AIT Technology Event

Innovations in Waste Management

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AIT
Asian Institute of Technology

Presentation Contents

1. Solid Waste Management
   - Current Trends
   - Technological Advancements

2. Wastewater
   - Current Trends
   - Technological Advancements

Issues for Waste Management

- Main Issue – Change of Perspective

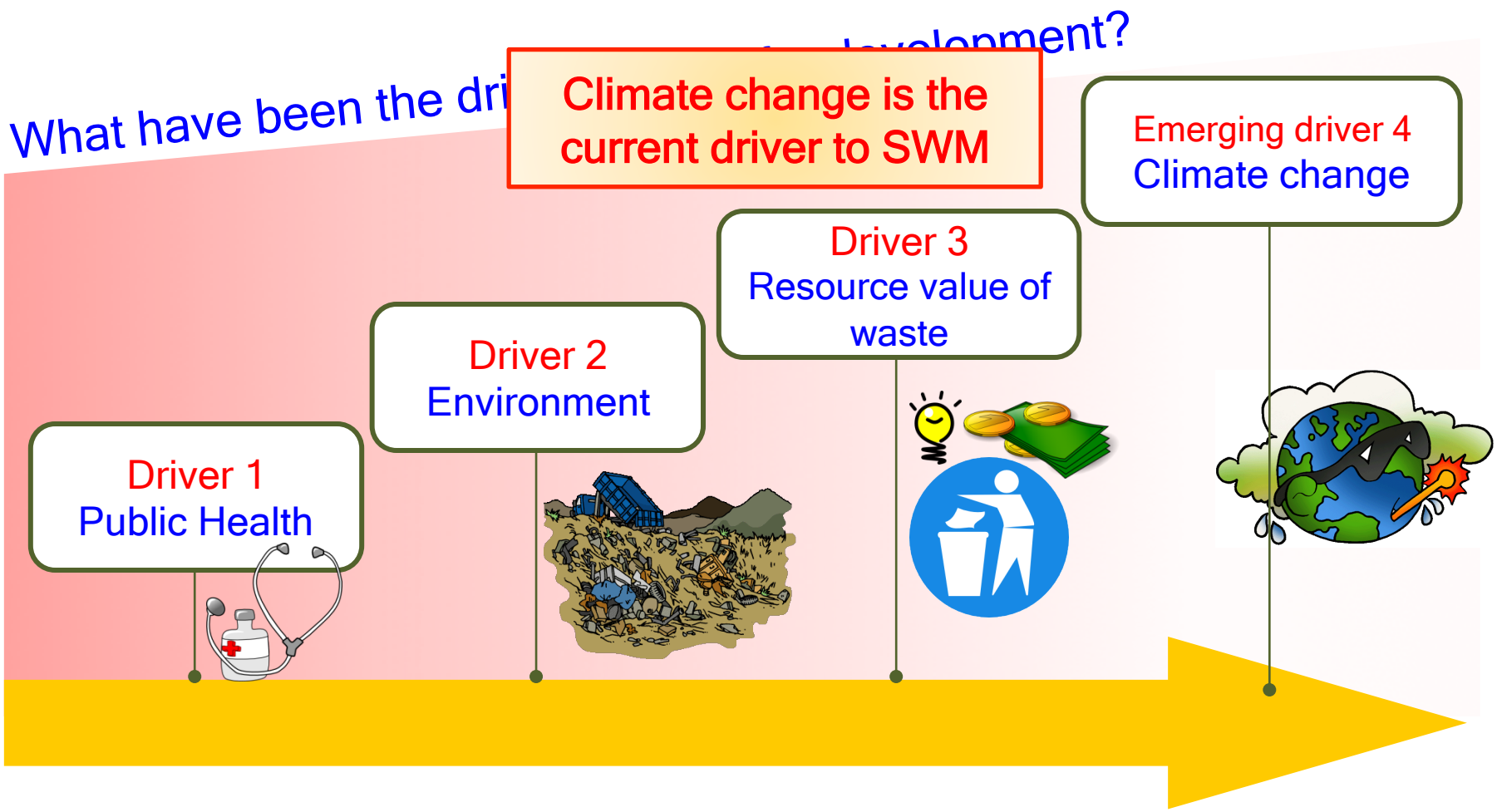
20th Century	21st Century
Waste Management	Resource Management

Solid Waste Management

Where most of us are now !

Where all of us should be

Development Drivers of SW Modernization – Technology Development

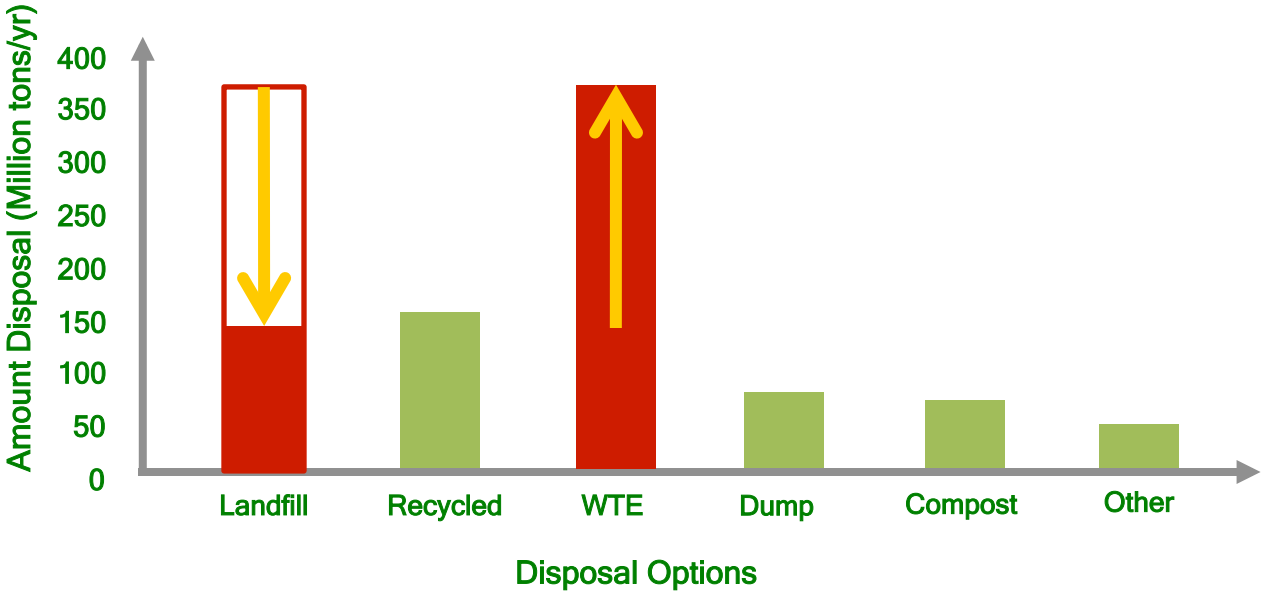


Waste Management Cost - Taxing Affair

- Globally, disposal cost SW $205.4 bn, In 2025 expected ↑ $375.5 bn
- 5-fold cost increase in low income countries, while lower-middle income countries will face 4-fold increases for Disposal
- 80-90% of municipality's SWM budget is drained towards SW collection services alone in developing countries
- Despite such high spending, waste collection is lower due to various inefficiencies: weaker management & supervision of collection etc.
- Landfill disposal costs is $5/ton - $25/ton for low-income countries & $15/ton - $30/ton for middle-income countries

Cost of Solid Waste Management is Increasing too!

