



# **Climate Change Challenges by the Paris Agreement**

## **and renewable energy application from waste**

# Overview

- Extreme winter weather and climate change
- Paris Agreement and Kyoto protocol
- Korea's Nationally Determined Contribution
- Reduction in Waste sector, green house gas
- Seoul's Waste manage and renewable energy
- Waste-to-energy, Landfill site Incheon (Seoul Metropolitan regional landfill)

- 
- **Extreme winter weather and climate change**

# Han river with ice



2018.01.29, Joonganglbo

# Niagara Falls,

on the border of New York and Ontario,(JAN., 2018)



<https://www.nbcnews.com/slideshow/frozen-niagara-falls-stuns-visitors-who-dare-brave-bitter-cold-n834276>

# Why is it So Cold?

-Climate Change May Be Part of the Answer -

- **The Arctic has warmed so much** — twice as fast in recent decades than other parts of the world — **when polar air descends to lower latitudes**, the cold snaps are warmer on average.
- <https://www.nytimes.com/2018/01/03/climate/cold-climate-change.html>
- World-renowned climate scientist Dr. Michael Mann explains **why the bitter cold and snowy conditions** gripping the US are “an example of precisely the sort of **extreme winter weather we expect because of climate change.**”
- <https://www.climaterealityproject.org/blog/perfect-storm-extreme-winter-weather-bitter-cold-and-climate-change>



# IPCC'S FIFTH ASSESSMENT REPORT

## OBSERVED CHANGES IN THE CLIMATE SYSTEM

- ❖ **Warming** of the **climate system**- unequivocal,
  - Since the 1950s, many of the **observed changes** are **unprecedented** over decades to millennia.
- ❖ The **atmosphere and ocean** have warmed.
- ❖ The amounts of **snow and ice** have **diminished**.
- ❖ Sea level has **risen**.
- ❖ The **concentrations of greenhouse gases** have **increased**.

# When Sea Levels Attack!

How long have we got?

years    sea level

8000    80m



8000 years



## TOTAL CONTRIBUTIONS

Antarctic ice sheet  
(South Pole)  
73m

1000    20m

8m

7m

400    6m

5m

300    4m

200    3m

2m

100    1m

Greenland ice sheet  
6.5m

New York    London    Taipei

800 years



Shanghai

Edinburgh

South London

New Orleans  
(lowest levee)

Los Angeles  
(Seafont)

San  
Francisco

Lower  
Manhattan

Hamburg

Saint  
Petersburg

Amsterdam

Venice

80 years



All other ice  
(Arctic included)  
0.5m

by 2100,  
worst case  
scenario: 1m

Already happened  
since 1870  
20cm

David McCandless // V3.0 // Feb 2014  
Illustration: Laura Sullivan, Joe Swainson, Fabio Bergamaschi

InformationIsBeautiful.net

Note:  
Heights above sea level  
vary across cities.  
Lowest points used

Source: IPCC, NASA,  
Realclimate.org,  
NewScientist.com,  
Potsdam institute,  
Sea Level Explorer





# **Paris Agreement and Kyoto protocol**

# PARIS(2015)

❖ attendance 50,000

- government, intergovernmental organisations, UN agencies, NGOs and civil societies. <http://www.cop21paris.org/about/cop21>



# PARIS AGREEMENT SUMMARY

## —Basic rules

- for the new climate change system **after 2020**
- Unlike the **1997 Kyoto Protocol** that obliged only **industrialized countries** to cut **greenhouse gas** emissions,
- The new climate pact makes it mandatory for **developing countries** to do so for the first time.
- The Paris accord sets a target of limiting global warming to **"well below" 2° degrees Celsius compared with the Industrial Revolution**,
  - with its even more ambitious goal set at 1.5 degrees.

# COMPARISONS BETWEEN KYOTO AND PARIS

<b>Kyoto Protocol</b>	<b>Paris Agreement</b>
<b>COP 3 JAPAN</b>	<b>COP21 FRANCE</b>
<b>Dec 1997</b>	<b>Dec 2015</b>
<b>37 Developed country</b>	<b>195 Developed and developing country</b>
<b>Until 2020</b>	

# COMPARE KYOTO AND PARIS

the aim of Annex I Parties  
**stabilizing their emissions at 1990 levels** by the year 2000  
(average 5.2% reduction)

**Holding the increase in the global average temperature** to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels,

As a result of more than 150 years of industrial activity,  
**the Protocol places a heavier burden on developed nations**

**Help developing nations** adapt more renewable sources of energy suggested mechanism that may provide funding

Kyoto mechanism

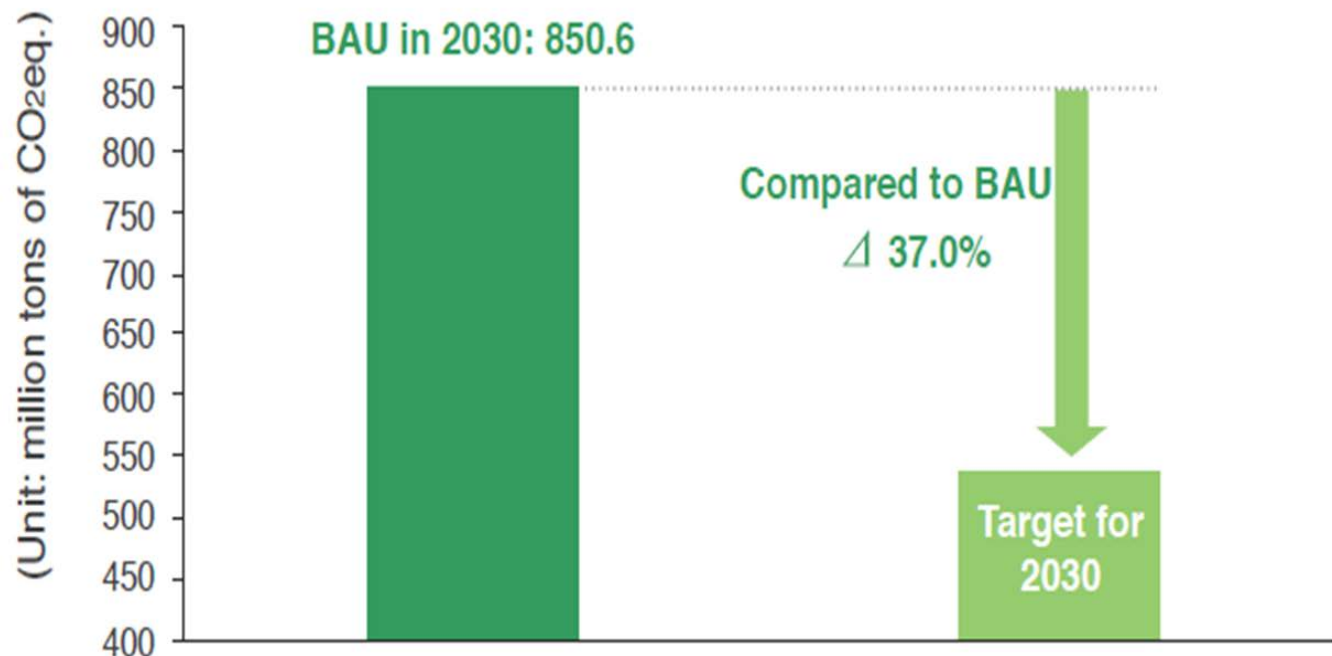
- 1) International Emissions Trading
- 2) Clean Development Mechanism
- 3) Joint implementation (JI)

The Paris Agreement entered into force on **4 November 2016**.

# ❖ Korea's Nationally Determined Contribution

# NATIONALLY DETERMINED CONTRIBUTION

- ❖ In June 2015, the determination was made **to cut GHG emissions by 37% from BAU— including domestic and overseas reductions using the International Market Mechanism (IMM)**—as its national GHG reduction target for 2030.

