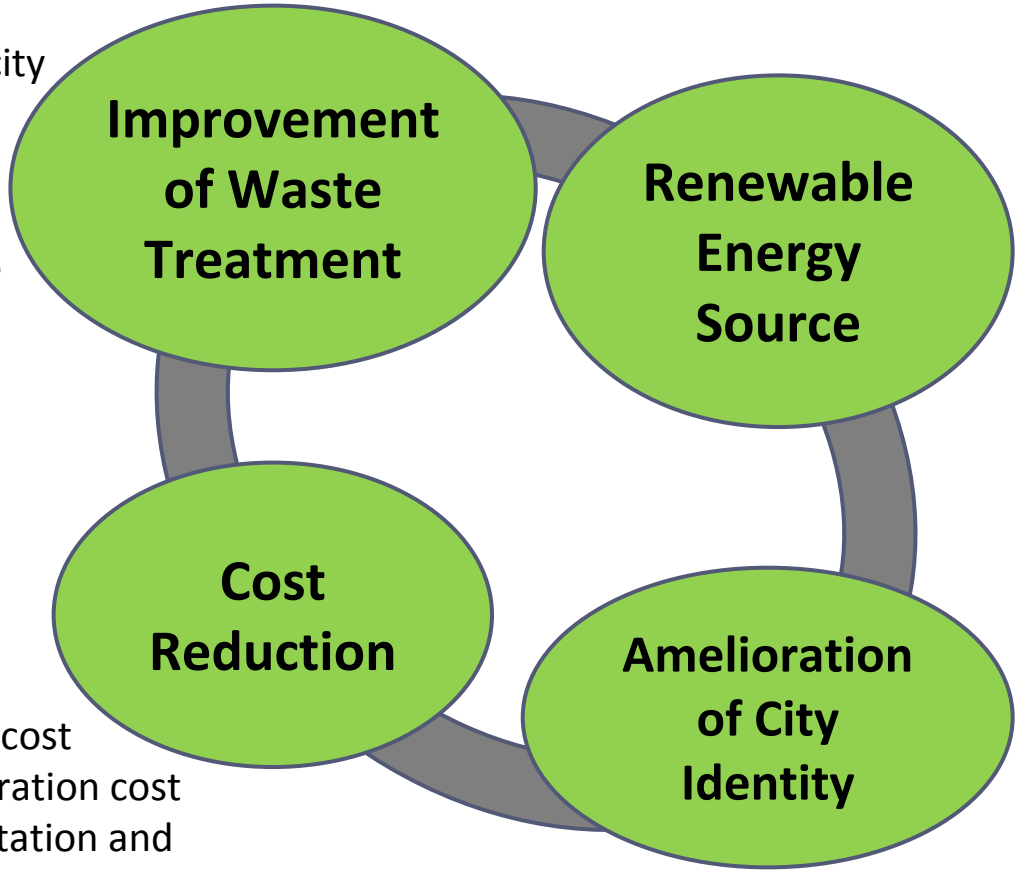


Visualization of encounter barriers and overcome strategies for constructing WTE supply chains

4.3 Demonstration: Bali WWTP for Bio-gas Production

4.3 Benefits of Bali WWTP Demonstration

- Increase waste treatment capacity
- Reduce waste treatment transportation
- Reduce land-use area

