Waste-to-Energy Plants' Energy Conversion Status and Its Efficiency in Korea

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1. Introduction

1. Introduction

Environmental Crisis

Limited Natural Resources (Petroleum: 40years, Natural gas: 58years, Copper: 28years)	1/3 reduction in fresh water supply per capita in 25 years Shortage of agricultural water	5-20% decline in global GDP per annum with the existing industrial structure (likely to cause the 2nd Great Depression)	50% increase in global energy consumption by 2030
Exhaustion of Natural Resources	**Water Shortage Problem**	**Increasing GHG Emissions**	**Increase of Energy Consumption**
			

1. Introduction

Environmental Crisis

The need for New & Renewable Energy Development as alternative fuel

1. Introduction

Environmental Conditions

- Environmental crisis
  Getting worse due to climate change
- Imbalance b/w energy supply and demand and resource crisis
- Continuous increase in energy demand and rising dependence on energy imports
- Increased emissions resulting from fossil fuel-centered economy
- Slowing economic growth
  And weakening growth momentum

Industrial Perspective :

- A waste management solution
- A waste recovery process
- A cost saving

Global Perspective :

- Renewable energy
- Secure energy supply
- Greenhouse gas abatement

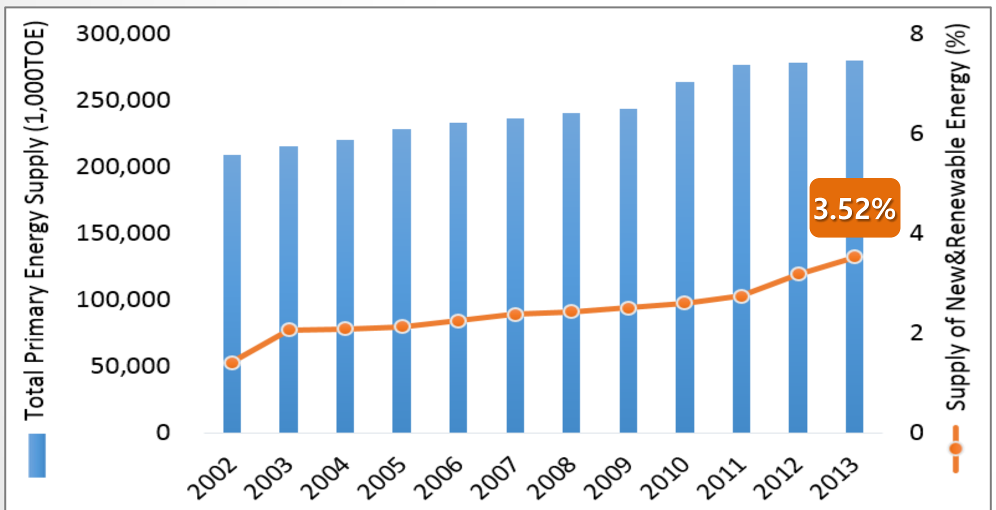
2. Outline of Waste-to-Energy

2. Outline of Waste-to-Energy

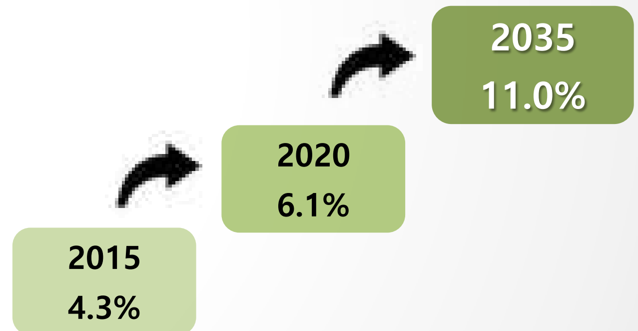
Waste-to-Energy : Comprehensive Countermeasure Establishment

- **Waste-to-Energy Comprehensive Policy (2008)**
- **Measure for Waste Resource and Biomass Energy (2008), Action Plan (2009)**
- **Policies for promoting New & Renewable Energy (2010)**