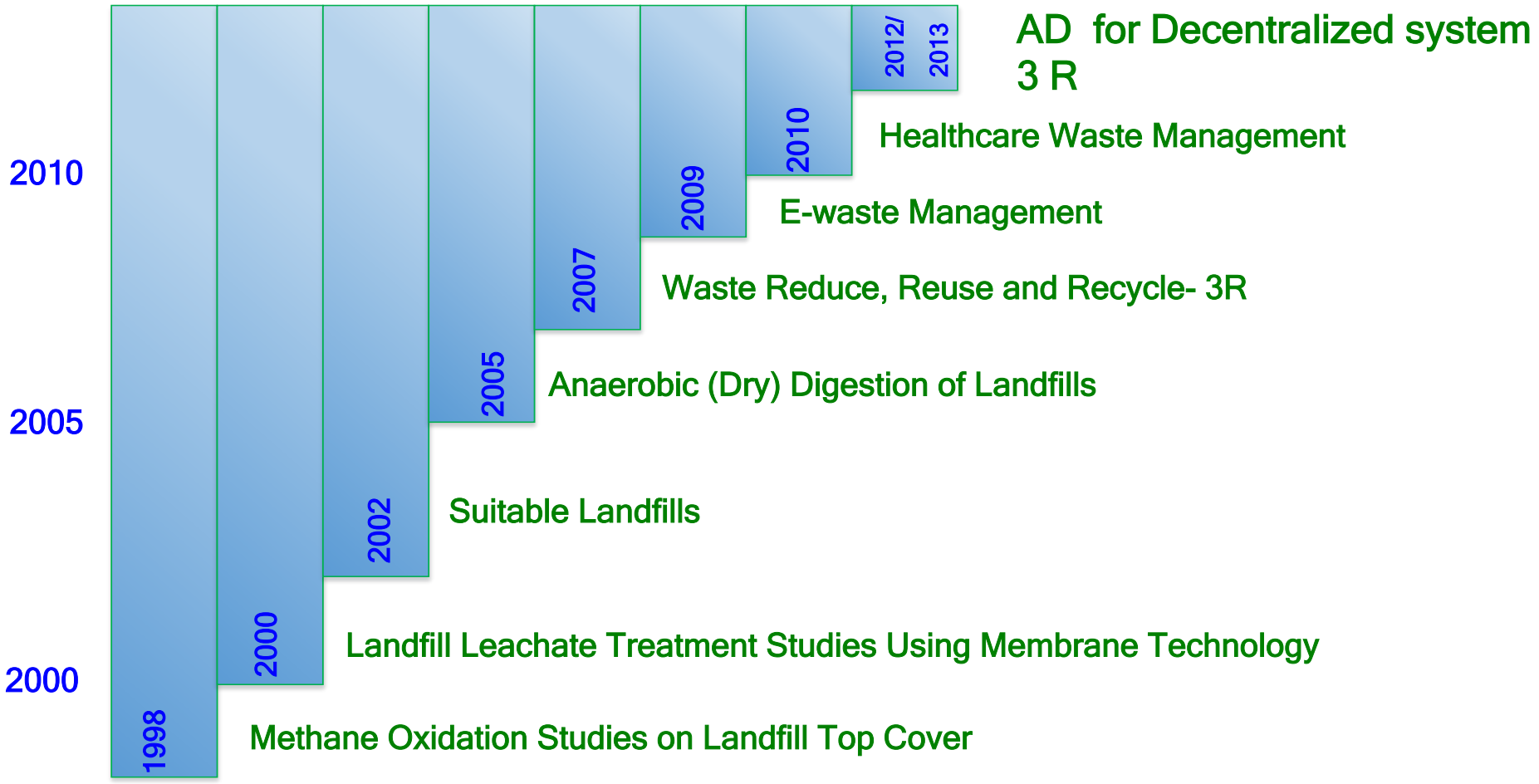
MSW Disposal Worldwide



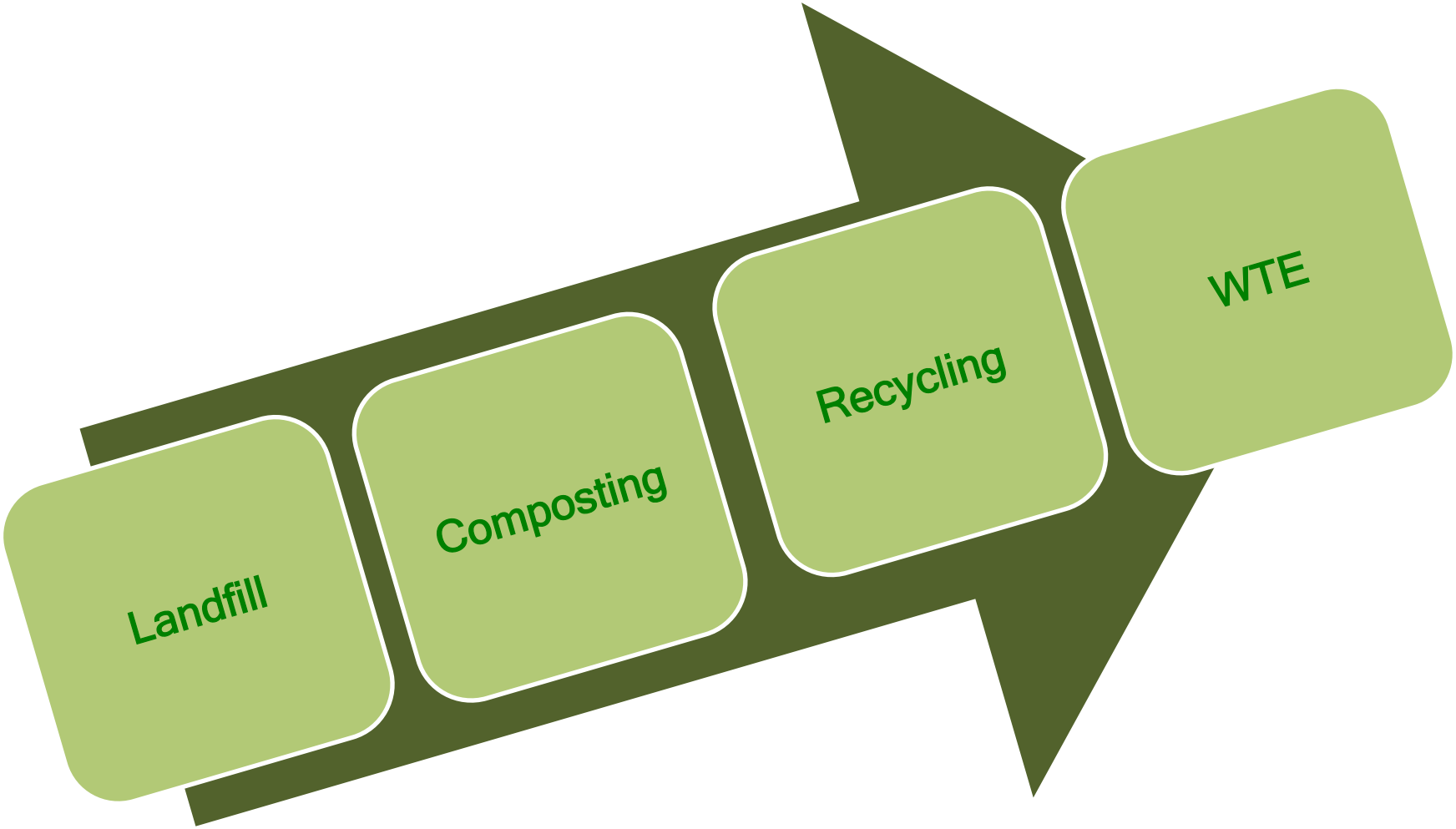
Most Asian towns & cities use open dumps & only about 10% of solid waste ends up in properly engineered & managed landfill sites