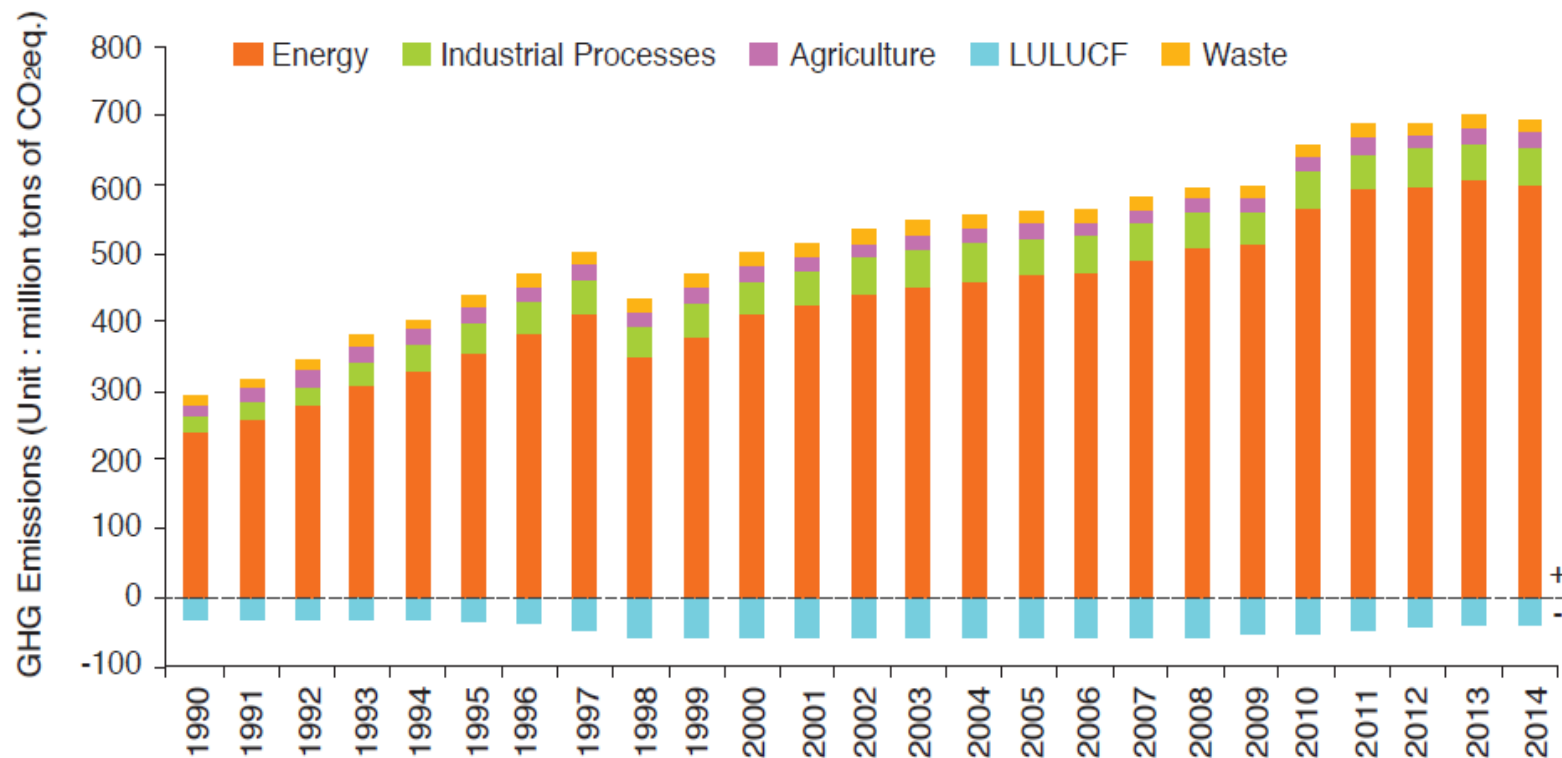




# NATIONAL GREENHOUSE GAS INVENTORY

- ❖ **Total GHG emissions in the ROK were 690.6 million tons of CO<sub>2</sub>eq.**
  - and net emissions including sinks were 648.1 million tons of CO<sub>2</sub>eq. in 2014.
- ❖ **Total emissions in 2014 declined by 0.8% from 2013**
  - attributed to the combined effects of less dependence on fossil fuel power plants for electricity generation, fewer livestock, **decreased volume of waste incineration**, and various GHG reduction policies implemented by the government.
- ❖ **Korea will gradually reduce our dependence on coal and nuclear power and plan to increase the share of renewable energy in our electricity generation mix to 20 percent by 2030.**

# Trends in National Greenhouse Gas Emissions and Removals (1990-2014)



# Waste sector

- Emissions from the Waste sector were **15.4 million tons of CO<sub>2</sub>eq.**
- In 2014, representing a **47.8% increase** from the 1990 level.
  - The major contributor of this emissions growth was the **Waste Incineration category that showed a 343.5% growth** from the increased volume of incinerated waste.
- However, emissions in 2014 for the Waste sector decreased by 3.3% compared to the previous year reflective of a 9.2% **emissions decrease from the Waste Incineration category.**
- In addition to the decreased volume in waste incineration, an increased volume of waste being directed to energy recovery also contributed **to the decrease in the Waste sector.**

- 
- **The reduction in Waste sector, green house gas**

# Solution

- **Waste minimization**

- is an approach that aims to reduce the production of waste through **education and the adoption of improved production processes** and less wasteful practices.

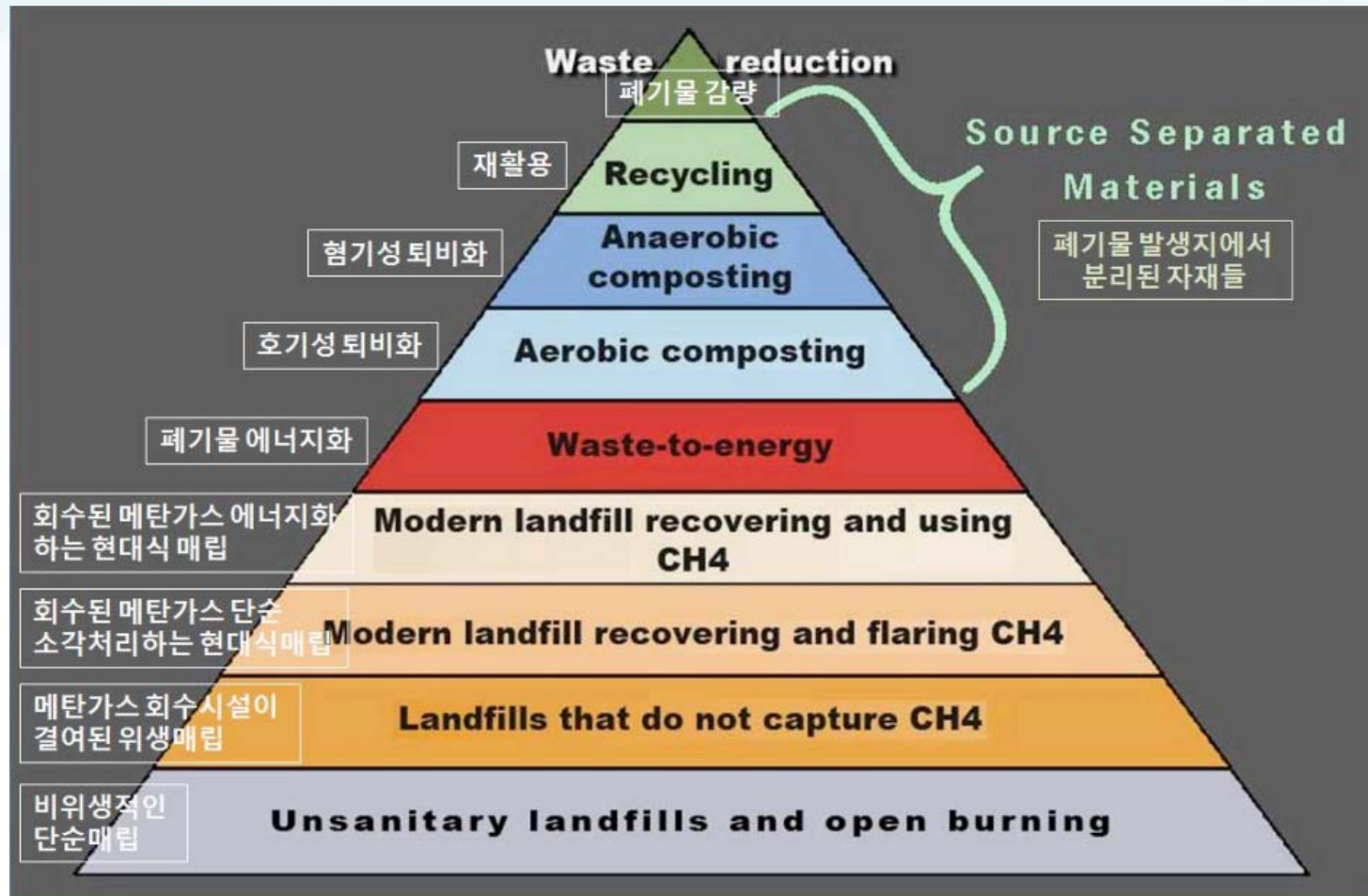
- **Recycling,**

- **by separating** certain materials within the waste stream and reprocessing them. Â The recycling of many materials is currently not financially viable.

- **Waste processing**

- is treatment and **recovery (use)** of materials or energy from waste through thermal, chemical, or biological means.

# HIERACHY OF WASTE MANAGEMENT

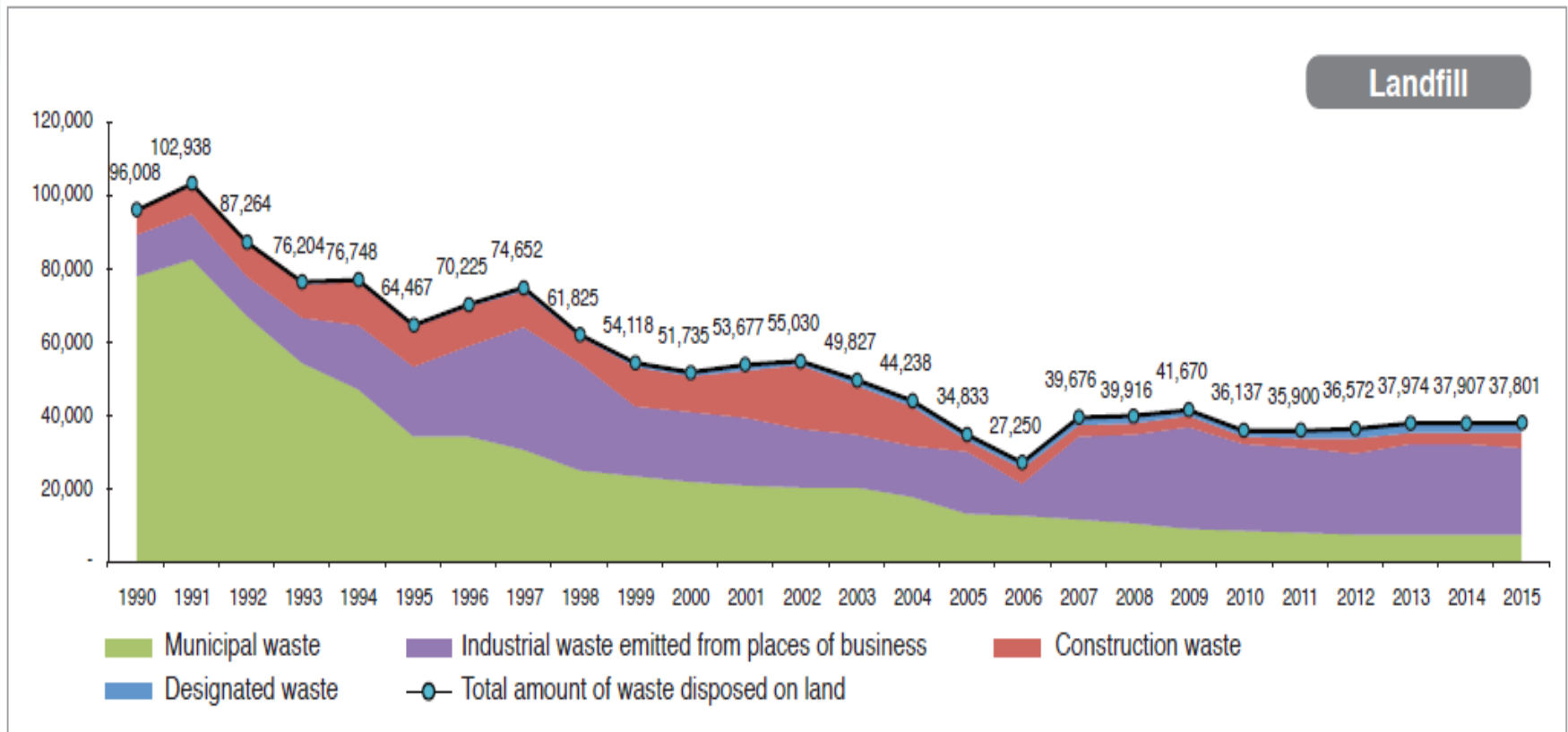


- Waste sector GHG emissions can be reduced by **creating a resource circulating society**
  - in which the input of natural resources and energy is minimized **by limiting the generation of waste** and encouraging waste recycling.
- Reducing waste generation and enhancing the rate of recycling
  - can **decrease landfill-use and incineration activities cutting GHG emissions.**