  - New energy (3) : Fuel cell, Coal liquefaction and Gasification, Hydrogen
  - Renewable (8) : Solar heat, Photovoltaic, Biomass, Wind power, Hydro-power, Geothermal heat, Tidal energy, Waste



<New & Renewable Energy Production for Primary Energy Supply(2002~2013)>

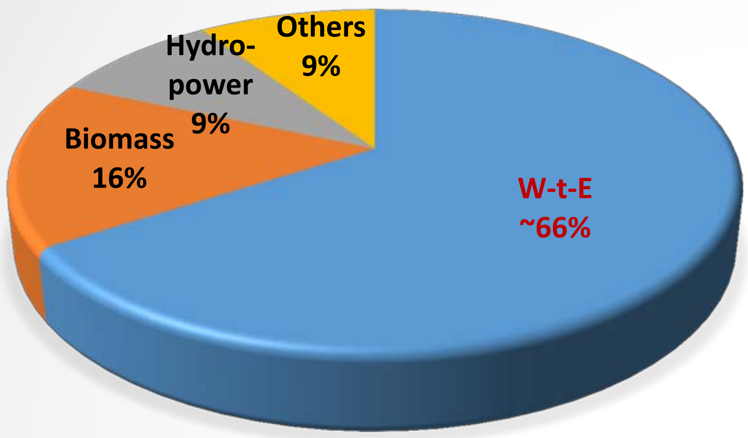


<National Target of New & Renewable Energy Supply in Korea>

* Source : The 3rd New & Renewable Energy Master Plan, Ministry of Knowledge Economy

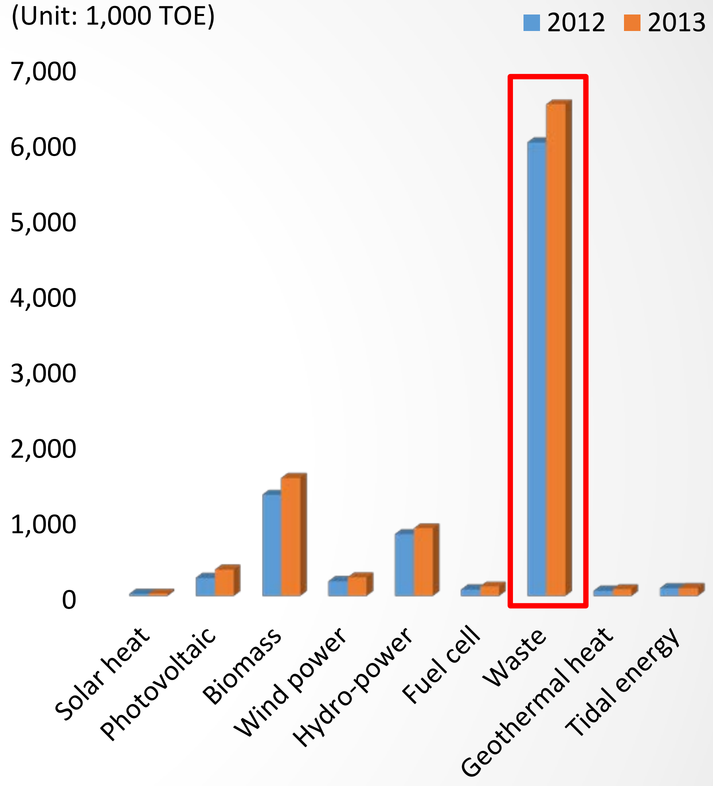
2. Outline of Waste-to-Energy

Waste-to-Energy; New & Renewable Energy



<The portion of supply for each new & renewable energy resource (2013)>

- **Waste**
  - Liquefaction and pelletization by thermal cracking
  - Technology of solid fuel manufacturing (SRF)
  - Combustible gas manufacturing techniques by gasification
  - Heat Recovery Techniques by Incineration



<Production of New & Renewable Energy (2012~2013)>

* Source : Korea energy management corporation, New & Renewable Energy Statistics 2013 (2014 Edition)