Landfilling does not solve the problem. It accumulates it one place

SWM Technology Development Trends – in AIT



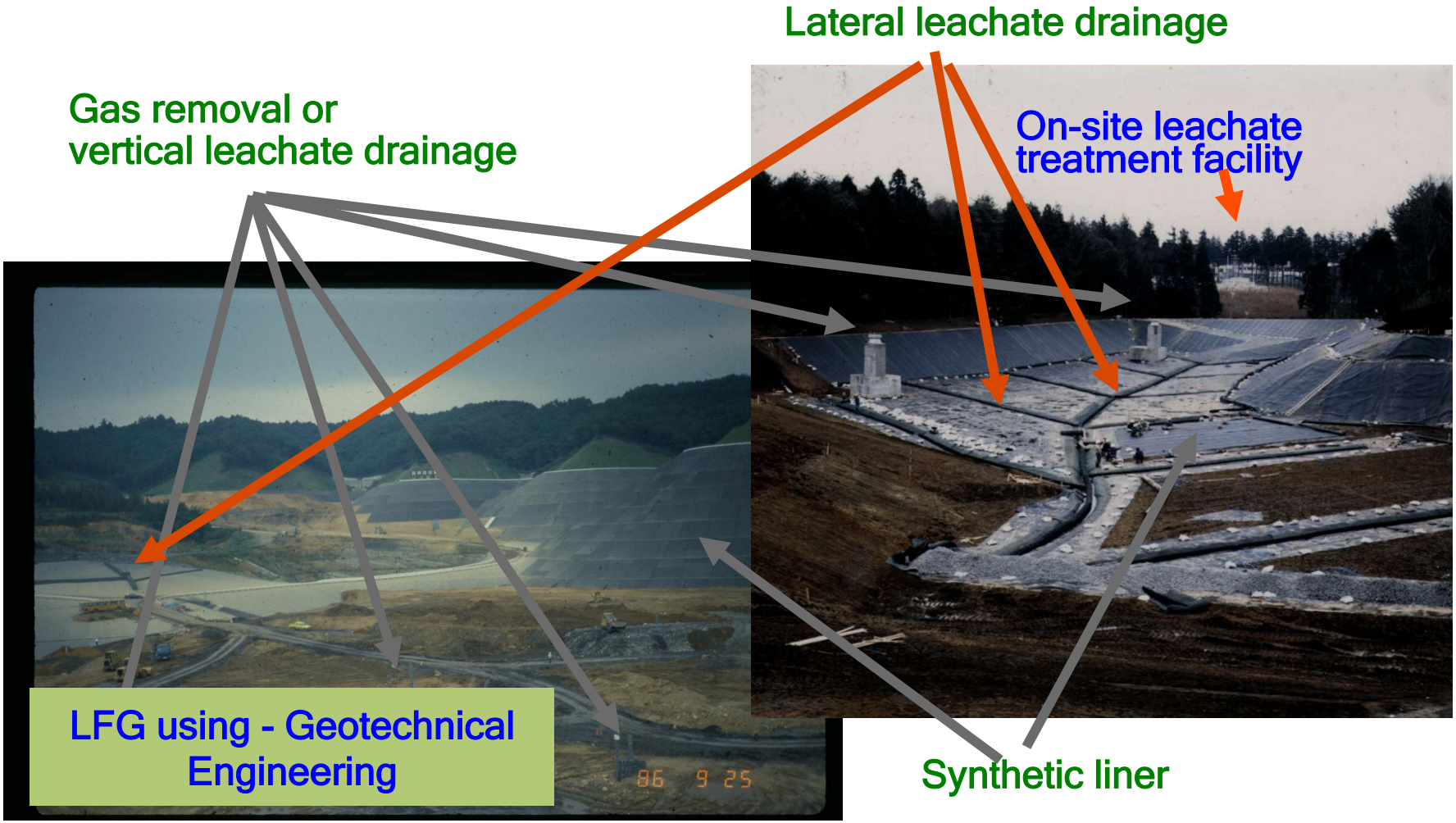
Technology Advancements



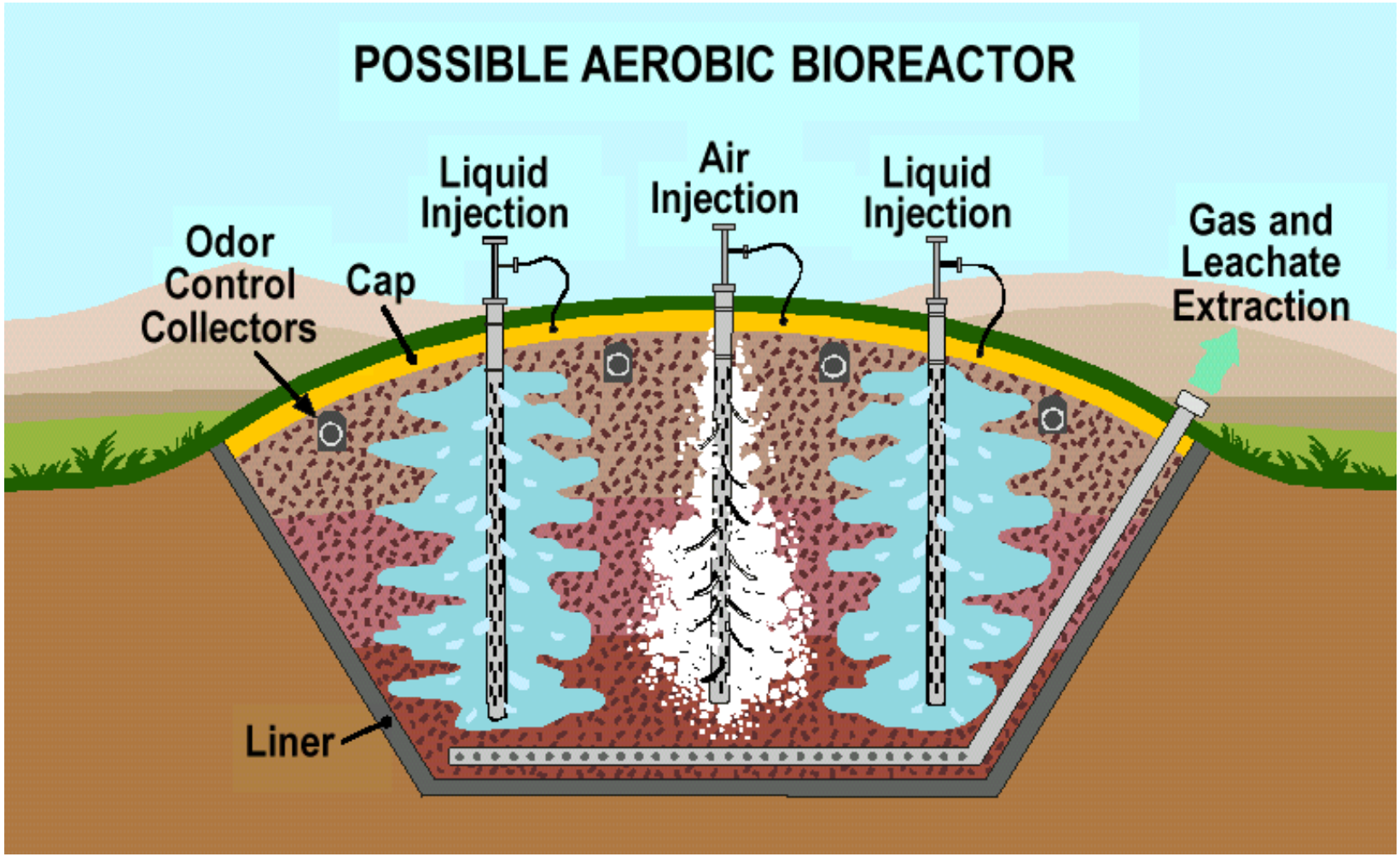
Landfill

- Landfill
  - Conventional methods
  - Advance transportation and storage
  - Landfill gas capture