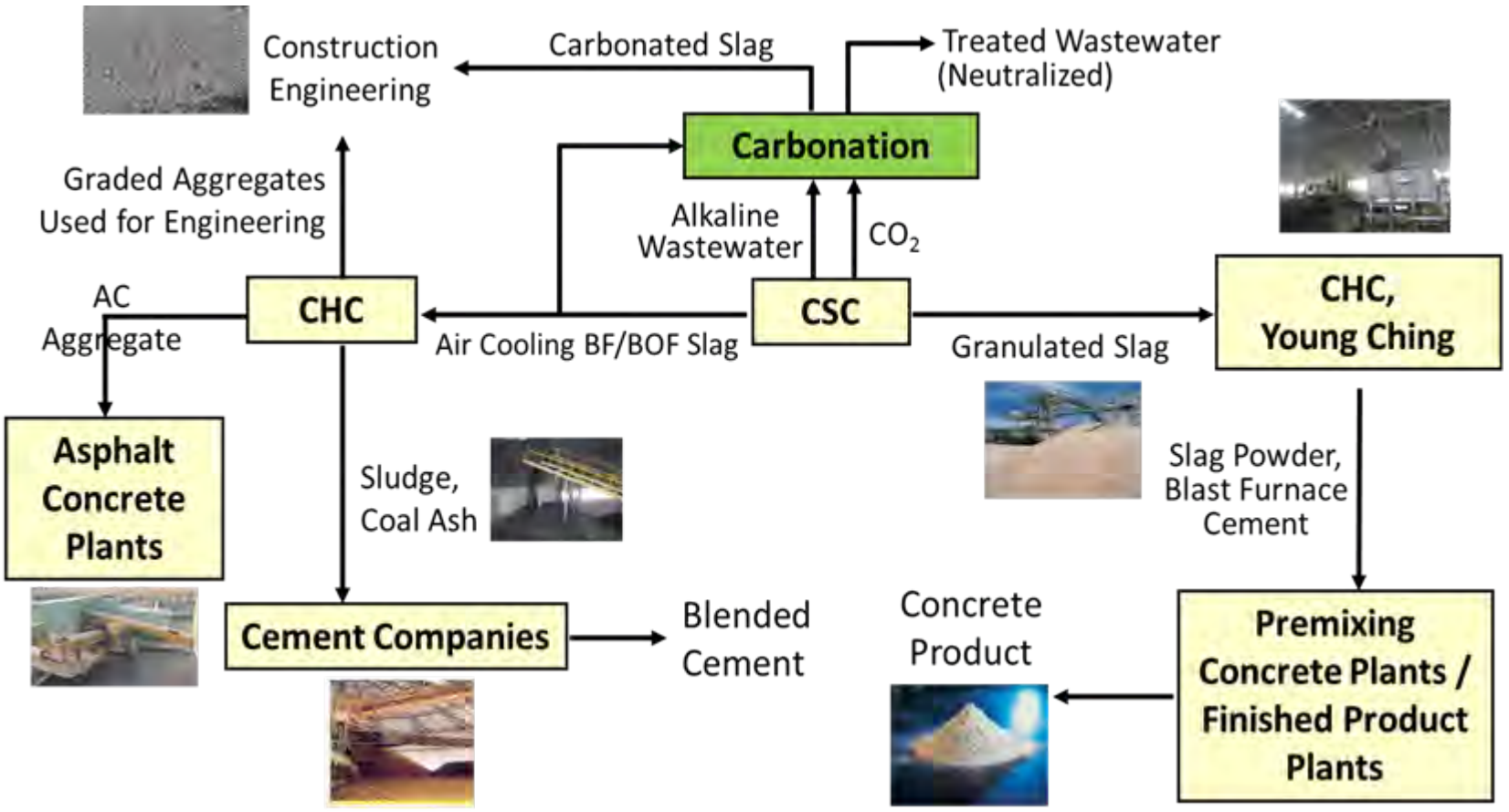


- Bio-gas production capacity = 1550 m^3 per year
- Bio-gas production capacity increases if waste treatment capacity increases
- Reduce nature gas import

- Free investment cost
- Free bio-gas operation cost
- Reduce transportation and storage cost
- Ameliorate land-use plans