2. Outline of Waste-to-Energy

Waste Treatment Policy

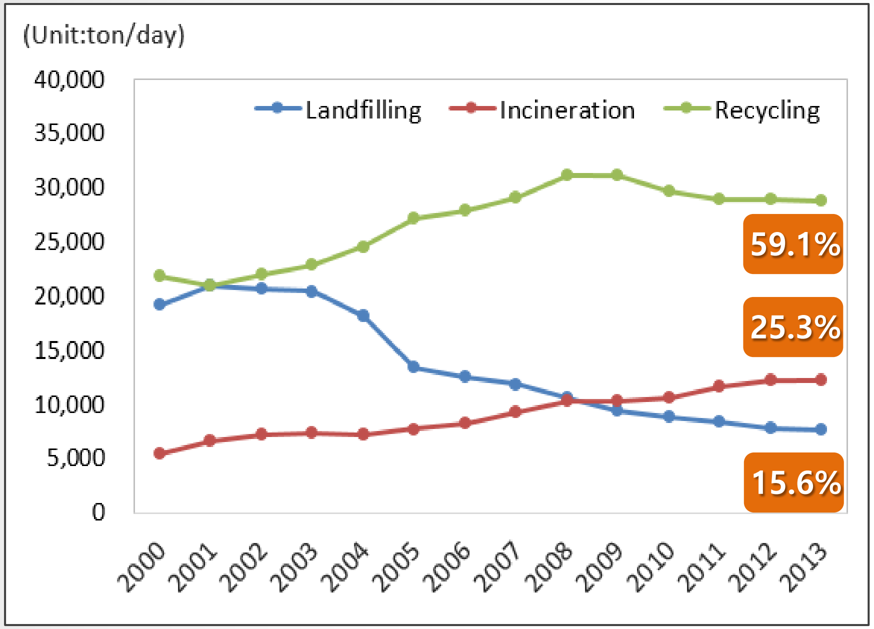
- 2012 — A Ban on the dumping of **Sewage Sludge and Livestock Manure** at sea
- 2013 — A Ban on the dumping of **Food Wastewater** at sea
- 2014 — A Ban on the dumping of **Organic Waste** at sea

Waste Treatment on Land

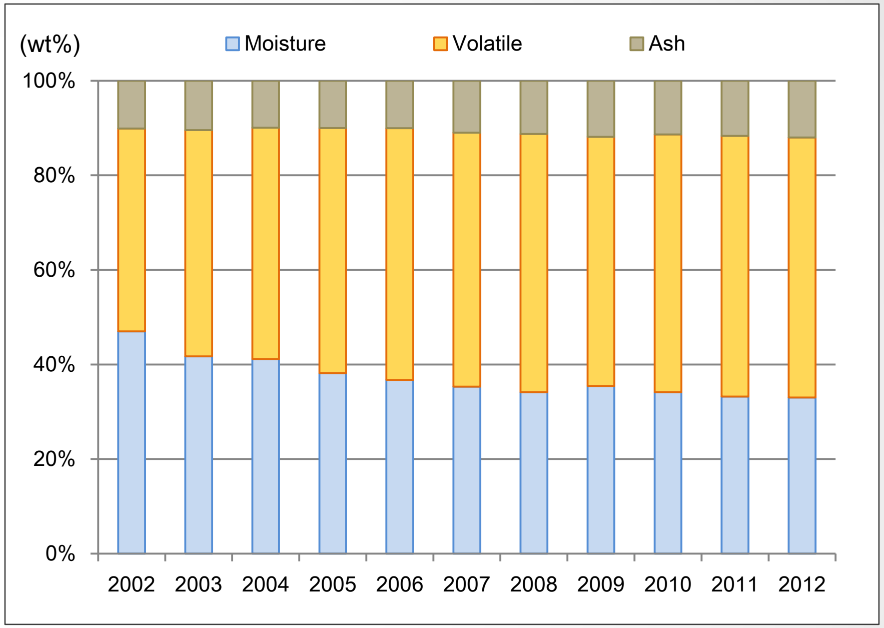
Lack of Landfill · Cost Saving · Exhaustion of Energy → **Incineration**