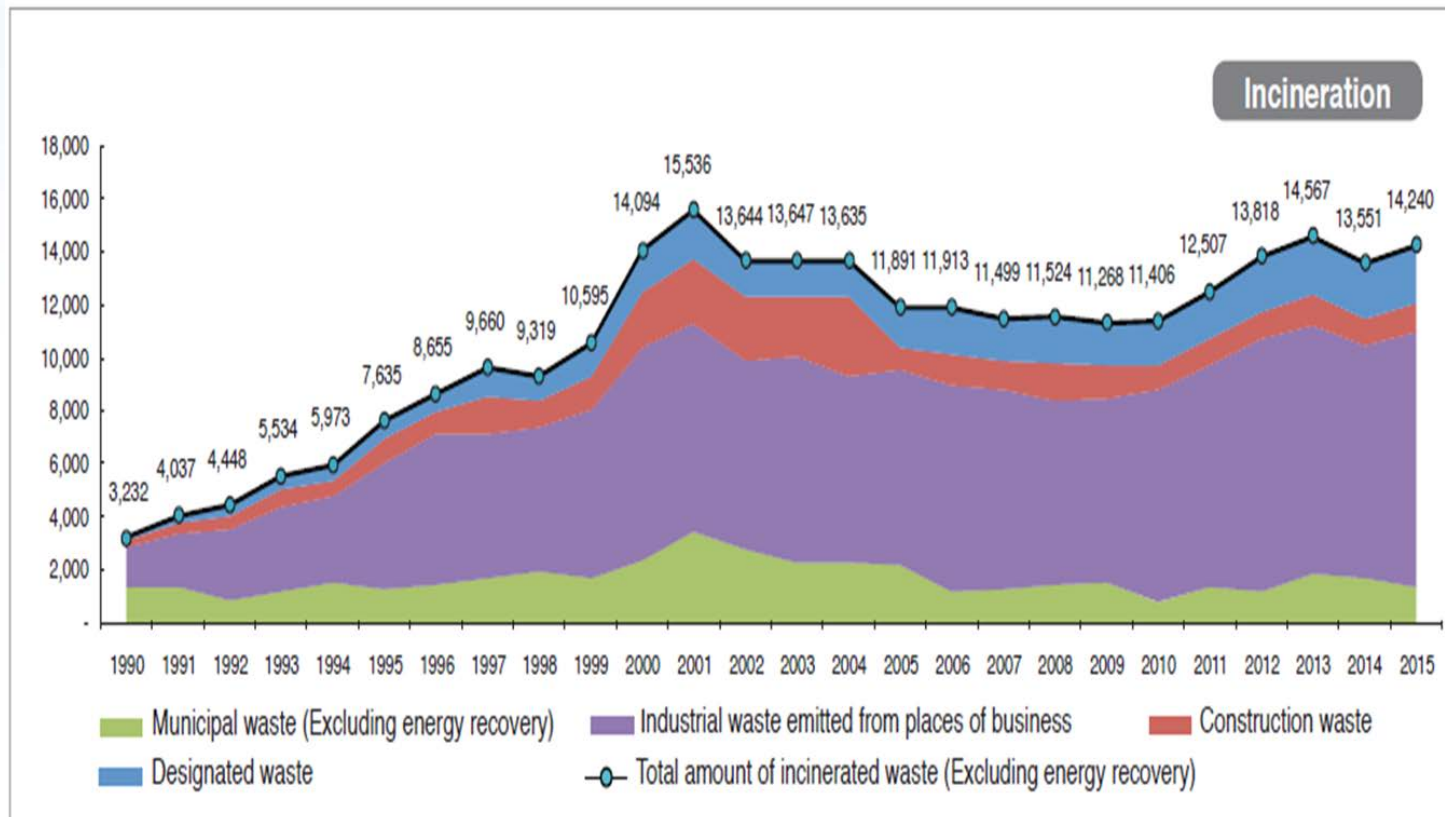
# Waste Disposal on Land in Korea

- In 2015, waste disposal on land amounted to 37,801 tons/day, decreased 60.6% comparing in 1990.



# Incineration in Korea

- In 2015, The volume of incinerated waste stood at 14,240 tons/day, increased 340.7% comparing in 1990.



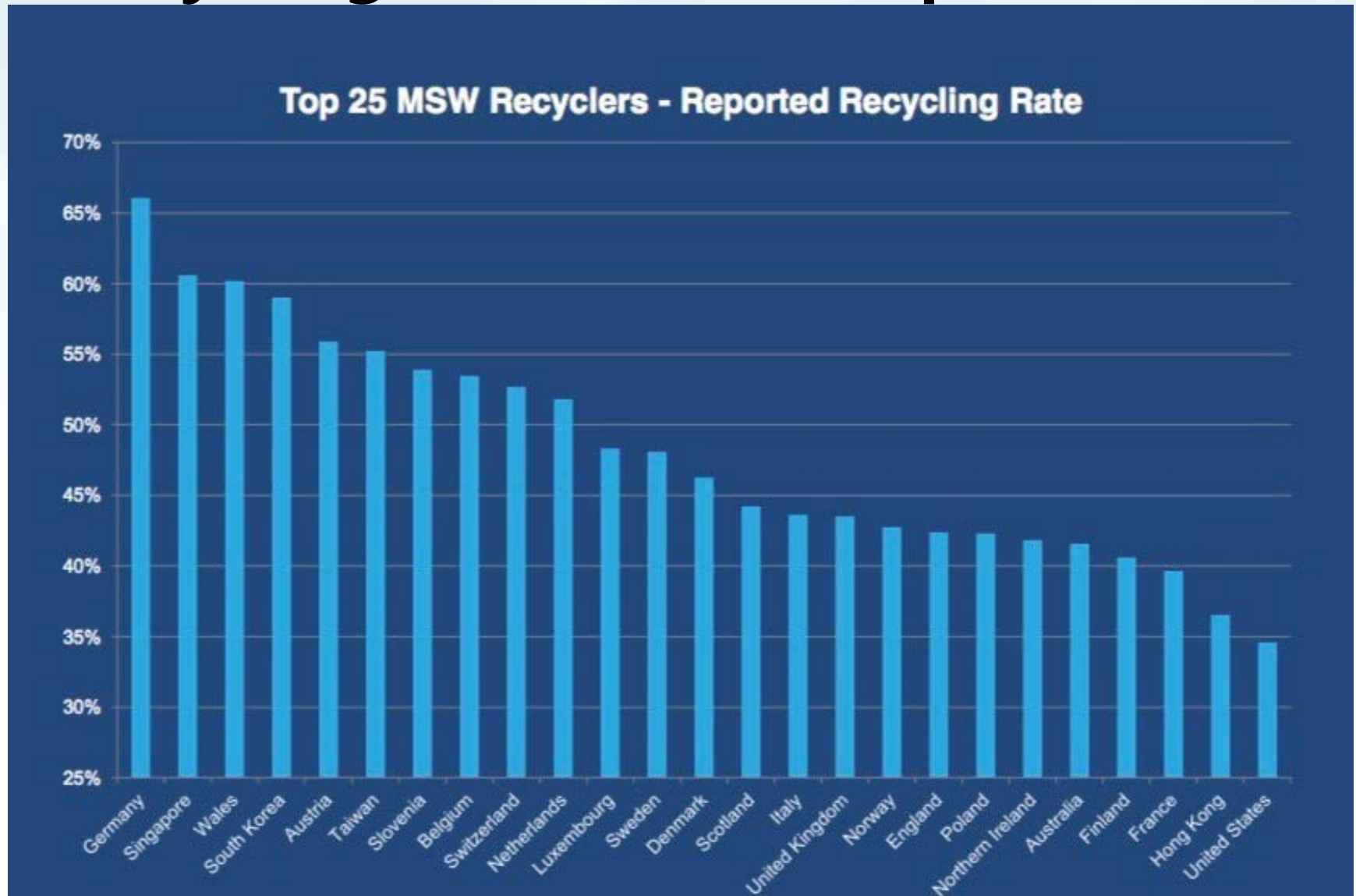
# Waste Recycling

- **The recycling rate of municipal waste** had remained at similar levels,
- whereas **the recycling rate of industrial waste** (excluding waste from construction sites) **increased** from 73.0% in 2011 to 78.2% in 2015.