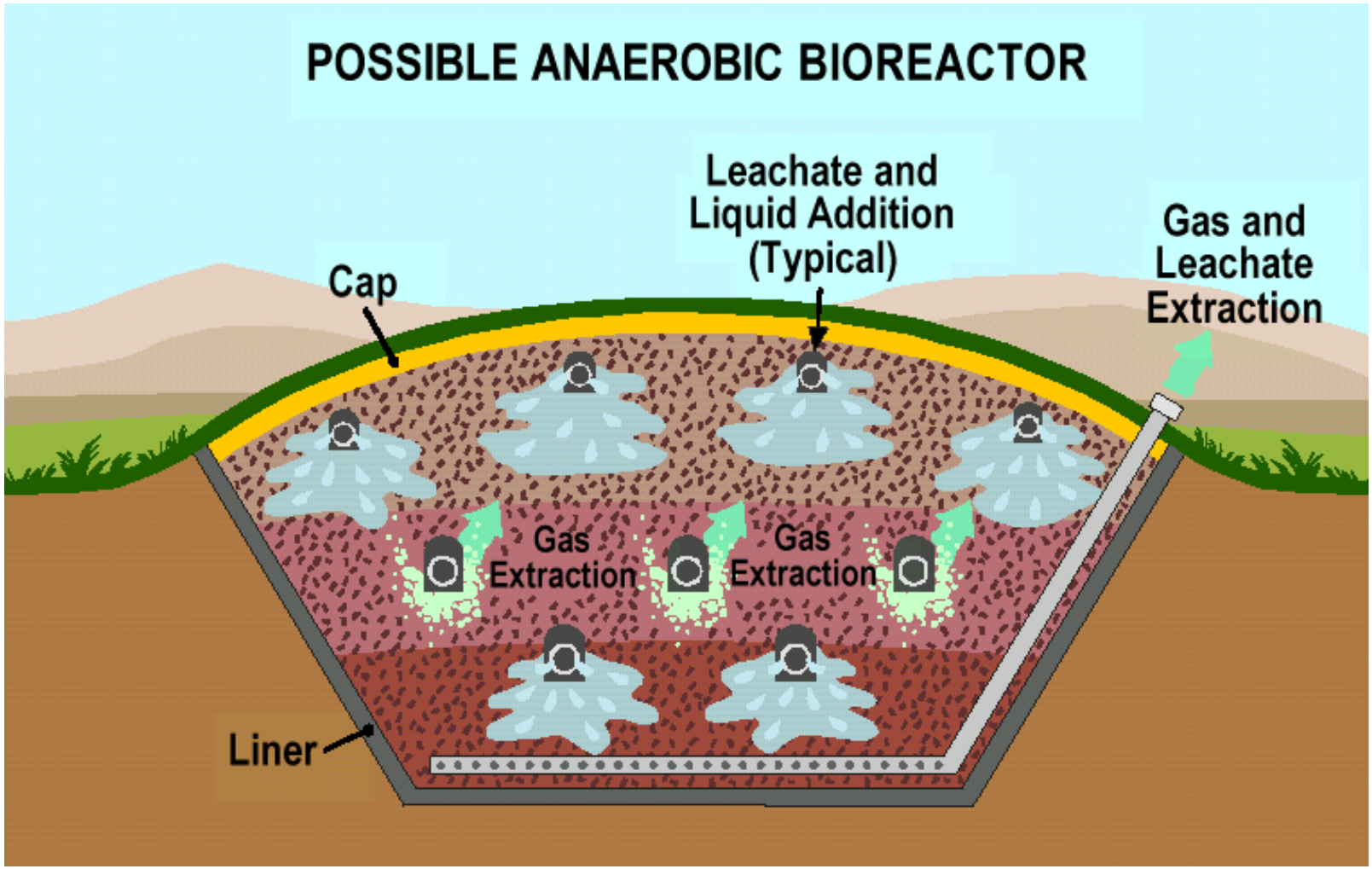
Dump Sites to Engineered Landfill



Dump Site to Bioreactor Landfill



Bioreactor Landfill

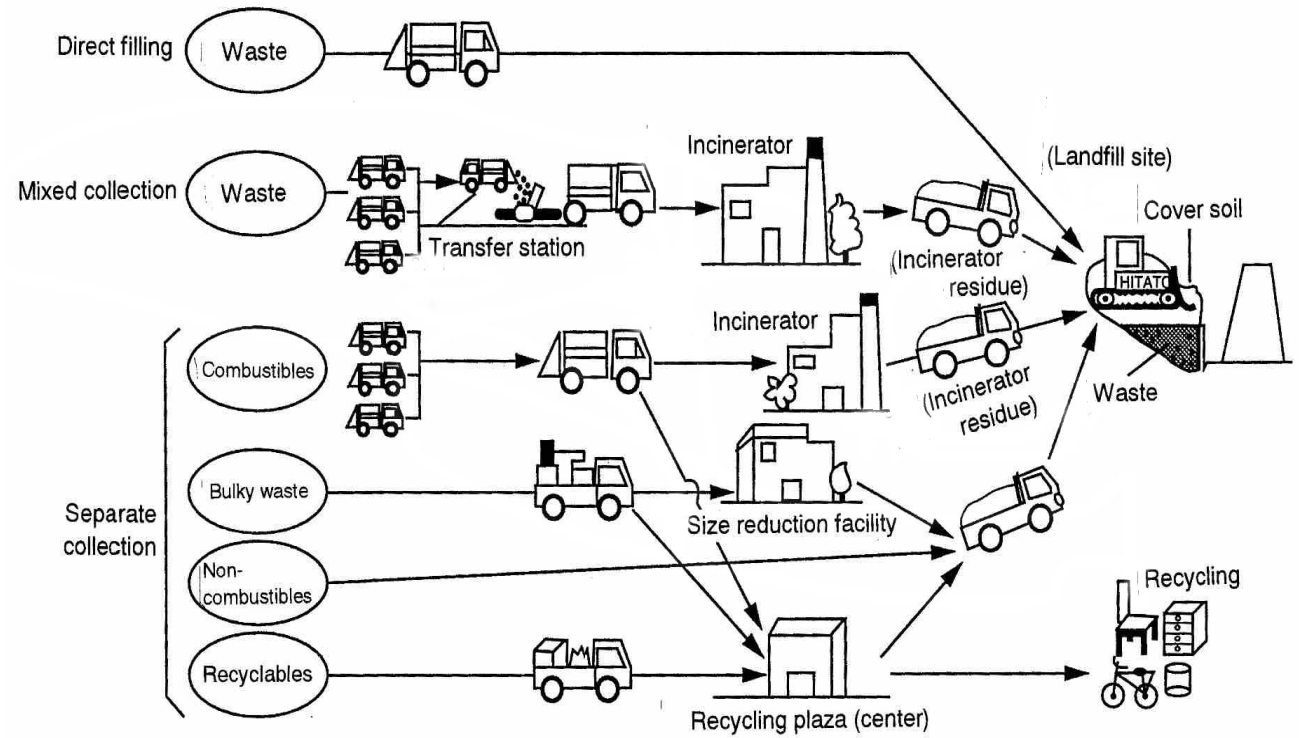


Composting

- Composting
  - Windrow composting
  - Bio drying

Recycling

- Recycling
  - Destructive
  - Reuse



Plastic and Tyres are emerging streams with great potential

Recycling Efforts in HDB Units

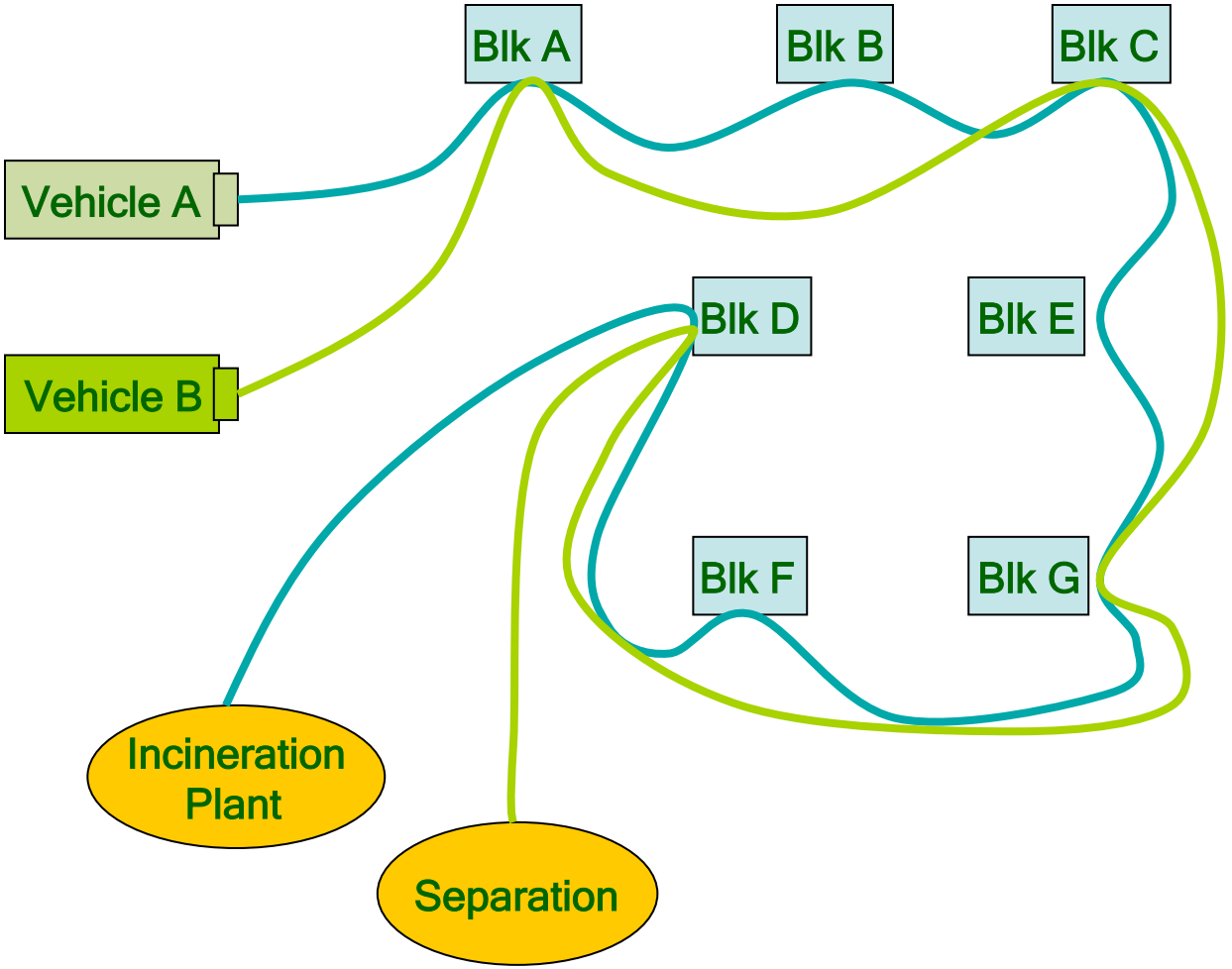
Recyclables collection

Bring through staircase

Recycling Efforts in HDB Units

Separate Rear Loader Vehicles are Used for Collecting Recyclables

Segregated Waste Stream Collection




09.24 09:14


RECYCLING BIN
ALUMINIUM CANS ONLY
RECYCLING BIN
GLASS CONTAINERS ONLY
LITTER BIN
NON-RECYCLABLE LITTER ONLY


11.07 08:58

Raw Recyclables Stored in MRF


11 5 2004


FERROUS
MIXED PLASTICS
ALUMINIU

Waste Recycling Technologies will Drive the Waste Management

Segregated Waste is a Resource not a Problem: Waste Management is driven by Recycling Technology Developers

Global WTE Facility in 2010

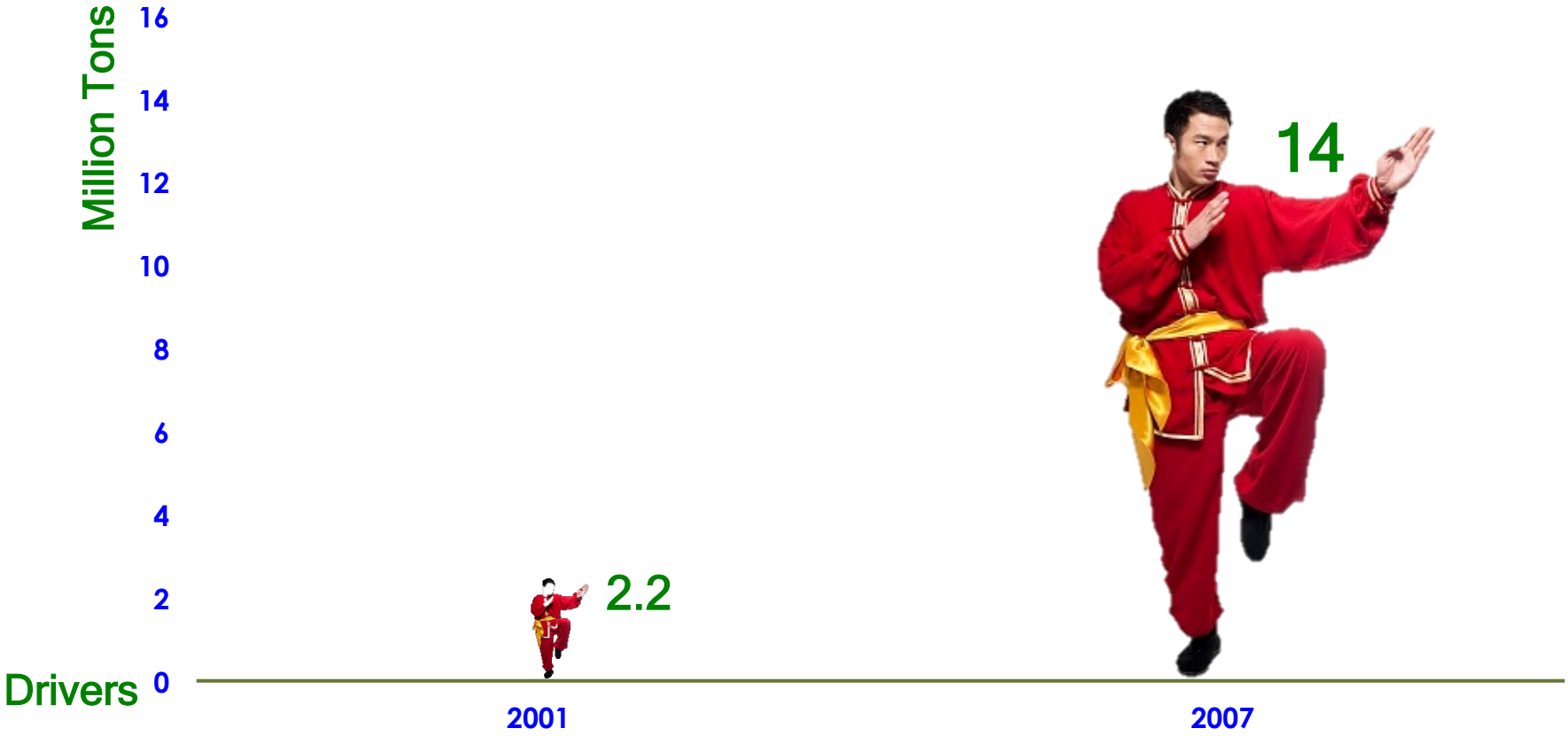
Japan : 700
Taiwan : 24
Korea : 26
Singapore : 4
2
China : 7

Others : 538

Global trend is moving towards WTE

Source: Waste to Energy: Technologies & Project Implementation
Rogoff & Screve, Elsevier Publication, 2011