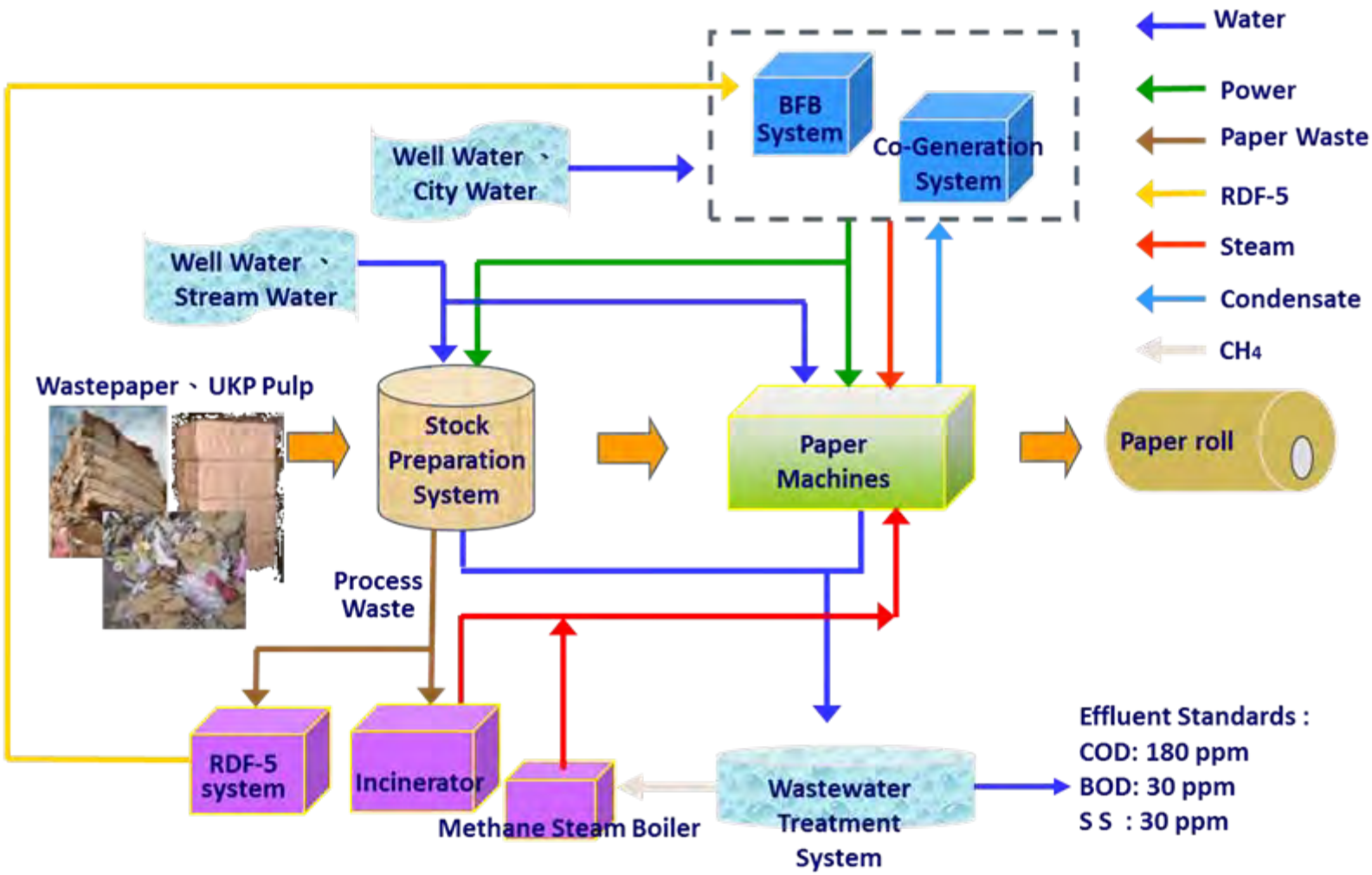
- Reduce GHGs emission of 30,000 ton per year
- Reduce CH_4 emission and leakage
- Avoidance of water pollution by food waste
- Improve life and environment quality