- Municipal and Industrial Waste Recycling Rates (%)

Type \ Year	2011	2012	2013	2014	2015
Municipal waste recycling rate	59.1	59.1	59.1	59.0	59.2
Industrial waste recycling rate	73.0	76.5	75.4	77.3	78.2

# Recycling rate of municipal waste



# Methane Gas Recovery

- As **methane generation** is decreasing **due to the decline of landfill waste** resulting from the growth of recycling and the changes in the properties of waste caused by minimized direct land disposal,
- the amount of methane collected from landfills is also being reduced
- Methane Gas Recovery in Landfills (thousand tons)

Type \ Year	2011	2012	2013	2014
Methane recovered from landfills	139	153	153	142

# Waste-to-energy projects

- **Waste-to-energy projects** are consistently expanding by **using more organic waste** and **flammable waste for energy conversion**.
  - As a result, 14 flammable waste pre-treatment facilities, 2 boilers that exclusively use solid fuel products, and 11 facilities that turn organic waste into biogas have been added between 2015 and 2016.
  - Moreover, **at the end of 2016, the Korea annually produced 290,000 tons of solid fuel products and 67 million cubic meters of biogas, and achieved a 14.2% rate of waste-to-energy** (1.656 million tons out of 11.69 million tons of available waste resources).
- The Korea continues to improve policies aimed at facilitating waste recycling.

- **Seoul's Waste manage and renewable energy**



# Introduction of Seoul

## Area

**605.21 km<sup>2</sup>**  
(0.6% of Korea)

## Population

**10,204,000**  
(20% of Korea)



## Administrative Zones

**25 Districts (Gu)**

**423 Dongs**



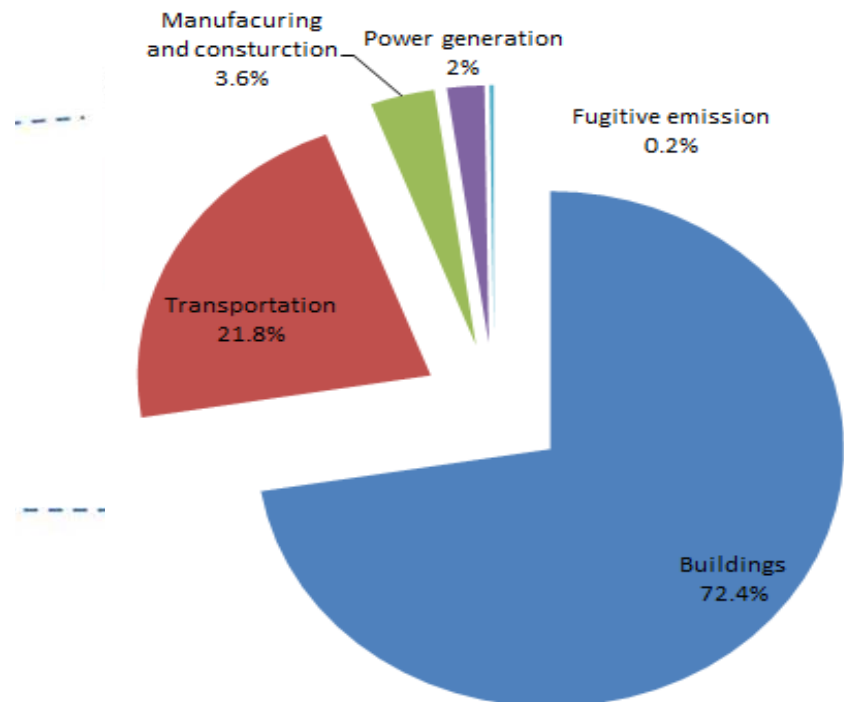
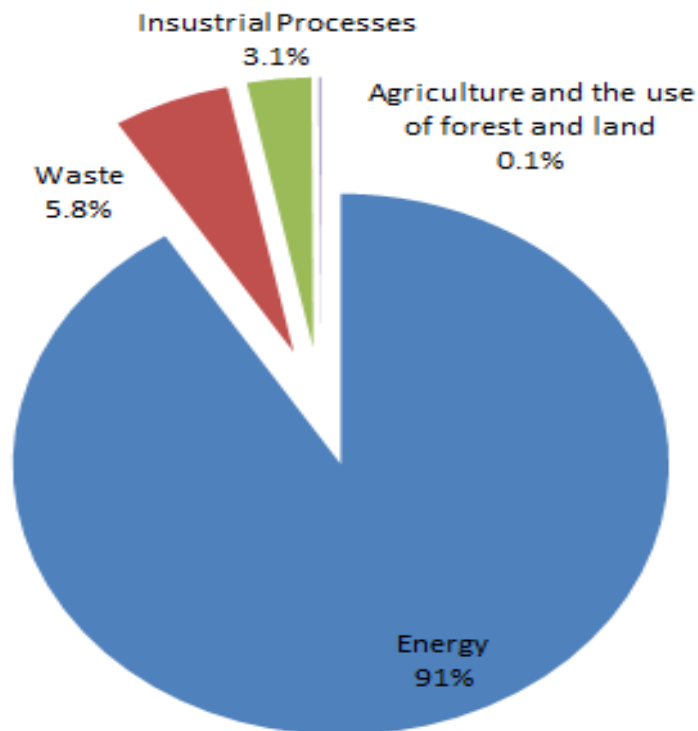
# GHG Emission in Seoul

## ■ Total annual emission of Seoul: 47,129 thousand tons

Seoul's total greenhouse gas emissions in 2014, considering both energy consumption and the environmental sector, amounted to 47,129 thousand tons of CO<sub>2</sub>, most of which were attributable to energy consumption.

## ■ Emissions by source

- Most of energy consumption (94.%) from buildings (72.4%) and transportation (21.8%)



# Implementation direction of climate change action plans

## Mitigation

### Building

Building energy efficiency improvement, energy saving, Eco-friendly design and maintenance

### Transportation

Establish public transportation policies, delivery of eco-friendly, green cars, install bicycle facilities

### Energy

Promote energy saving, **increase renewable energy**, clean fuel use and supply of collective energy

### Waste

**Reduce waste generation, promote recycling, Waste-to-energy**, co-use of resource recovery facility

## Adaptation

### Improving Climate

Greening projects, stream & ecosystem restoration projects

### Public Healthcare

Policies to prepare for heat waves and tropical night phenomenon, measures to prevent contagious diseases

### Water Management

Water quantity and quality management, rainwater recycling

### Flood Control

Reinforce facilities to prepare for torrential rainfalls, prevent flooding

## Citizen Participation

### Citizen Participation

Environmental education at homes & schools, improve citizen participation programs – Eco-mileage, CAP

# Changes in municipal Waste Management

~ 1969yr

1970yrs

1980yrs

1990yrs

2000yrs

2010yr ~

## Era of Waste Cleaning

- Waste recycling is led by private sector
- Inert materials used for building housing site and Han-river's bed
- No separation of waste and disposed at landfill together
- Nanjido landfill in use/a Metropolitan landfill under construction



## Era of Framing Waste Management Infrastructures

- Public sector joins in recycling
- Enacts volume-based fee system
- Construct waste incinerators
- Nanjido landfill closed/a Metropolitan landfill in use
- Partially initiate food waste management



## Era of Waste to Resources

- Introduce EPR system
- Expand separation of all food waste
- Regional use of incinerators to their capacities
- Construction of a SR center for smaller electric home appliances

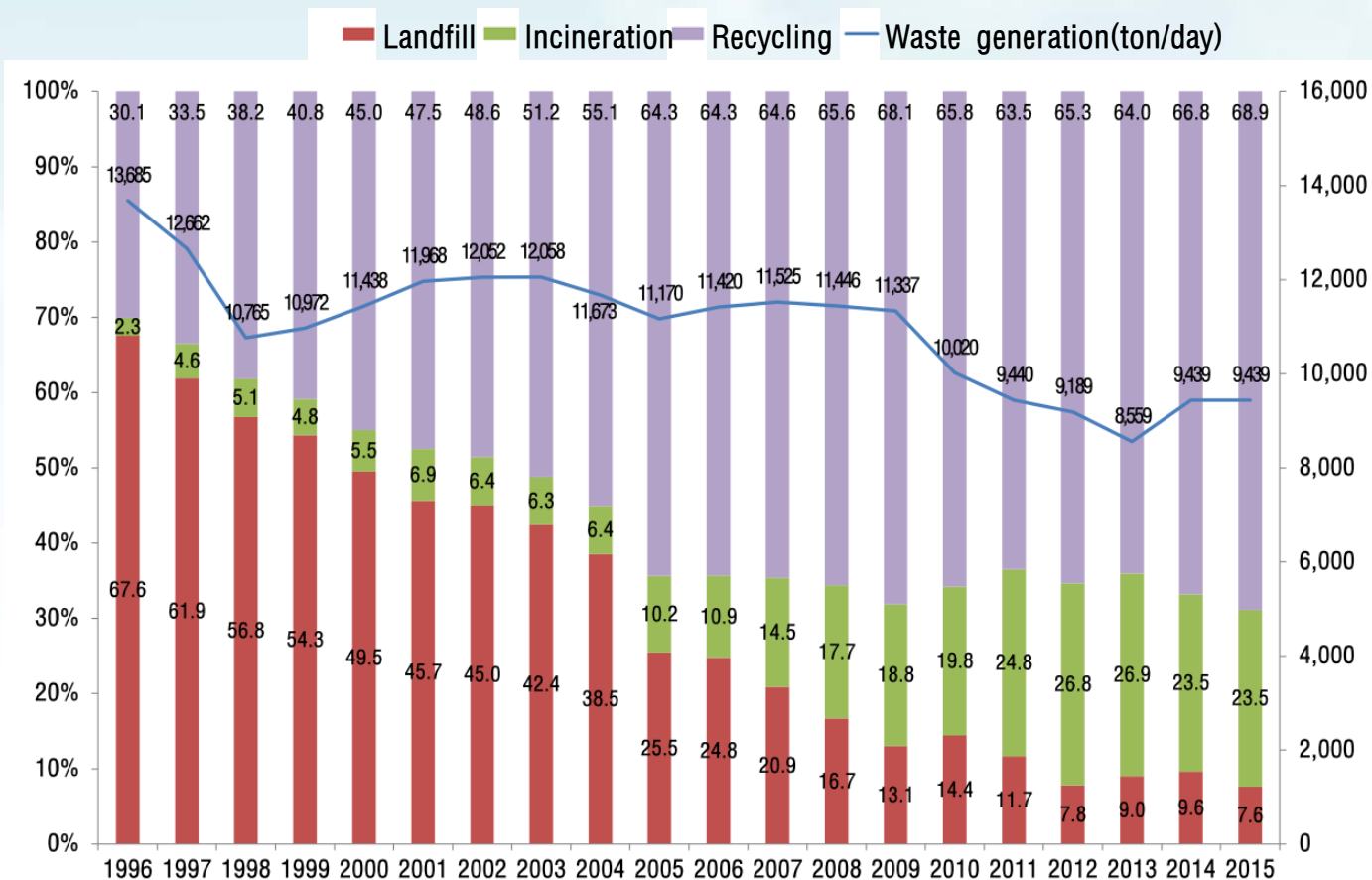


## Era of Waste-Zero

- Expand markets for used goods
- Food waste reduction
- Encourage up-cycling
- Initiate waste to fuel