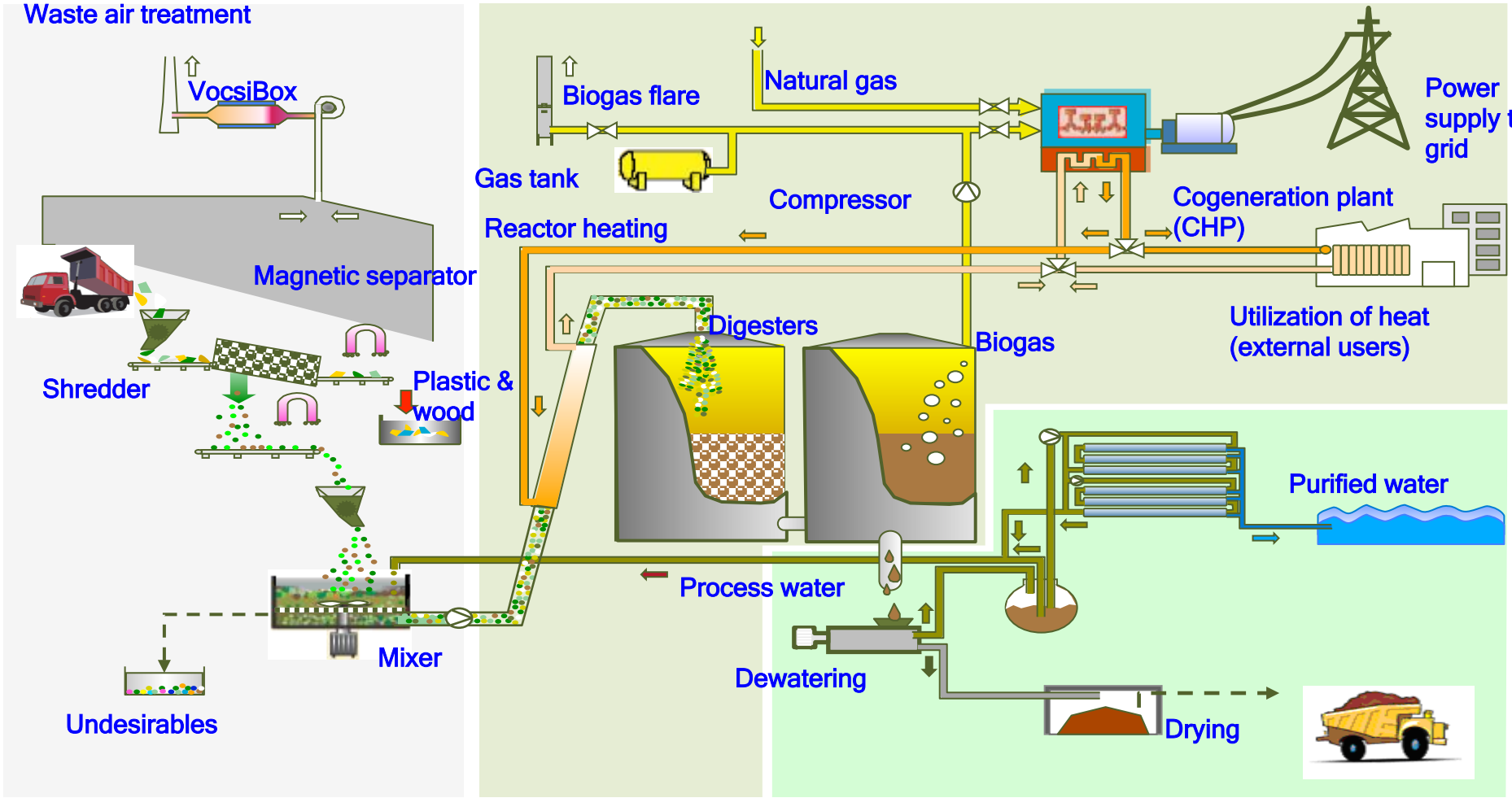
Largest Recent WTE Market: China



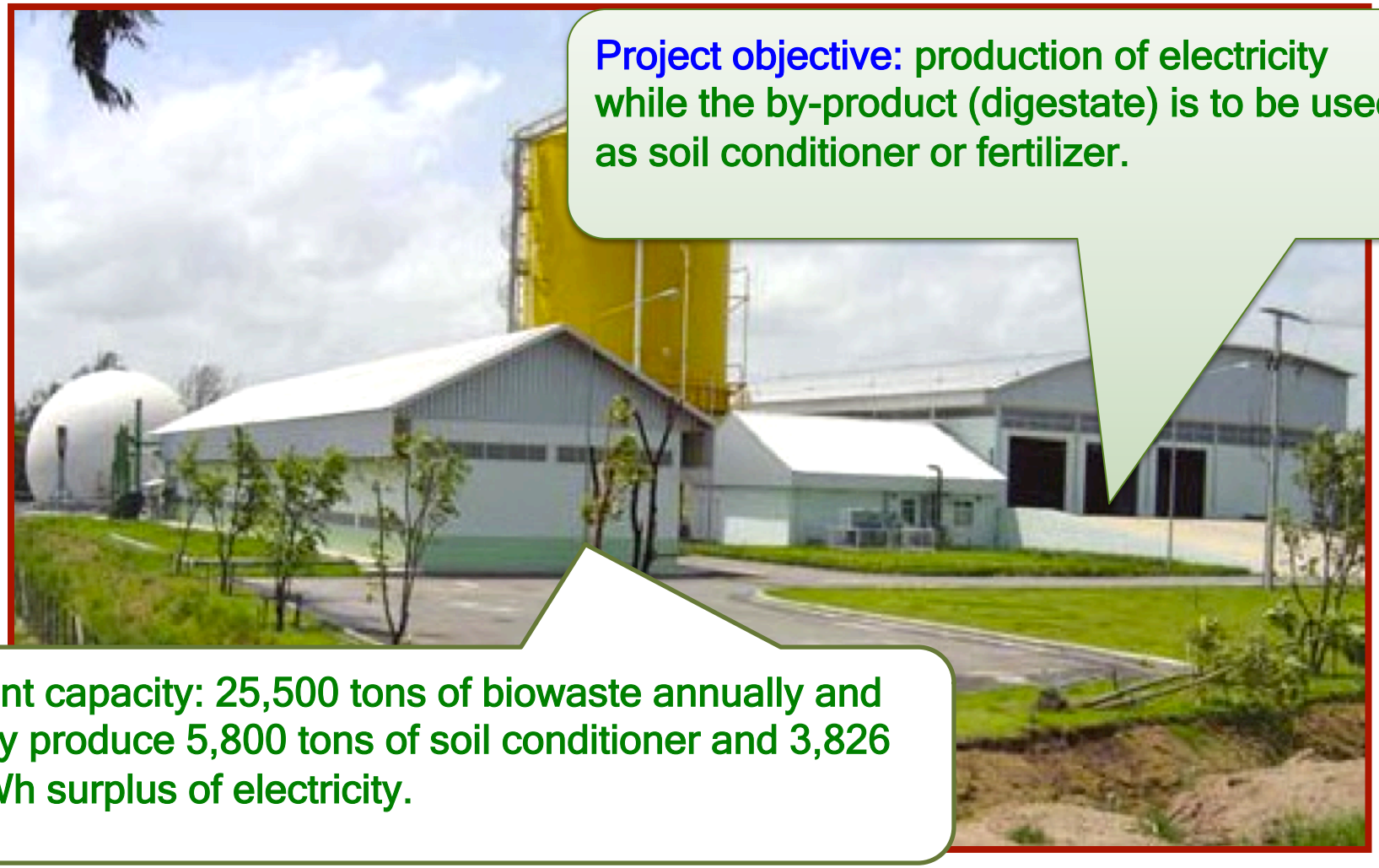
- Proactive Government Policy to Promote WTE
- Energy Price & Sources: Renewable Energy

Source: Waste to Energy: Technologies & Project Implementation Rogoff & Screve, Elsevier Publication, 2011

Anaerobic Digestion



Waste to Energy and Fertilizer Project (Rayong, Thailand)



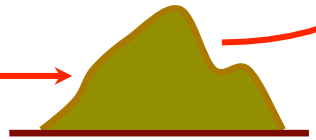
Project objective: production of electricity while the by-product (digestate) is to be used as soil conditioner or fertilizer.

Plant capacity: 25,500 tons of biowaste annually and may produce 5,800 tons of soil conditioner and 3,826 MWh surplus of electricity.

Where is the Gas Storage?

Solid Waste Management- Decentralized Integrated Anaerobic-Aerobic Treatment of OFMSW


Waste delivery


OFMSW


Shredder



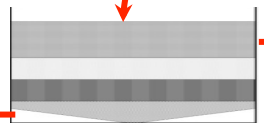
Inoculation and mixing tank


Organic waste

Liquid digestate

Biogas


Gas holder


Dewatering (drying bed)

Solid digestate


Heating System


Compost


Composting


Power Grid


Generator

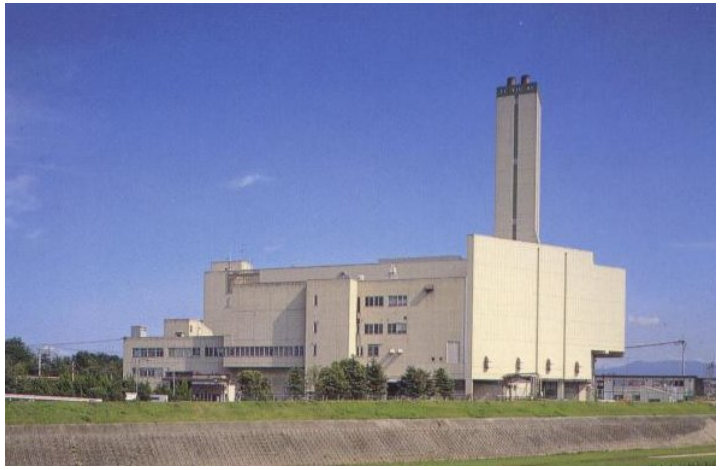

Gas Engine

Solid Waste Management-
The Unit Operated at the Research Station, AIT

Synova Power

Technological research and development done at AIT is currently being used and ventured into for industrial purposes (WTE)

Incineration



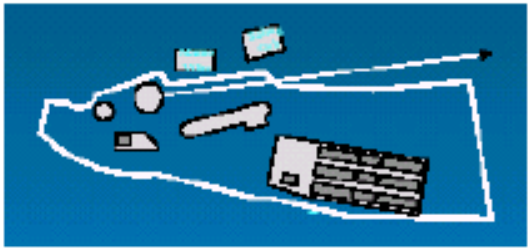
Wastewater Management

Current Wastewater Technologies

- Current technology is well established.
- It's a reactive step towards solving environmental problems
- National standards were established in view of these technology
- But do they meet the NATURAL STANDARDS ?

Driver: Small and Compact – Decentralised WTPs

Membrane Wastewater Treatment vs Conventional

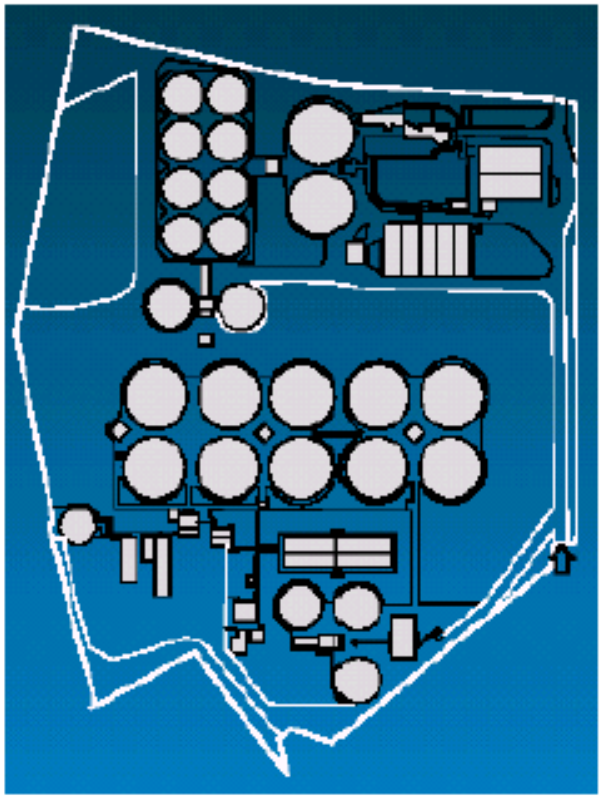


Swanage (28000 pe) - 0.7 ha

Membrane Bioreactor

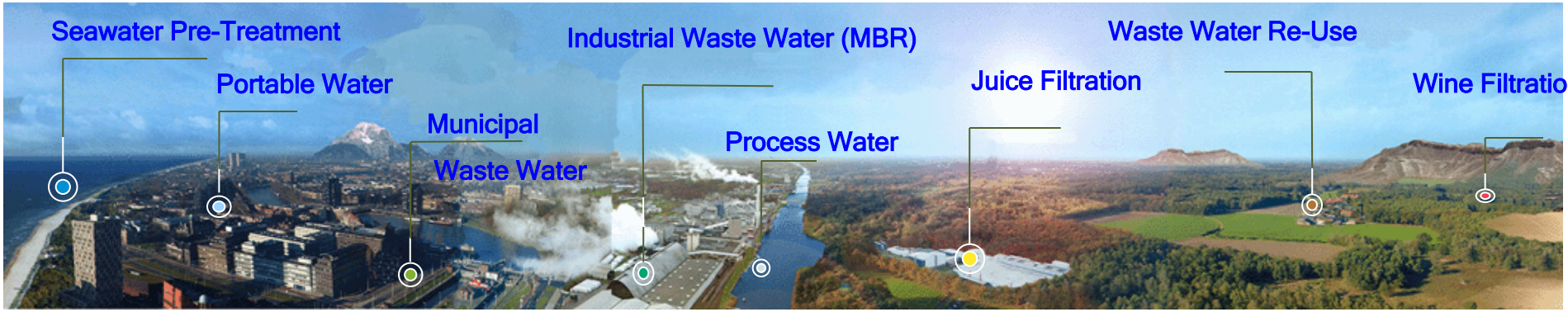
Compact treatment systems is the driver for WWT