4.3-1 Taiwan: Lin-Hai Industrial Park



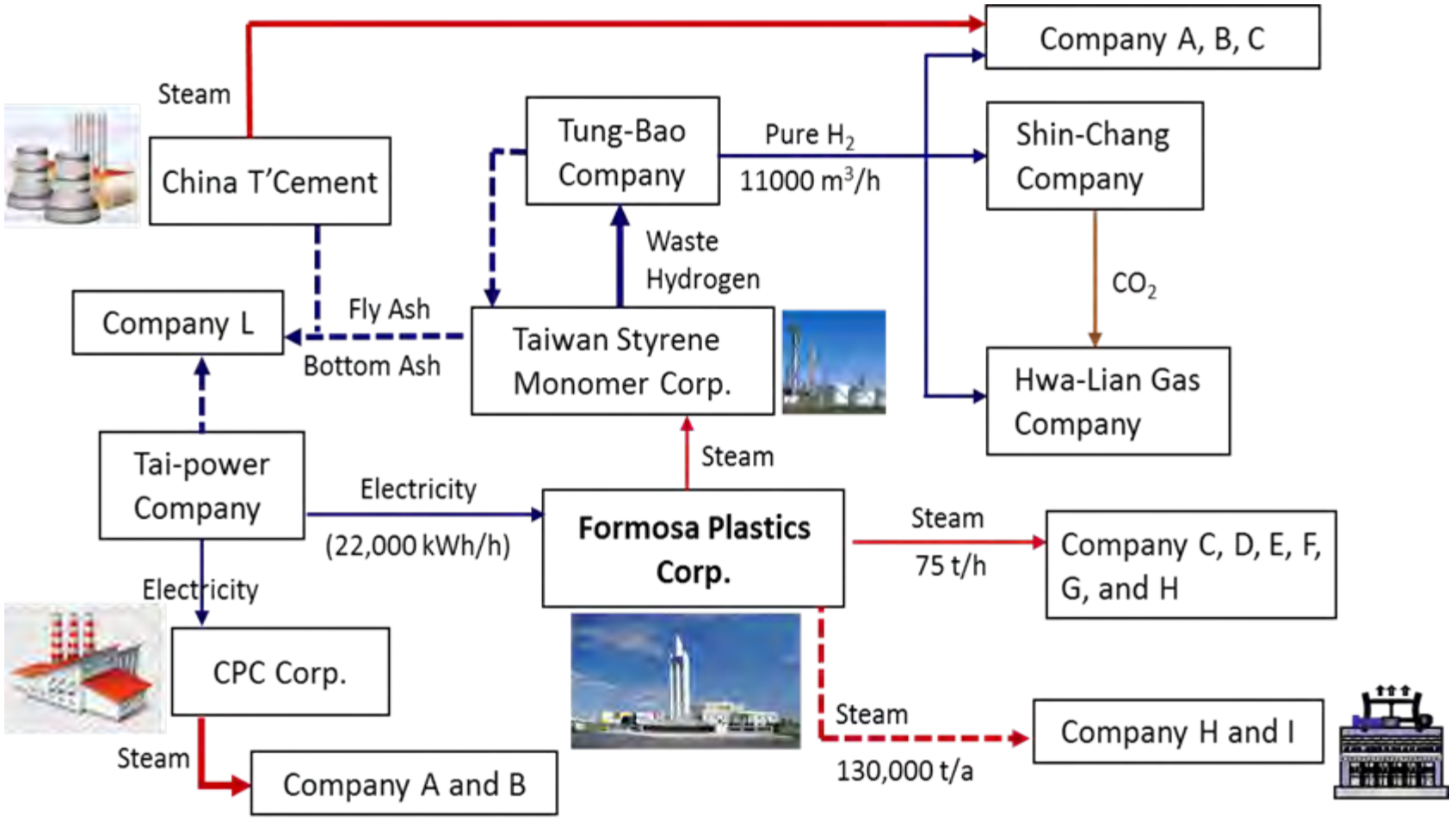
Conceptual diagram of green supply chain in the case of alkaline solid wastes in Lin-Hai Industrial Park

4.3-2 Taiwan: Da-Yuan Industrial Park



Papermaking Process Integration within Cheng Loong Corp in Taoyuan Industrial Park

4.3-3 Taiwan: Formosa Plastic Corp.