Paradigm shift of waste management and related activities in Seoul]

# Changes of waste management in Seoul



Waste generation has been restricted from 13,685 tons per day in 1996 to 9,439 tons in 2015  
Waste recycling, mainly consisting of recyclables and food waste, has been up 60~70% since 2005  
Waste incineration with energy recovery has also risen up to 23.5% in 2015 from 2.3% in 1996  
Dramatic change has happened to waste landfill by dropping from 68% in 1996 to 8% in 2015



# VOLUME-BASED WASTE FEE SYSTEM

(1995)

## ❖ 'Polluter – pays' Principle

- to require users to purchase designated VBWF plastic bags to dispose their wastes.

## ❖ Objectives

- induce reduction in generation of waste at source
- encourage the collection of recyclable wastes by providing free collection service for recyclables



일반쓰레기봉투	
※사용 가능 지역※ < 송파 1.2동/방이 1.2동/신천동(잠실) 4.6동 >	
1. 5L*20	2,000원
2. 10L*20	3,600원
3. 20L*20	7,000원
4. 50L*5	4,750원
5. 100L*5	9,450원



# Volume-based waste fee system

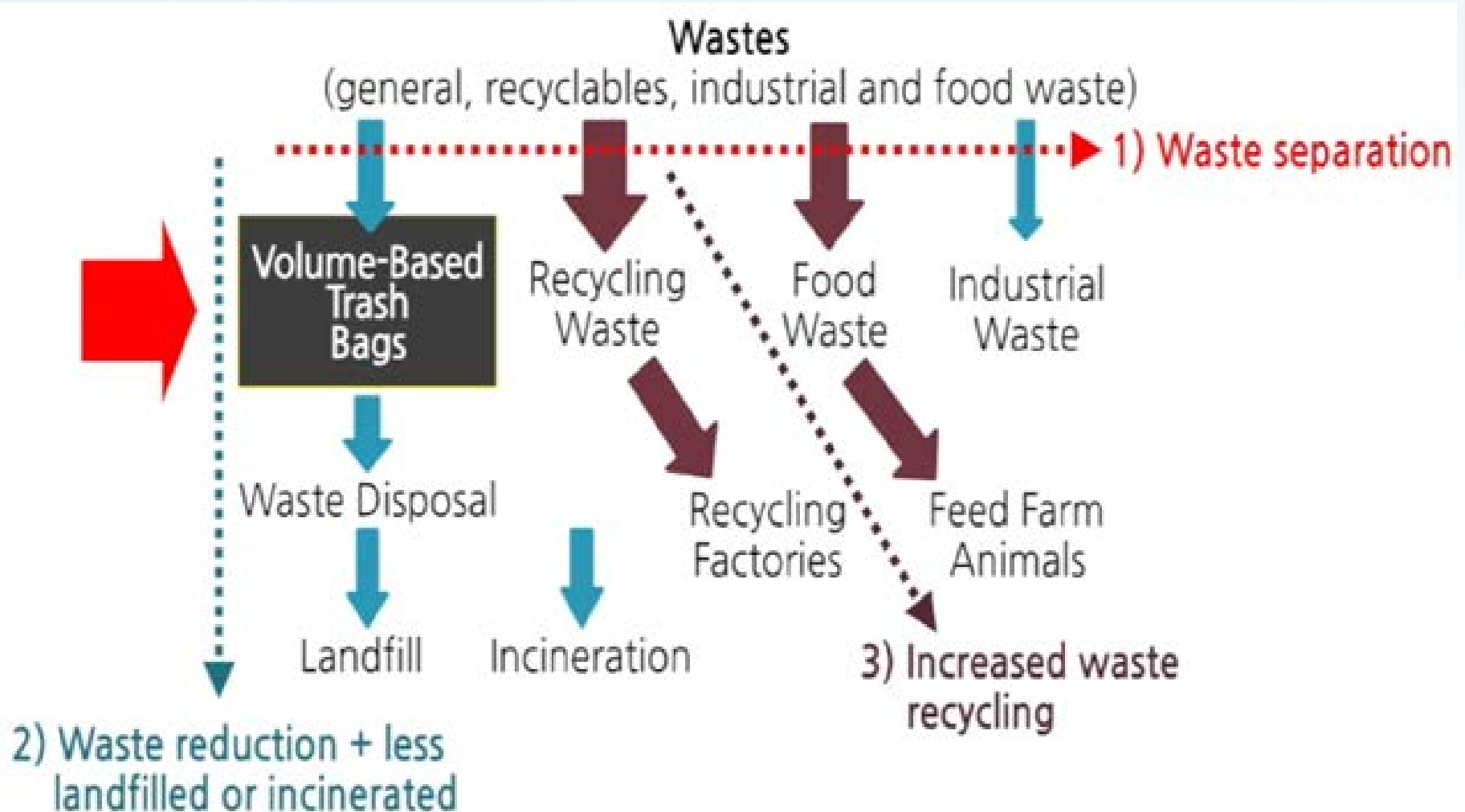
- How it works (before 1995)





# Volume-based waste fee system

- How it works (after 1995)