Scale: 200 m



Glastonbury (30000 pe) - 4.5 ha

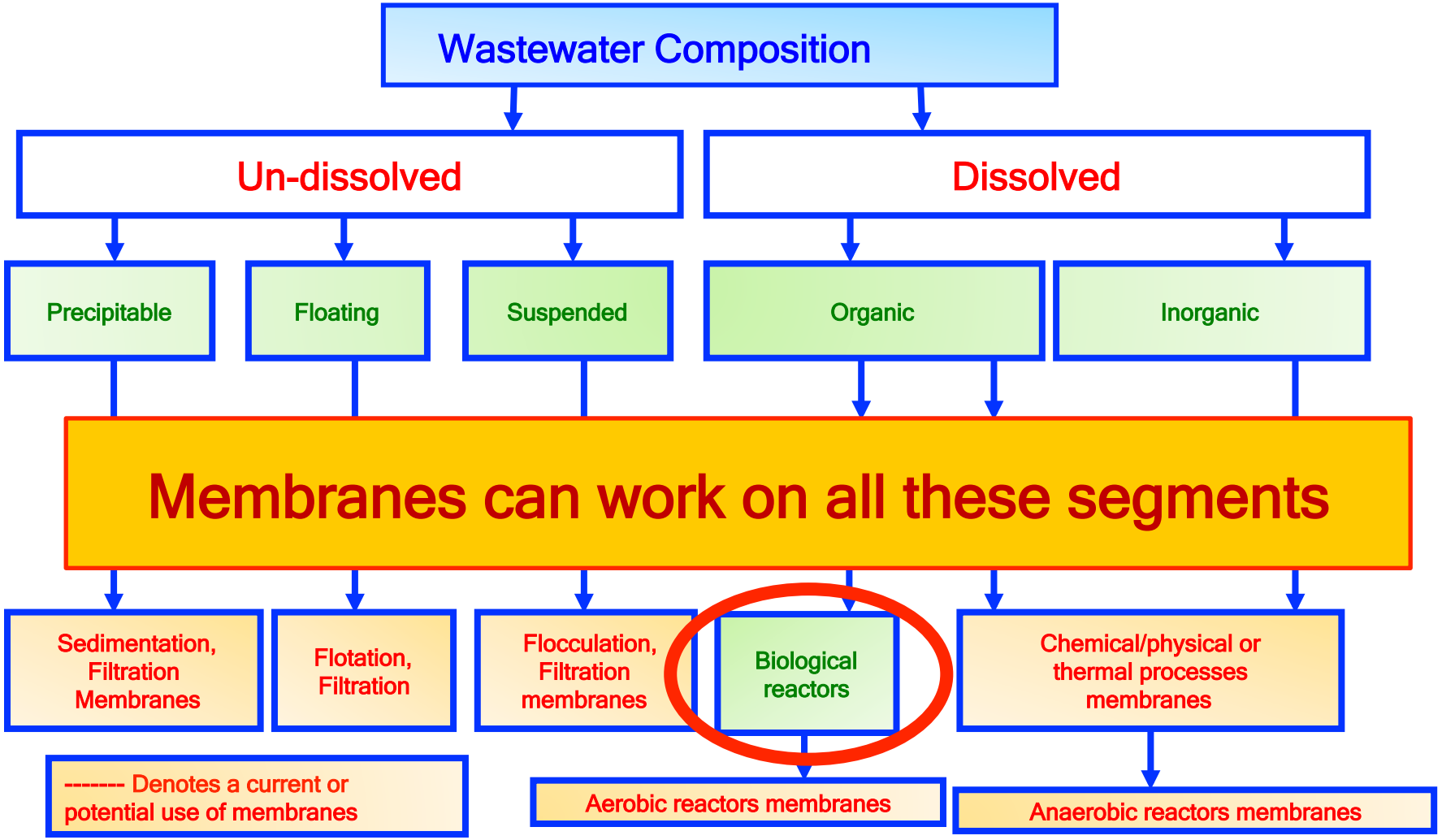
Purification



Common Element: Membrane Technology

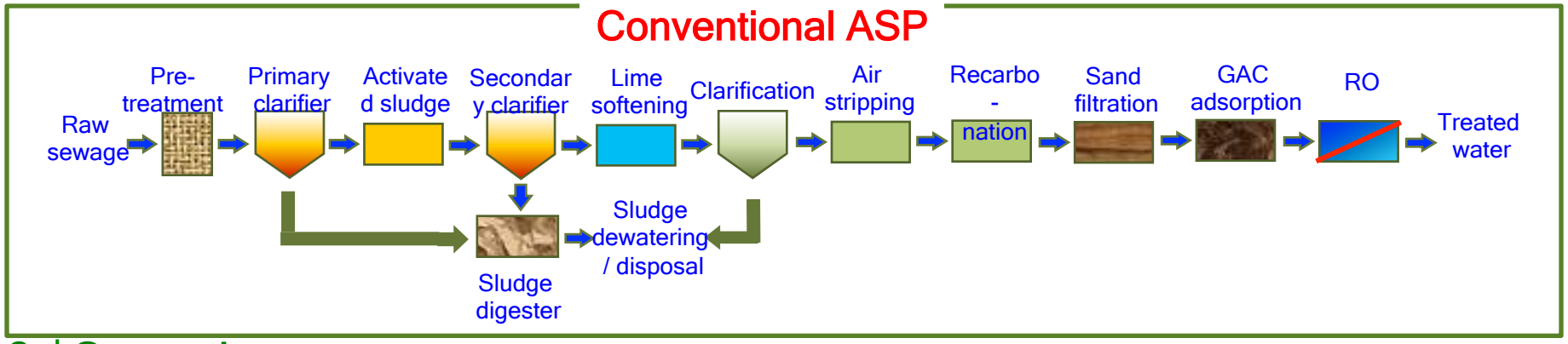
All over the world

Criteria for Choice of Wastewater Treatment Technologies

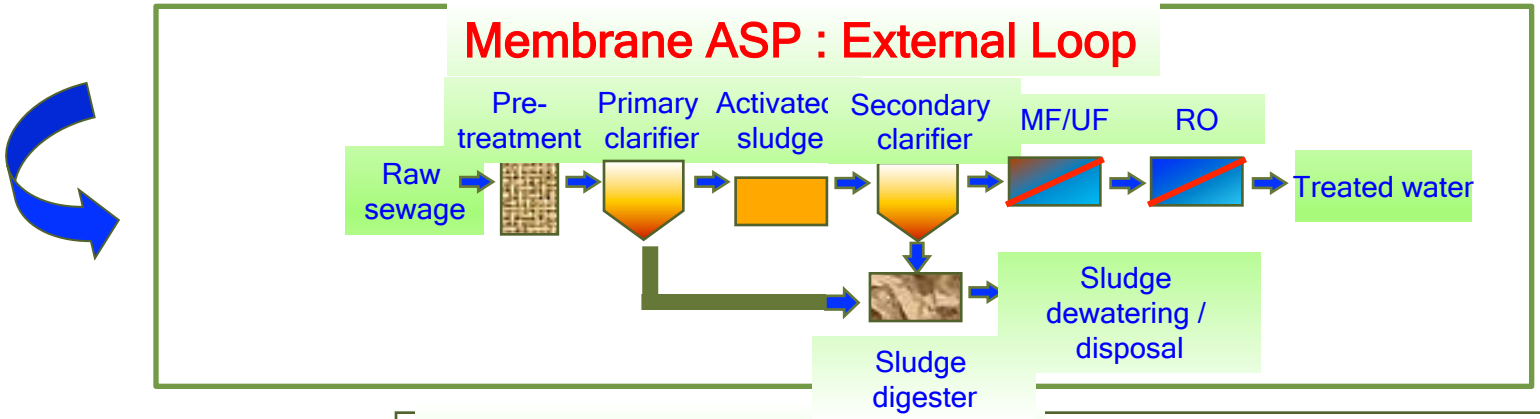


Conventional & Membrane Biological Process

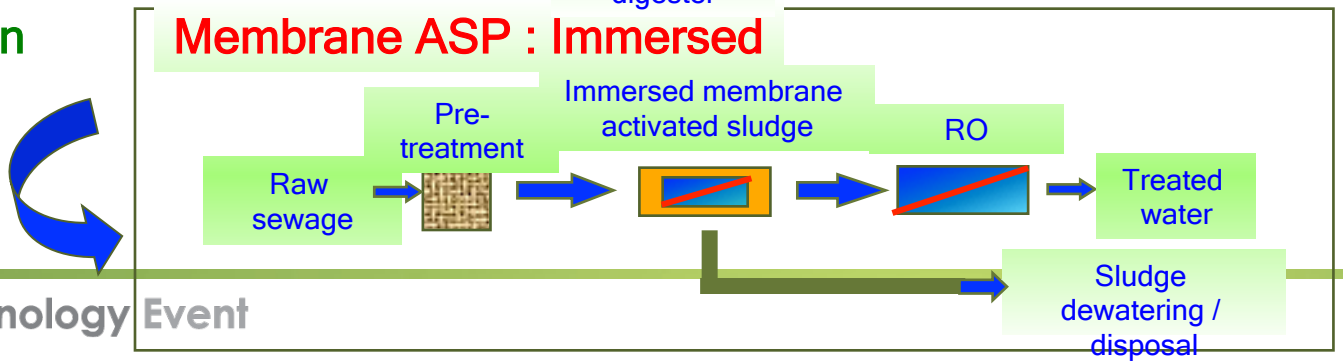
1st Generation



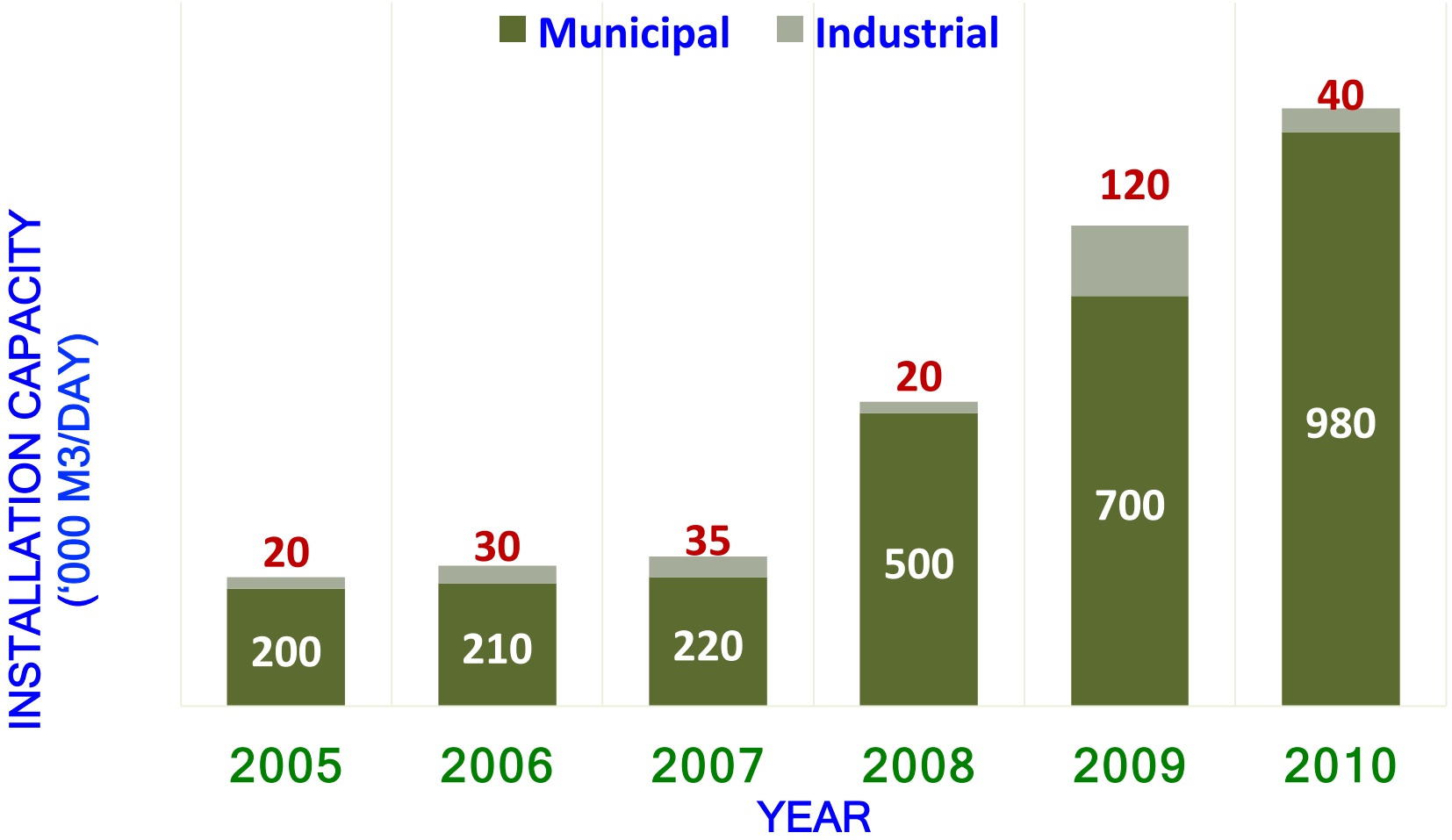
2nd Generation



3rd Generation

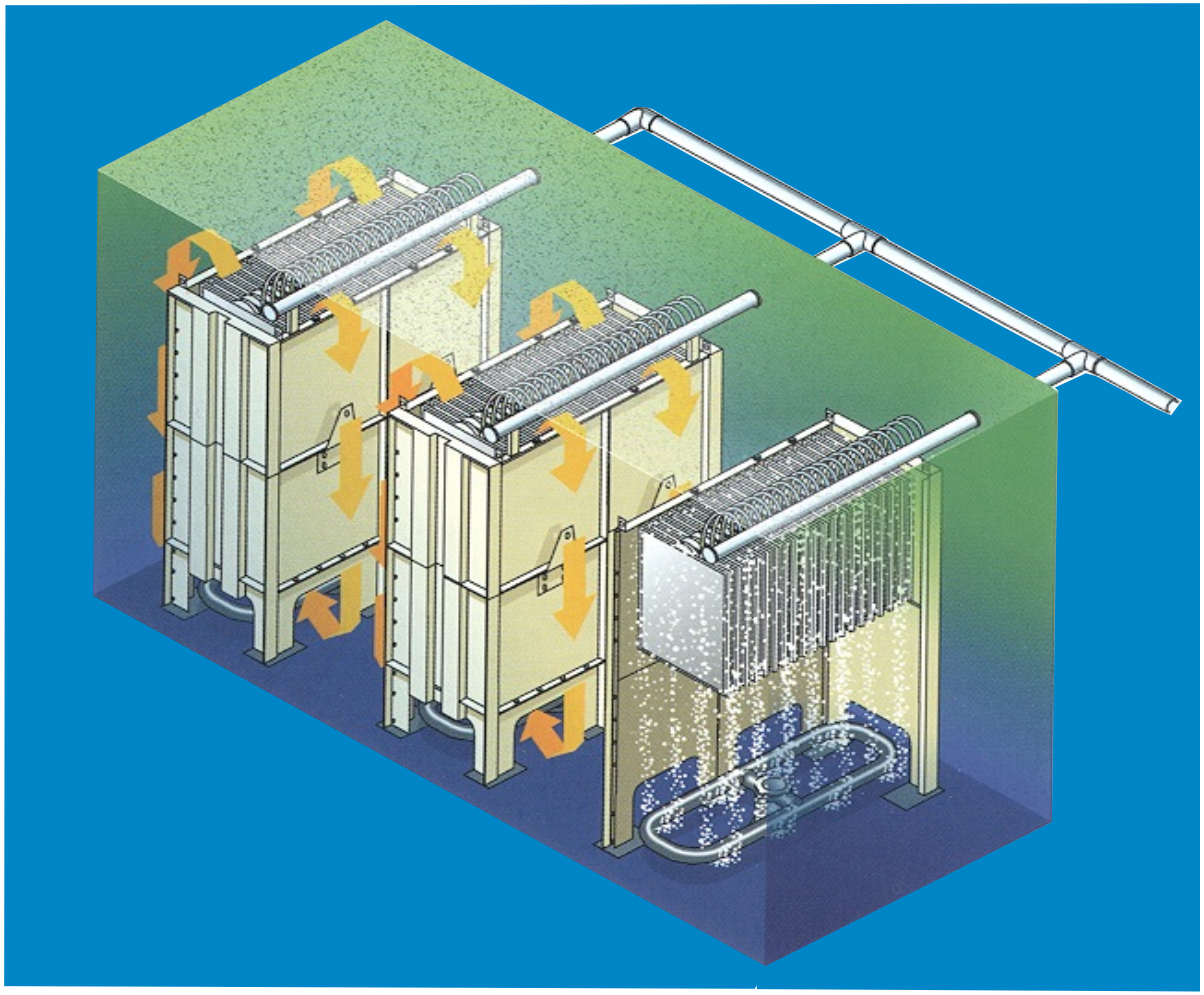