Schematic diagram of construction of green supply chain in Lin-Yuan Industrial Park

4.3-4 Environmental and Socio-economic Benefits

Aspects	Themes	Indicators	Units	Industrial Parks in Taiwan		
				Lin-Hai	**Da-Yuan**	**Lin-Yuan**
Environmental	Pollution Reduction	NO_x Emissions	t/y	1,270	-	160
		Particles Emissions	t/y	181	-	15
		SO_x Emissions	t/y	1,830	-	370
		CO_2 Emissions	t/y	574,000	18,000	32,300
	Resource Recycling	Ratio of Waste Recycling	%	84.7	30.6	-
		Amount of Waste Recycling	t/y	669,487	284,550	-
		Ratio of Waste Recycling	%	-	28.9	-
		Amount of Steam Supply	t/y	1,880,709	940,000	630,000
		Amount of Industry Gas Supply	t/y	116,463	-	8,600
	Green infrastructure	Area of green land	m^2	57,000	5,600	202,000
Economic	Energy Efficiency	Heavy Oil Reduction	kL	40,663	13,800	-
		Boiler Heat Utilization	%	-	-	60.5
	Benefits	Annual value of productions	USD/y	305 billion	105 billion	77.5 billion
		Cost Reduction	USD/y	100 million	2.87 million	5.3 million
Social	Community Development	Number of Employee per year	persons	40,717	11,027	4,395
		Number of companies	units	526	168	27
		Public Satisfaction of environment	-	Excellent	Excellent	Excellent
		Cognition of eco-industrial park	-	Excellent	Excellent	Excellent

V. Conclusions

5.1 Strategies on Building WTE Supply Chain (1/3)

1. Broaden the Source Material Collection and Increase the Co-digestion Efficiency of Bio-organic Wastes

- Garbage and agricultural waste shall be processed via steam cooking process
- Kitchen waste, septage, hog farm waste and municipal sludge shall be processed by the co-digestion process
- Install a centralized energy recycle center for colleting wasted bio gas from the digestion process
- Co-digestion of various organic wastes will enhance the bio-gas generation and energy recycle

2. Establish an Integrated, Centralized and Authorized Management Agency to Execute the Integration of All Energy and Natural resources.

- An industry sponsorship Institute may be a more appropriate management agency responsible for recycle and reuse of various organic

5.1 Strategies on Building WTE Supply Chain (2/3)

3. Promulgate Better and Thorough Regulations and Provide Economic Incentives to Strictly Regulate the Recycle and Reuse of Bio-organic Wastes

- Carry out in both directions of **Top-Down** as well as **Bottom-Up** in executing a policy.
- Establish the **Feed-in Tariffs (FITs)** purchasing price guarantee system.
- Establish stringent codes for increasing the collection of kitchen waste and reducing environmental pollution

4. Establish an International Manufacturing Cooperation Mechanism, Technical Platform and Basic Structure

- Promote the integration of all incineration plant transformation
- Establish a new medium to small size regional bio-energy center
- Integrated with the low carbon community policy to integrate the regional bio-energy development plan