# Separation of waste



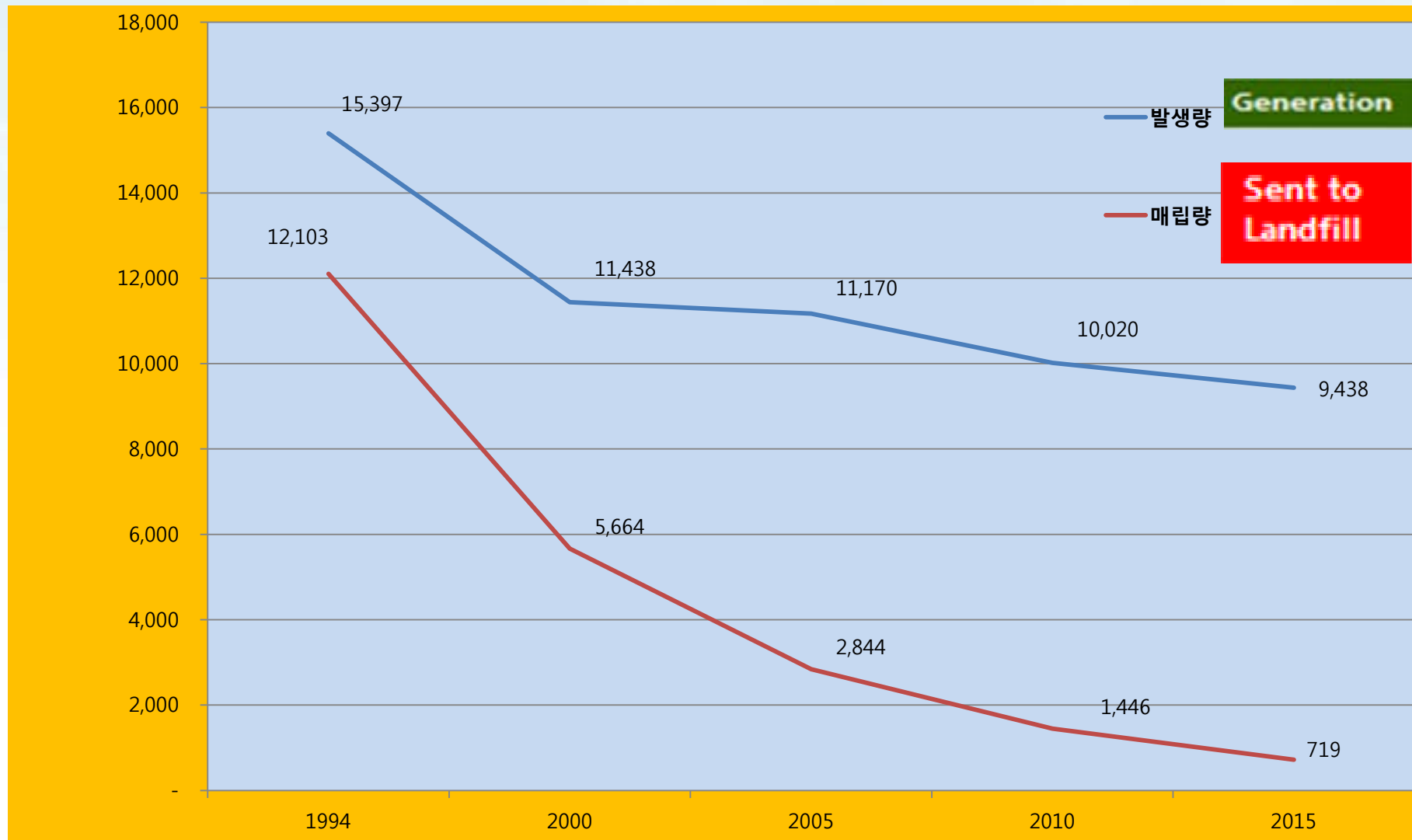
# RFID food waste disposal system



# Trends of waste management achievements

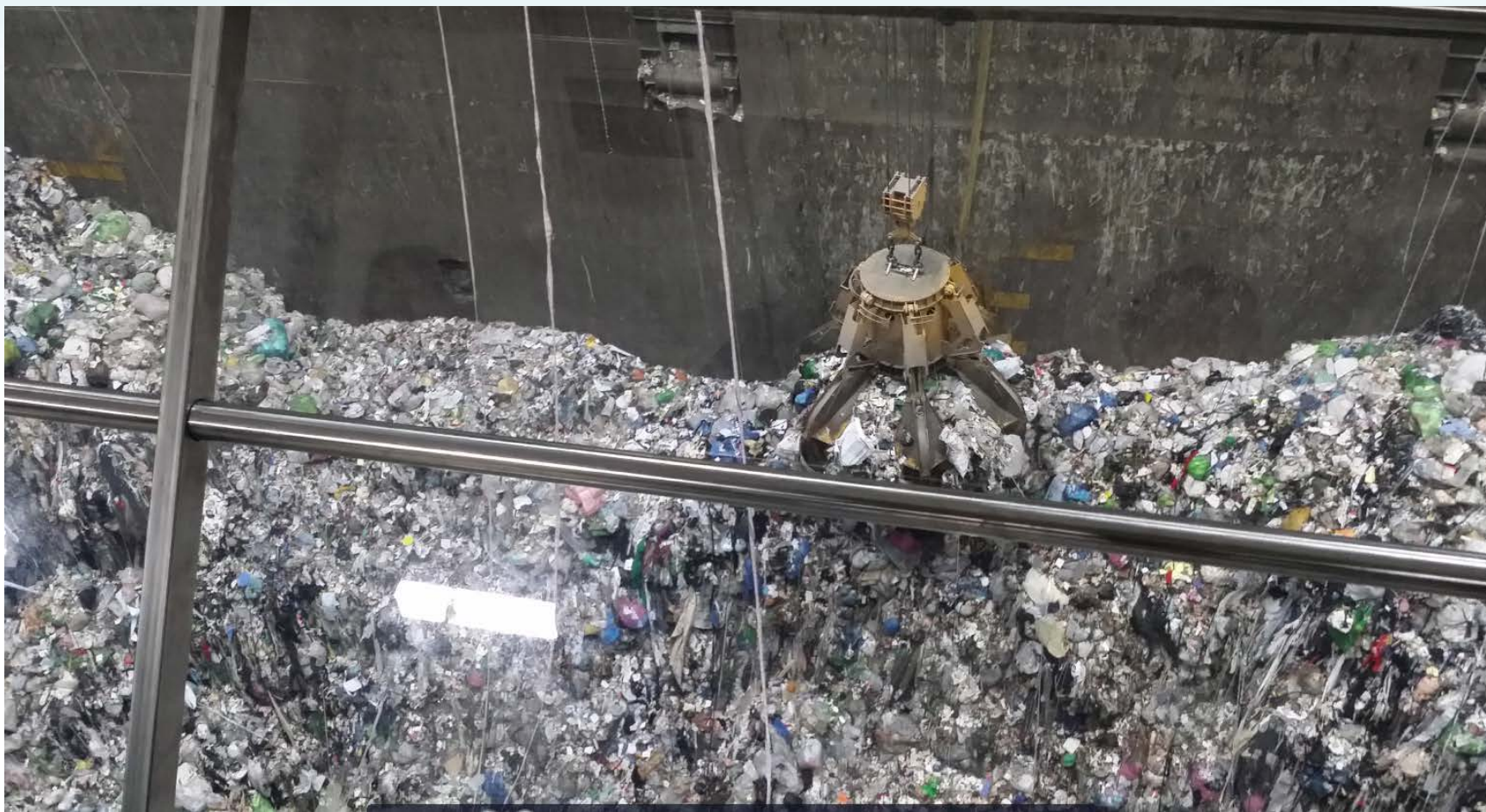
2015

(TON/DAY)



- Waste generation got **40% lower** since implementation of unit pricing in 1995
- Waste sent to Sudokwon Landfill **fell by 94%** comparing in 1995

# Mixed waste in Mapo resource center





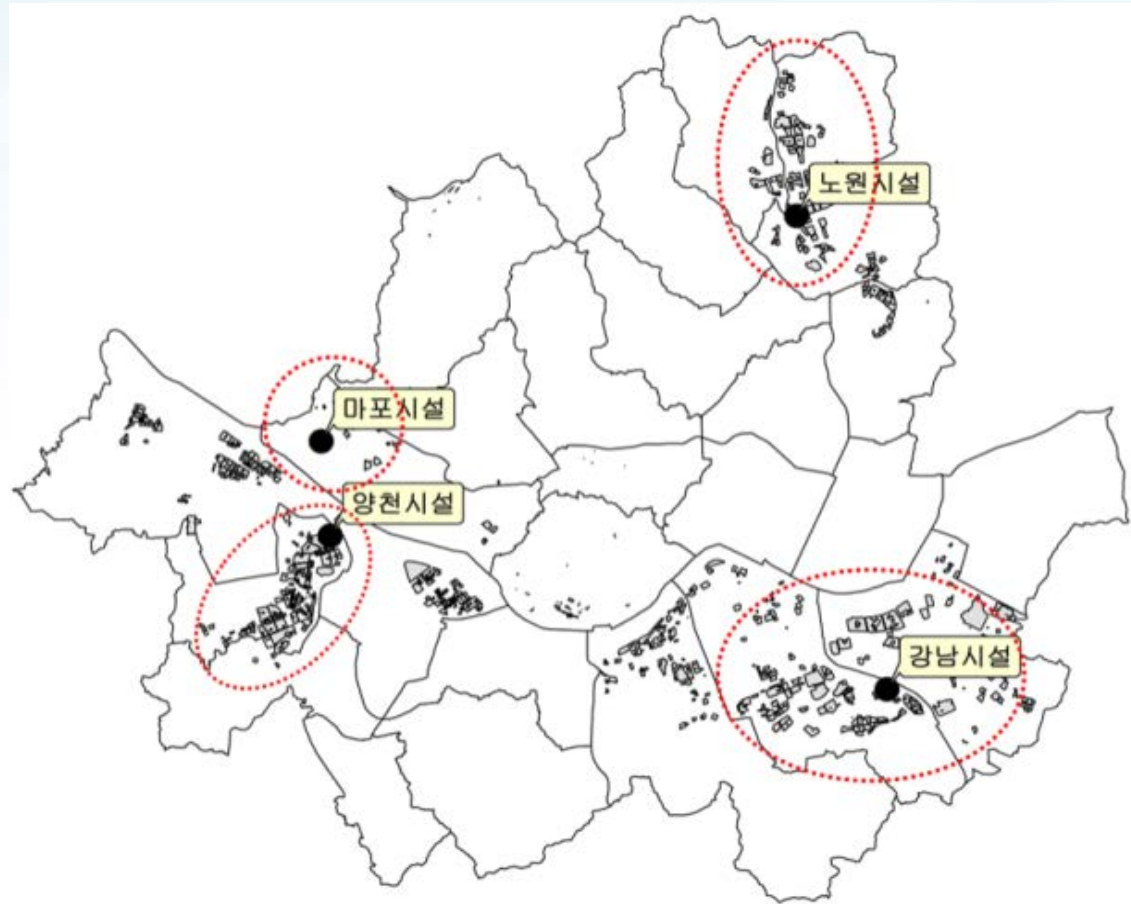
# Mixed waste

- **Set out** from its sources
- **Collected** by public waste collectors
- Hauled to **transfer station** to stock or Waste-to-Energy Facilities **to burn the waste**
- Waste-to-Energy Facility turns waste into two kinds of residuals, **bottom ash and fly ash**
- Bottom ash is usually disposed at **landfill site** and **fly ash** is sent to **landfill site** for **hazardous waste to manage in a more strict way**

# Use of Landfill Gas for District Heating

- Collected landfill gas has been used as **regional heating fuel**.
- Landfill gas is used as **part of the fuel of the Korea District Heating Corporation** that supplies heating to three public buildings, **16,335 apartment households** and 36 office buildings.
- Landfill gas occurs naturally and unless used as such, it leads to exhaust of **methane or carbon dioxide**, which is known to cause global warming.

District heating networks in Seoul



# Waste as Resources

## ■ Four Resource Recovery Facilities in Seoul

### - Features

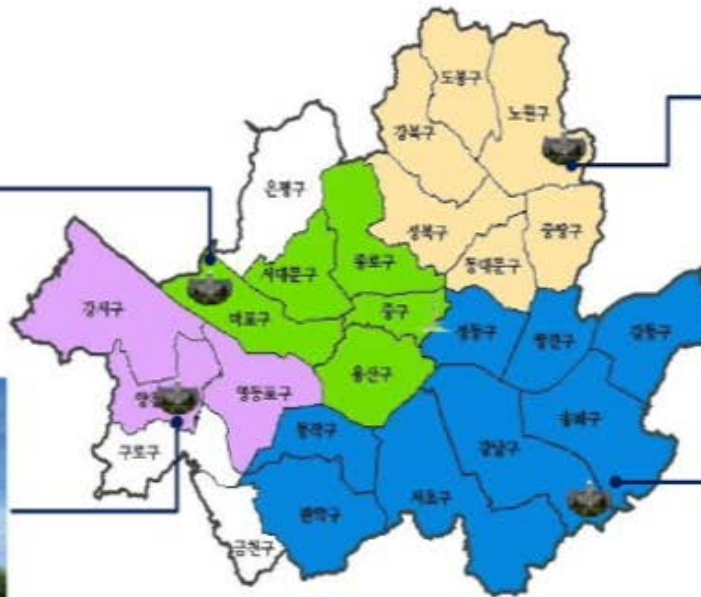
- Incineration + Heat Recovery
- Co-utilization of Resource Recovery Facilities



**Mapo Resource Recovery Facility**  
(Built in 2005, 750 ton/day)



**Yangcheon Resource Recovery Facility**  
(Built in 1996, 400 ton/day)



**Nowon Resource Recovery Facility**  
(Built in 1997, 800 ton/day)



**Gangnam Resource Recovery Facility**  
(Built in 2001, 900 ton/day)



# Renewal of Landfill Management System

- **The restoration of the Nanjido as World Cup Park was a turning point for landfill management.**
- After the Nanjido dumping site was closed, the government made huge revisions to relevant regulations.
- The government prescribed methods to prevent environmental damages by the facility during burial of wastes. It also specified to treat and monitor pollutants for a certain period of time after the landfill was closed.