MBR Market: Market Evolution of MBR Systems in Municipal and Industrial End-user Segments by Installed Capacity



(China), 2005-2010

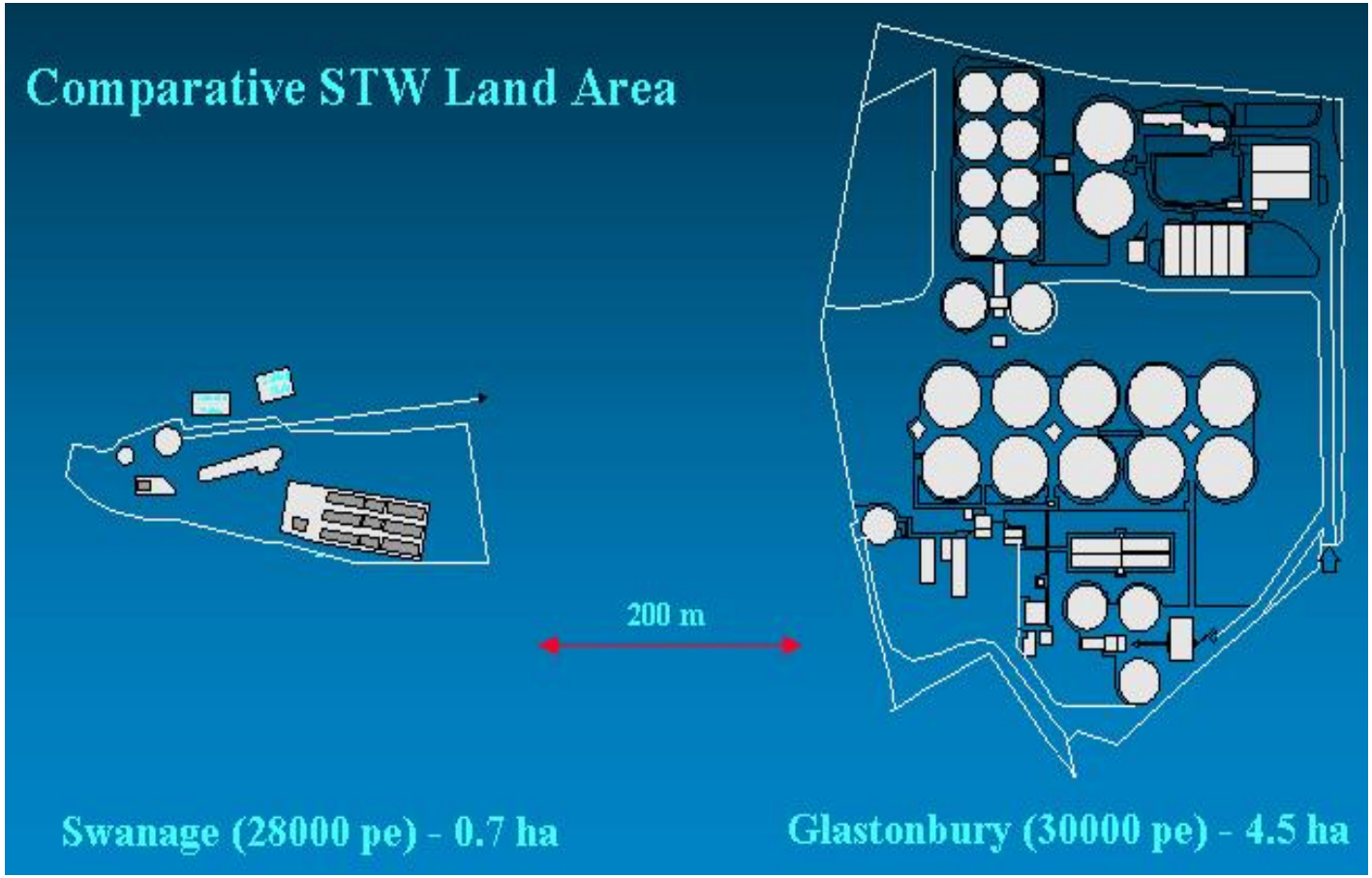
Kubota Process – Schematic Operation



Swanage Site and Outfall

Swanage Site and Outfall

Swanage STW


Comparative STW Land Area
200 m
Swanage (28000 pe) - 0.7 ha
Glastonbury (30000 pe) - 4.5 ha

Plug and Play Membrane Module from MBR

Case Study on MBR : Retrofit of SBR

Lone Tree Water Treatment Plant (Englewood, Colorado, USA)