5.1 Strategies on Building WTE Supply Chain (3/3)

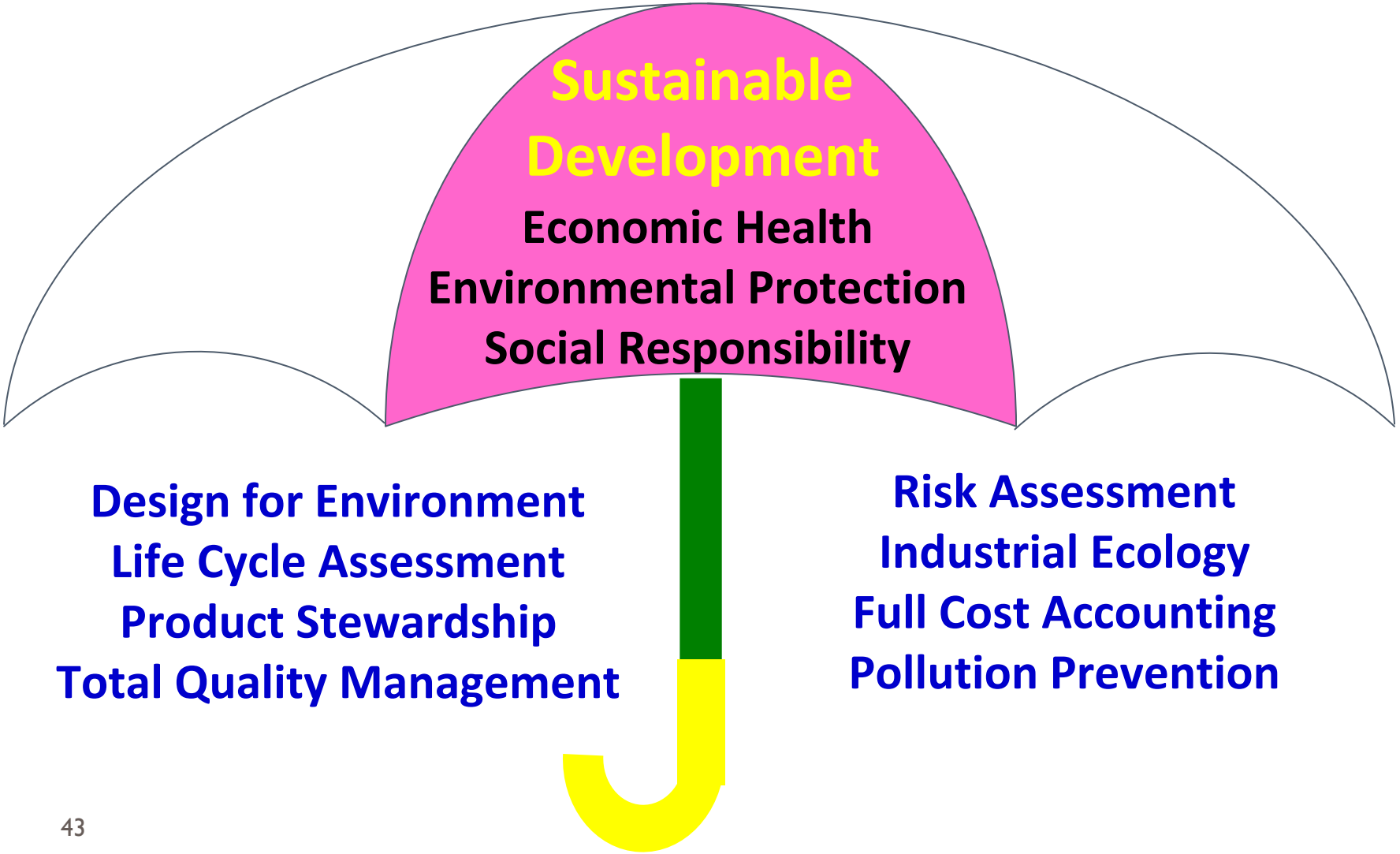
5. Build a Biomass Model Plant, Improve the Biogas Quality and Biogas Application Engineering Technology

- Establish the **commercialized model** and model the cost effects of collection and transportation
- Wastes from the **large** industrial plants be used as the energy source for **power generation**
- Wastes from the **small** scale livestock industry be used as the energy source for **heating purpose**
- Integrate the steam cooking system and garbage incineration plant to form a regional biomass center

6. Accelerate the Promotion Plan of Biomass Energy Generation, Enhance the Technology Development and Application Research in Biomass

- Establish the technical platform and pertaining infrastructures
- Promote the resource re-generation model utilizing the anaerobic digestion technology

5.2 Green Engineering and Sustainable Technology (GEST)



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Thank you for your attention !!!

Questions and Comments ??

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