Regulations on Municipal Waste Landfill Management Method

Section	Landfill Establishment	Landfill Management Method during Landfill Use	Post-care Management Method after Landfill Use
Contents	<ul style="list-style-type: none"> <li>• Site selection</li> <li>• Environmental impact evaluation</li> <li>• Compensation for affected areas</li> <li>• Base construction                             <ul style="list-style-type: none"> <li>- Groundwork</li> <li>- Cutoff</li> <li>- Leachate transport pipe</li> <li>- Leachate treatment facility</li> <li>- Landfill gas collection</li> </ul> </li> <li>• Inspection</li> </ul>	<ul style="list-style-type: none"> <li>• Leachate treatment                             <ul style="list-style-type: none"> <li>- Blocking leachate</li> <li>- Transporting leachate</li> <li>- Treating leachate</li> </ul> </li> <li>• Landfill method                             <ul style="list-style-type: none"> <li>- Internal entry way</li> <li>- Burying by stage</li> <li>- Covering with soil</li> </ul> </li> <li>• Landfill gas treatment                             <ul style="list-style-type: none"> <li>- Landfill gas collection</li> <li>- Landfill gas transport</li> <li>- Landfill gas treatment and utilization</li> </ul> </li> <li>• Disease prevention</li> </ul>	<ul style="list-style-type: none"> <li>• Post-care management period                             <ul style="list-style-type: none"> <li>- within 30 years</li> </ul> </li> <li>• Post-care management personnel: dedicated manpower</li> <li>• Rainwater drainage method                             <ul style="list-style-type: none"> <li>- Rainwater drainage facility</li> </ul> </li> <li>• Leachate management                             <ul style="list-style-type: none"> <li>- Leachate examination</li> <li>- Leachate treatment</li> </ul> </li> <li>• Groundwater and seawater quality examination</li> <li>• Landfill gas management                             <ul style="list-style-type: none"> <li>- Landfill gas examination</li> <li>- Landfill gas treatment method</li> </ul> </li> <li>• Structure and ground stability                             <ul style="list-style-type: none"> <li>- Investigation point and method</li> </ul> </li> <li>• Environmental monitoring                             <ul style="list-style-type: none"> <li>- Surface water</li> <li>- Soil examination</li> <li>- Disease</li> <li>- Dafting surrounding</li> <li>- Report : every 5 years</li> </ul> </li> </ul>

# What happened to Nanjido

- In late 1990s, Seoul city government began environmental pollution prevention projects to stop the environmental deterioration and established an Eco Park (called the World Cup Park later) on top of it.
- The World Cup Park is becoming more and more ecologically healthy as time passes.

Nanjido in maps (1919) → Nanjido covered with grasslands and rice paddies (1977) → Nanjido waste disposed at (1985) → Nanjido restored as an Eco Park (2013)





# What happened to Nanjido

- During Nanjido waste landfill, there were no landfill gas collection, no leachate collection and no soil covering. It was not a waste landfill just but a waste dumping.
- A part of waste were blown away over boundary of landfill site. Occasionally fire broke out by spontaneous combustion of landfill gas. Biodegradable materials in waste got harmful insects, rodents and birds crowded.
- In the meanwhile, the surrounding area became home to the socially vulnerable people most of whom were searching for recyclables from waste heap as a means of living.