2. Outline of Waste-to-Energy

Waste Treatment Status



<Trend of MSW Treatment (2000~2013)>



<Change of MSW composition (2002~2012)>

* Source : Korea Incinerating Conference

- **Increase of Waste Incineration**
- **Resource recovery from waste by high oil price**

  - Increase in Recycling ratio and Decrease in Landfill ratio

WtE Plants in Korea

- **Total 191 Incineration facilities in Korea (2013)**
  - 39 WtE Plants : MSW(Municipal Solid Waste) incineration facility

Incheon
Incineration facility: 9
WtE Plant : 3

Seoul
Incineration facility : 5
WtE Plant : 5

Gyeonggi-do
Incineration facility : 25
WtE Plant : 15

Gangwon-do
Incineration facility : 16
WtE Plant : 1

Chungcheongbuk-do
Incineration facility : 11
WtE Plant : 1

Gyeongsangbuk-do
Incineration facility : 24

Chungcheongnam-do
Incineration facility : 12
WtE Plant : 2

Daegu
Incineration facility : 1
WtE Plant : 1

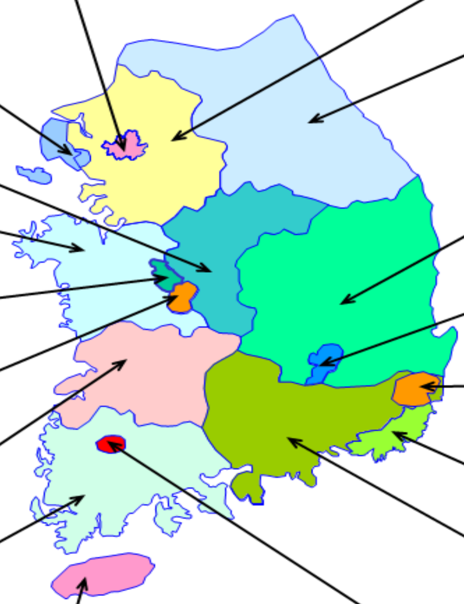
Sejong
Incineration facility : 1

Ulsan
Incineration facility : 2
WtE Plant : 1

Daejeon
Incineration facility : 1
WtE Plant : 1

Busan
Incineration facility : 3
WtE Plant : 2

Jeollabuk-do
Incineration facility : 3
WtE Plant : 2



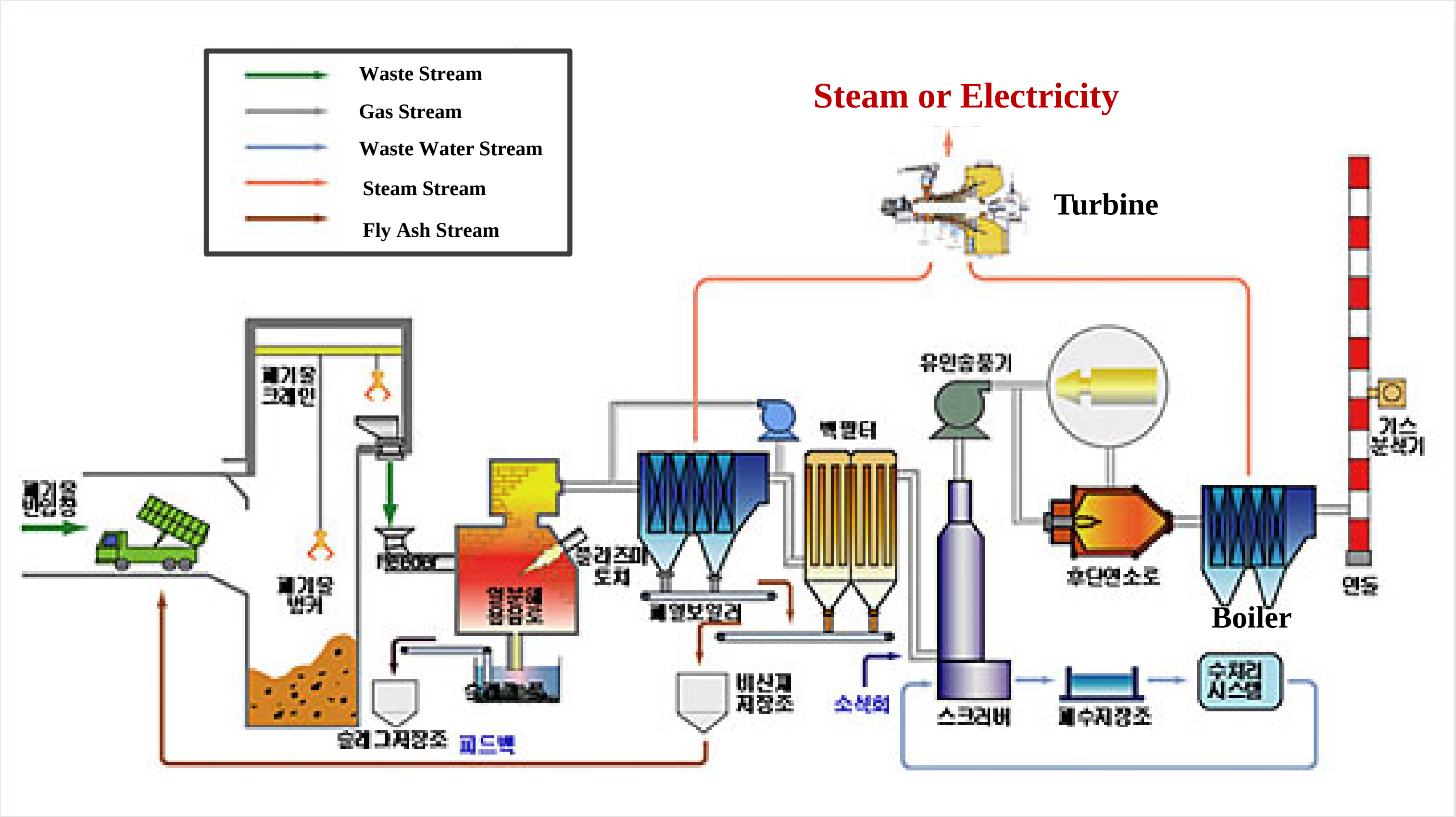
Jeollanam-do
Incineration facility : 51

Jeju Island
Incineration facility : 7
WtE Plant : 1

Gwangju
Incineration facility : 1
WtE Plant : 1

Gyeongsangnam-do
Incineration facility : 19
WtE Plant : 4

Energy Production in WtE Plant



<Schematic Diagram of Incineration facility>

* Source : GS Energy

Heat loss : Incinerator wall, Mismatch of pollution prevention facility, Ash, etc.