Evolution of MBR

Time	Event	Technology

1960s

- ✔ Dorr Oliver develops first MBR

1970s

- ✔ Thetford-systems (ZENON) commercializes Cycle-Let for water reuse in USA

1980s

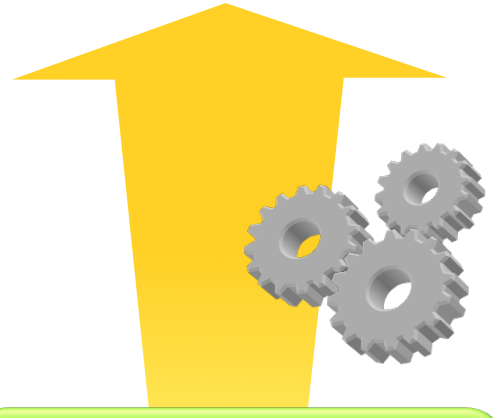
- ✔ University of Tokyo experiments with hollow fibre MBR
- ✔ Nitto-Denko files a Japanese patent on a immersed MBR
- ✔ TechSep (Rhone-Pounlence) commercializes PLELIADE for water reuse in Japan

1990s

- ✔ Zenon commercializes Zeeweed® in North America and Europe
- ✔ Mitsubishi Rayon commercializes an MBR in Japan
- ✔ Kubota commercializes an MBR in Japan

2000s

- ✔ Mitsubishi Rayon replaces their fine hollow with a braid based HF membrane (ZeeWeed®)
- ✔ Toray introduces a copy-like version of kubota module
- ✔ Kolon and Para (Korea) introduce copies similar of ZeeWeed®
- ✔ Puron (Germany) introduces a copy-like version of ZeeWeed®
- ✔ USF commercializes Memjet



- Immersed reinforced and unsupported hollow fibre
- Immersed Flat sheet/ hollow fibre
- Pressurized Tubular Membrane
- Pressurized Flat Sheet

Generation of Immersed MBR

1990-1995
Decentral & small WWTPs

- ✔ <5,000 PE,< 1,500 m^3/d, < 0.5 MGD
- ✔ No/little pretreatment
- ✔ Long HRTs (>24 h)
- ✔ High SRTs(up to 50d)
- ✔ High TSS (15-25 g/L)
- ✔ Low design (< 15 L/(m^2h))
- ✔ External manual membrane cleaning or CIP cleaning

1996-2000
Small to Midsize WWTPs

- ✔ <30,000 PE, <9,500 m^3/d, <2.5 MGD
- ✔ First fine screening
- ✔ HRTs 12 h and less
- ✔ SRTs (around 25 d)
- ✔ TSS (12-16 g/L)
- ✔ Design flux (16-25l/(m^2h))
- ✔ In-situ Maintenance, ex-situ recovery cleaning

2001-2005
Midsize to Large WWTPs

- ✔ <100,000 PE, < 37,800 m^3/d, <10 MGD
- ✔ Fine screens
- ✔ Enhanced biological MBR design
- ✔ Flux design acc. To hydraulic case study (up to 30-40 l(m^2h peak)
- ✔ Fully automated membrane train cleaning
- ✔ Low energy consumption (< 1kWh/m^3)

2006-today
Large WWTP

- ✔ > 100,000 PE, >37, 800 m^3/d, >10 MGD up to 100 MGD
- ✔ Fine screens
- ✔ Huge cassettes (“D or Double D”)
- ✔ Flux design acc. to hydraulic case study (up to 30-40 l/(m^2h) peak)
- ✔ Fully automated membrane train cleaning
- ✔ Low energy consumption (< 0.5 kWh/m^3)

Remarks: PE = people, MGD = mega gallon per day

Comparison of Energy Consumption

MBR: application of aeration and vacuum

1 kWh/m^3
Before 2000s

MBR: Cross flow

3-6 kWh/m^3

1960-1980

Biological WWT

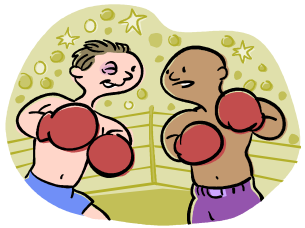
Competitive

Now

< 0.5 kWh/m^3

Municipal WW: 0.4-0.8 kWh/m^3

Industrial WW: upto several kWh/m^3



Increasing Module & Cassette Capacity with Time

An example: ZeeWeed®

ZW-145
13 m^2

ZW-150
14 m^2

ZW-500a
46 m^2

ZW-500c
23 m^2

ZW-500d
32 m^2

1993

2008

ZW150-12M
Cassette
168 m^2

ZW500A-8M
Cassette
370 m^2

ZW500C-22M
Cassette
510 m^2

ZW500D-48M
Cassette
1520 m^2

Relation of Density/Treatment Capacity and Price

An example: ZeeWeed®

ZW-500a(1997)

Packing density 153 m^2/m^3
Avg.Daily Flux 20L/ m^2/h
Capacity 180 m^3/d

ZW-500c(2000)

Packing density 183 m^2/m^3
Avg.Daily Flux 22L/m^2/h
Capacity 270 m^3/d

ZW-500d(2003)

Packing density 162 m^2/m^3
Avg.Daily Flux 22 L/ m^2/h
Capacity 800 m^3/d

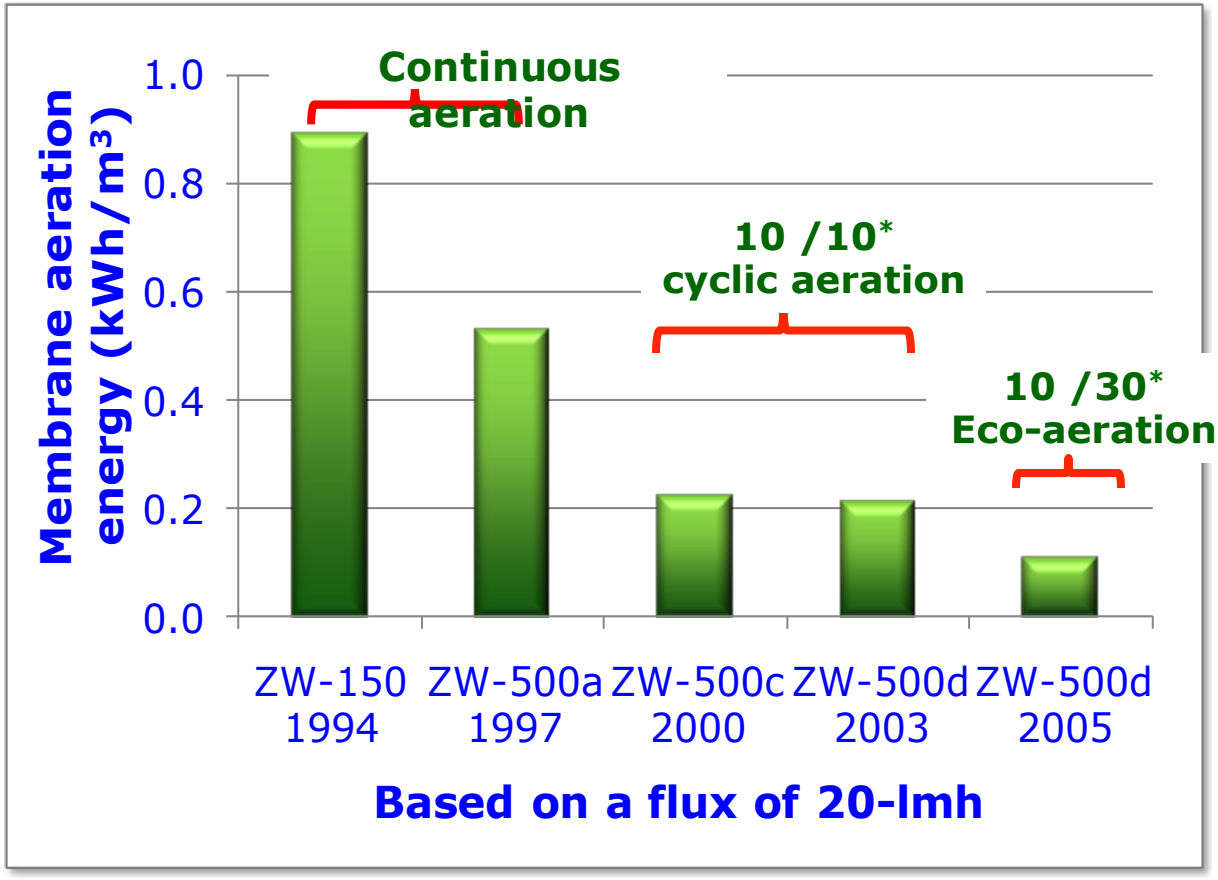
ZW-500d(2008)

Packing density 162 m2/m3
Avg.Daily Flux 27 L/ m2/h
Capacity 960 m3/d

Increasing Performance

Decreasing $ /m^3

Evolution of Energy Reduction through Aeration Strategy



Moreover, cyclic aeration

- ✔ Eliminate dead zone due to tank hydraulics
- ✔ Prevent air from penetrating fibre bundle
- ✔ Better solid accumulation on membrane

Remarks: a/b* mean filtration cycle a seconds on and b seconds off

Application of Membrane Bioreactor (MBR) in Caravelle Hotel, Ho Chi Minh City

Twenty-six-storey hotel with;

- 355 rooms, 3 restaurants, 1 canteen, 6 large meeting-halls, 7 small meeting-halls.

Water consumption: 350 m^3/day

- Water for living rooms: 200 m^3/d
- Water for restaurants, canteen: 135 m^3/d
- Water or staff and employees: 15 m^3/d

The quantity of waste water approximately equals to the quantity of supply water

- ✓ When the hotel construct (1997) effluent quality standards were not so stringent (TCVN 5945-1995 / level C)
- ✓ So only simple treatments were built and operated to meet the effluent standers

Space for New Treatment Units

Due to the limited space, part of the car-park was used to build the wastewater treatment plant

This space has an area of:

4.7 m x 14.8 m = 69.56 m^2
car-park height = 2.5 m
(With an area of 70 m^2)

New treatment plant consist of

- Anoxic tank
- Aeration tank
- Membrane containing tank
- Chemical tanks
- Oil removing tank
- Equipment room
- Electrical control cabinet

Aeration tanks constructed within the limited space

Compacted system within small available car park area

Operation and Performances

Item	Value
Energy consumption	28.95 kW/h
Chemical consumption	35L NaOCl 15 % / 5 days
Operator	1 worker
Operation cost	1000 VND / m^3

Before and after treatment

Parameter	Effluent	Standard
COD (mg/L)	≤10	-
BOD_5 (mg/L)	≤ 5	30
Turbidity (NTU)	≤ 1	-
TN (mg/L)	≤ 5	10
TP (mg/L)	≤ 4	10
pH	6 - 8	6 - 8

Conclusion

The Past

- AIT has 50 yrs. of experience in research and development of new and innovative technologies.
- Created world class knowledge base and collected experience not only from Thailand but all over Asia to develop the region.
- Worked hand in hand with industries to solve practical problems.

The Future

- Innovation is the heart of any good research.
- AIT has and will prefer to work with industries

Thank You

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