Vehicles in waiting line



Waste unload



Landfill with no covering



Seagull



leachate from the slope



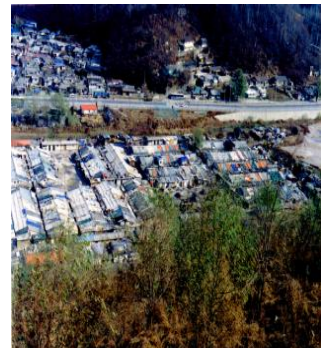
Fire caused by landfill gas



Junkman in higher class



Junkman in lower class



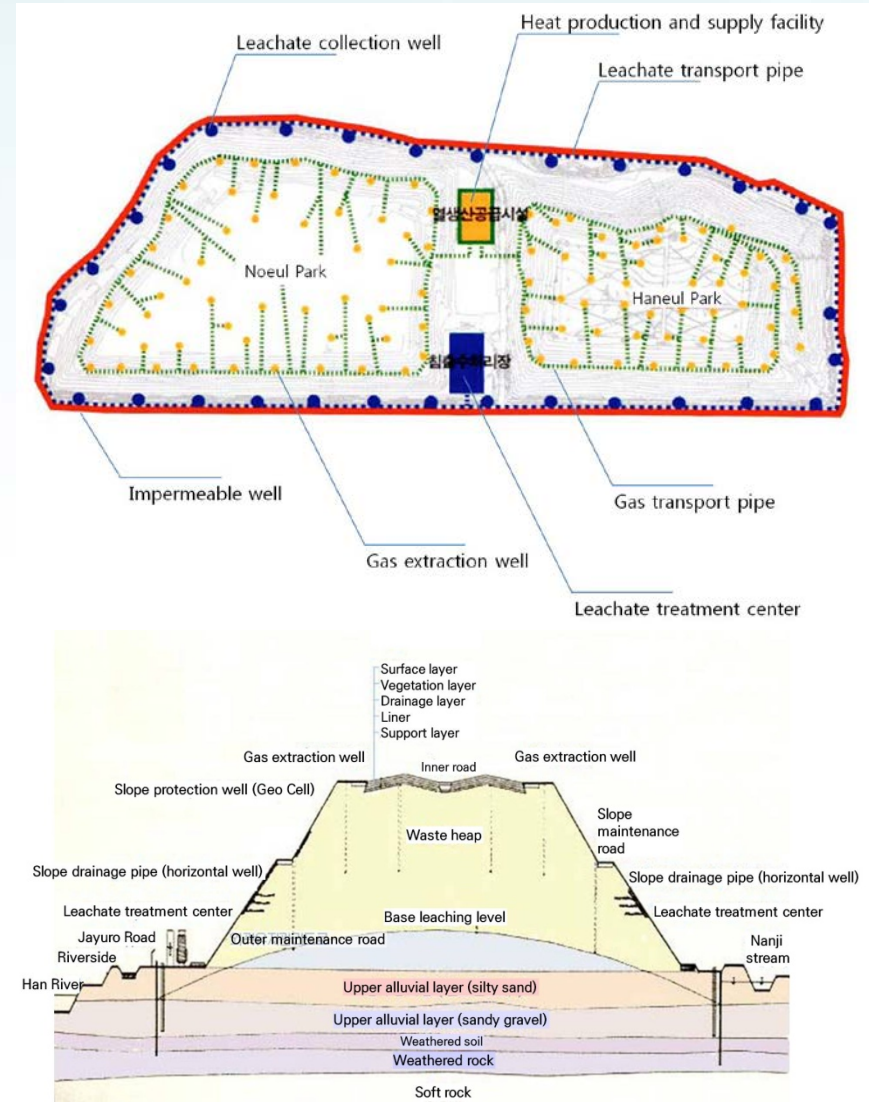
Junkman village

# Details and Progress

## I Stabilization work

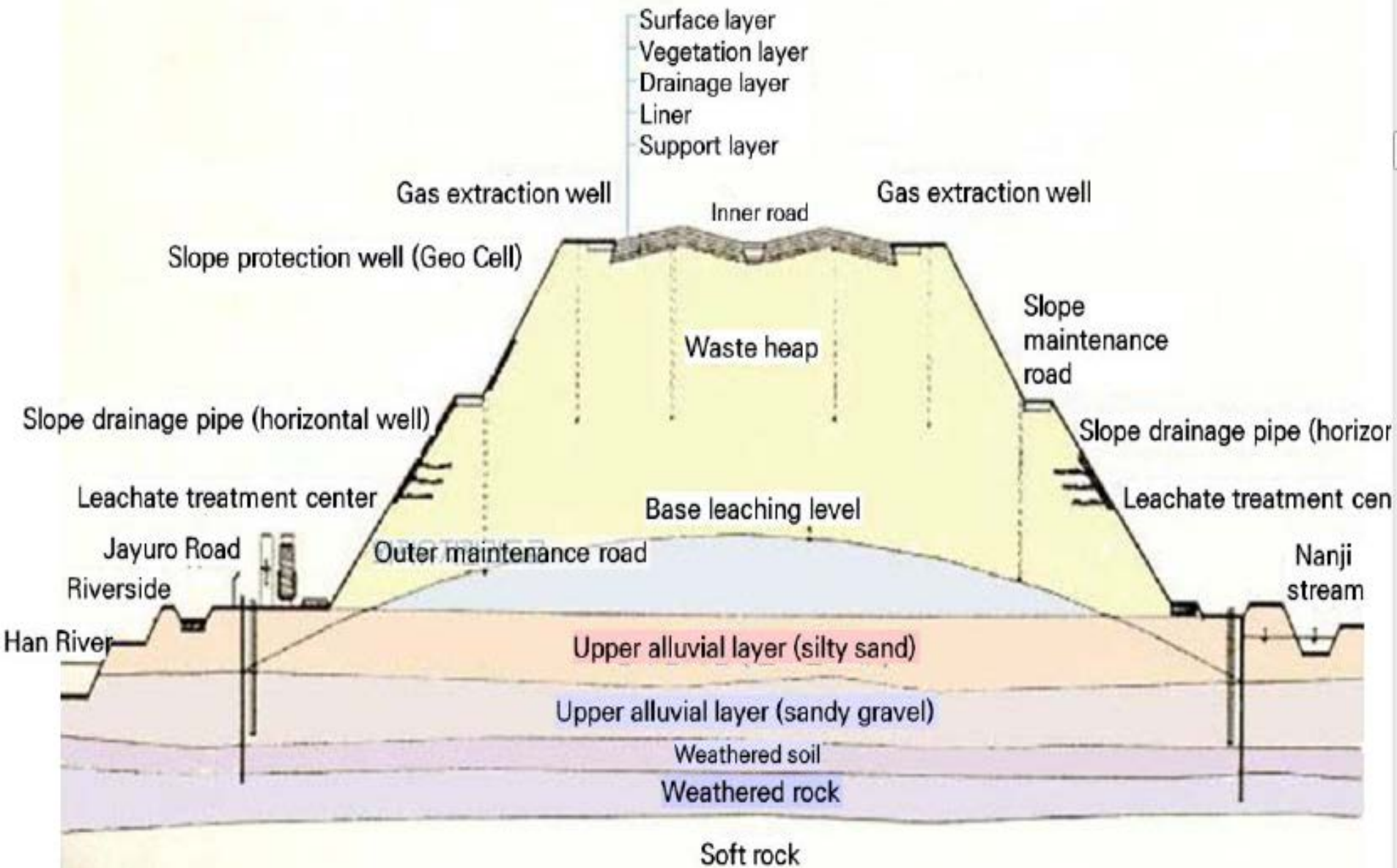
### Overview of stabilization work

- The goal of the stabilization work was to restore the environment, while keeping the huge garbage heaps as it is.
- The stabilization work included.....
  - installation of the impermeable wall in order to prevent leakage of leachate from dumping site,
  - the treatment of leachate,
  - the collection and treatment of landfill gas,
  - slope stabilization to manage side of waste heaps,
  - and the construction of grassland after covering the top of landfill with soil.





# Cross-section of Nanjido Landfill Stabilization Work Plan



# Details and Progress

## I Stabilization work

### Landfill gas treatment

- In order to remove the foul odors and dangers of explosion due to landfill gas, the upper part of the dumping site was covered with a blocking.
- **The 106 landfill gas collection wells were installed on the upper part of the landfill to extract landfill gas from waste heaps, and collected gas was transferred to the treatment facility through a 14km long gas pipe.**
- Landfill gas was used as fuel of regional heating system and remaining gas was incinerated in the gas stack.



Landfill gas extraction well installation



Landfill gas transport pipe being installed on slopes



Landfill gas combustion test



Heat production facility using landfill gas



# Construction of Landfill Gas Treatment Facilities



Landfill gas extraction well installation



Landfill gas transport pipe being installed on slopes

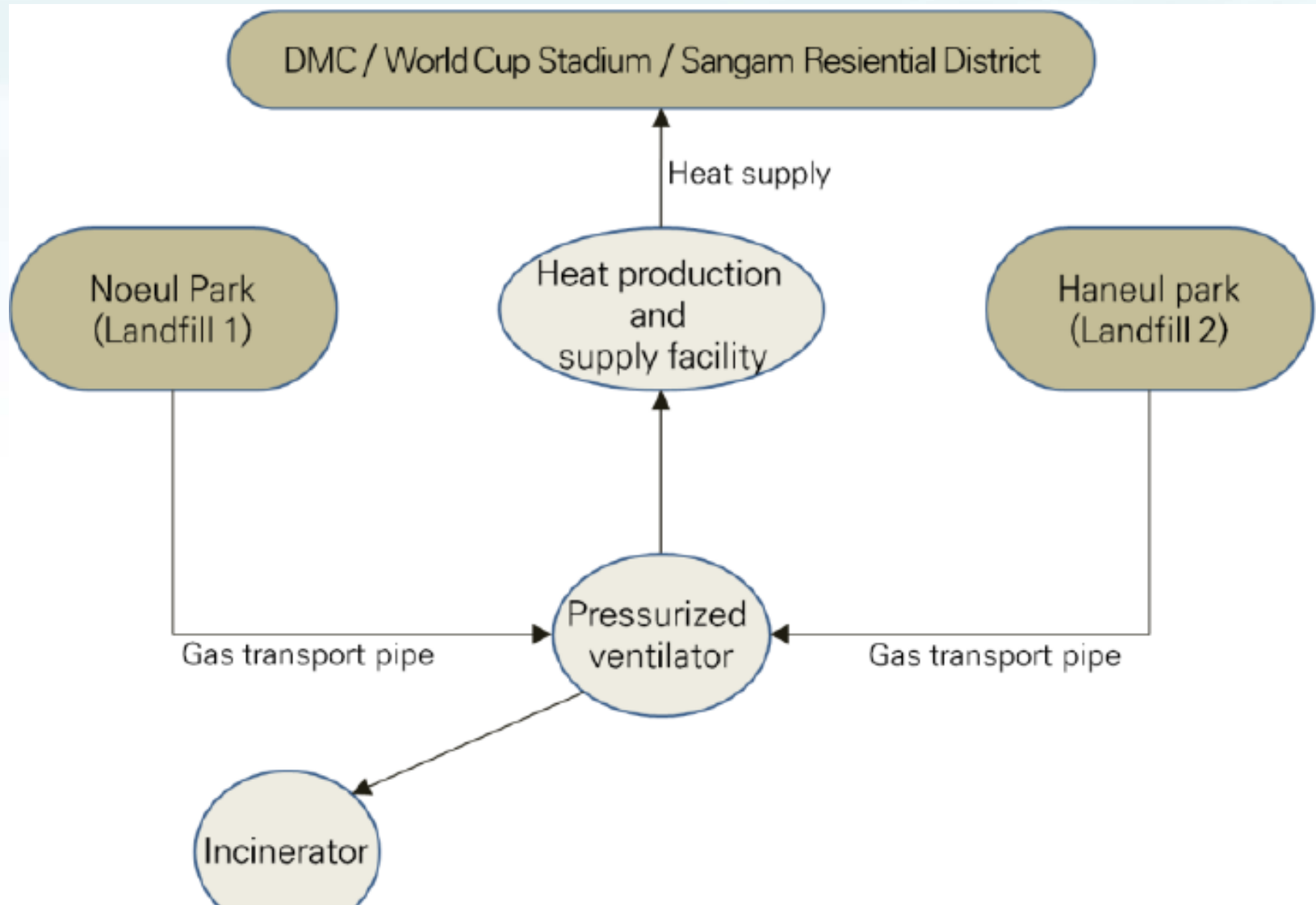


Landfill gas combustion test



Heat production facility using landfill gas

# Nanjido dumping site Gas Treatment Method





# 2002 ~ Present



# ❖ **Waste-to-energy, Landfill site Incheon (Seoul Metropolitan regional landfill)**

# Seoul Metropolitan area



# Landfill Site Incheon

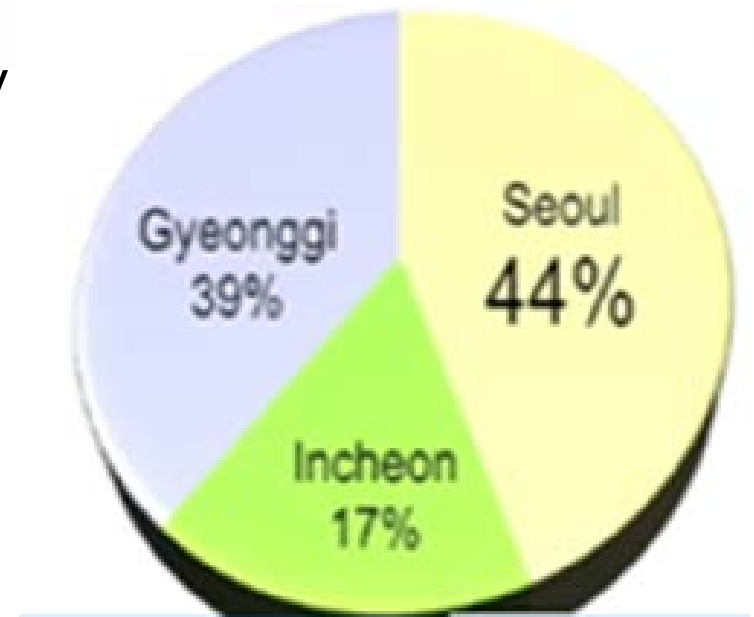
## SEOUL METROPOLITAN REGIONAL LANDFILL



# Sudokwon landfill

## (Landfill Site Incheon)

- The largest landfill site in the world, around 2000 hectares, operated since 1992.
- 13,400 tons of waste daily from Seoul, Incheon and Gyeonggi with a population of 24 million people.
- Landfilled waste amount by city





## • Four landfill cells

- 1<sup>st</sup> cell : landfill completed in 2000
- 2<sup>nd</sup> cell : currently open, expected until 2018
- 3<sup>rd</sup> and 4<sup>th</sup> cells: to filled from the year 2018

1<sup>st</sup> Cell



Cell area: 2.5 km<sup>2</sup>  
Operation period: 1992 - 2000  
Capacity: 64 km<sup>2</sup>

2<sup>nd</sup> Cell



Cell area: 2.5 km<sup>2</sup>  
Operation period: 2000-2018 (expected)  
Capacity: 67 km<sup>2</sup>

3<sup>rd</sup> & 4<sup>th</sup> Cell



# Waste as Resources

- **Electricity from landfill gas**
    - 50MW Landfill Gas Electricity Generation Project  
The world's largest power plant utilizing landfill gas  
⇒ could provide electricity for 43,000 of residents
    - **Registered as a CDM(Clean Development Mechanism) project**,  
generating electric power worth of US \$30Million annually and a  
certified emission reduction equal to 850,000CO<sub>2</sub> tons
- ⇒ **Economic benefit**
- +
- Environmental benefit**



Source: Sudokwon Landfill Corporation (2010) Ten Years History of  
Sudokwon Landfill Site Management Corporation: Dream the Green



- **Thank you for Listening**

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