2. Outline of Waste-to-Energy

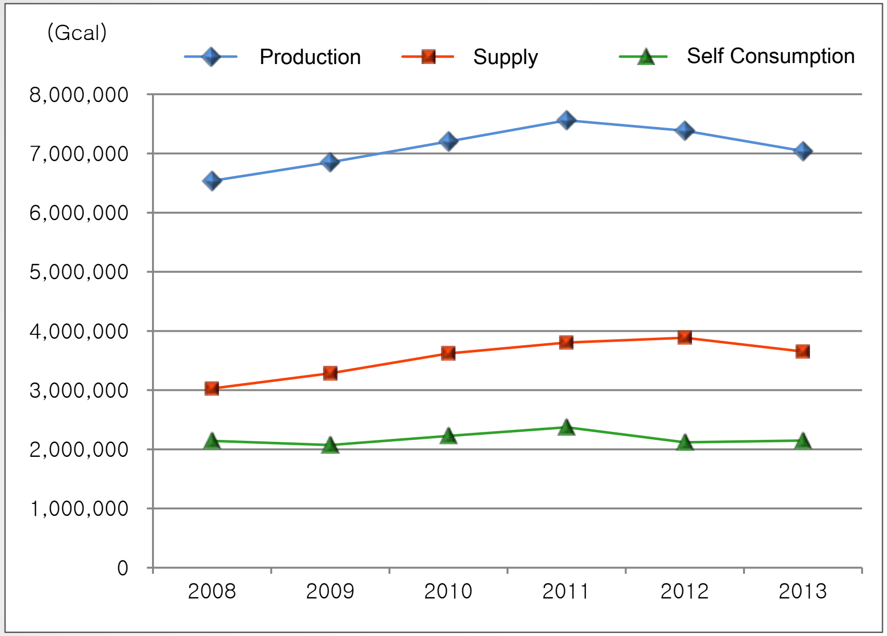
Energy Recovery Status

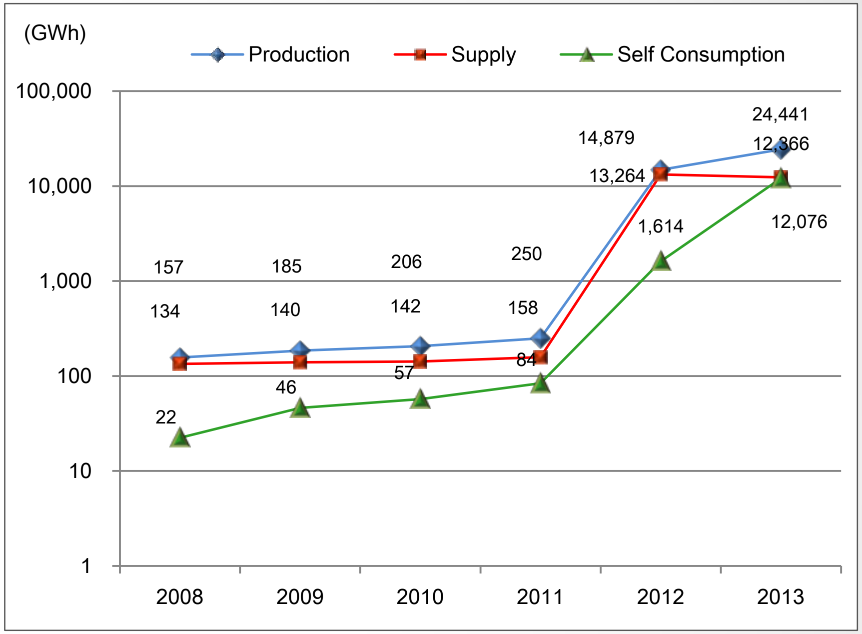
<Recovery and Utilization Status of Waste Heat (2013)>

Year	Capacity (ton)	Waste heat generation (Gcal)	Waste heat utilization (Gcal)			Energy Recovery (%)
			Total	Electricity	Steam	
Average	**3,364,482**	**7,041,028**	**4,720,987**	**1,068,977**	**3,652,010**	**67**
January	301,224	623,550	427,523	73,720	353,803	69
February	279,576	560,024	389,251	69,702	319,549	70
March	286,634	629,202	444,474	74,611	369,863	71
April	249,076	519,184	370,593	85,931	284,662	71
May	259,693	546,324	371,117	76,853	294,264	68
June	264,379	582,171	372,089	103,259	268,830	64
July	317,396	643,571	406,867	117,638	289,229	63
August	268,813	595,802	358,406	111,309	247,097	60
September	285,724	618,913	395,220	113,167	282,053	64
October	267,916	548,426	379,500	91,009	288,491	69
November	284,057	516,501	354,113	70,998	283,115	69
December	299,994	657,360	451,834	80,781	371,053	69

2. Outline of Waste-to-Energy

Energy Recovery Status





<Energy Recovery Status (2008~2013)>

<Status of MSW Treatment (2008~2013)>

* Source : Korea Incinerating Conference

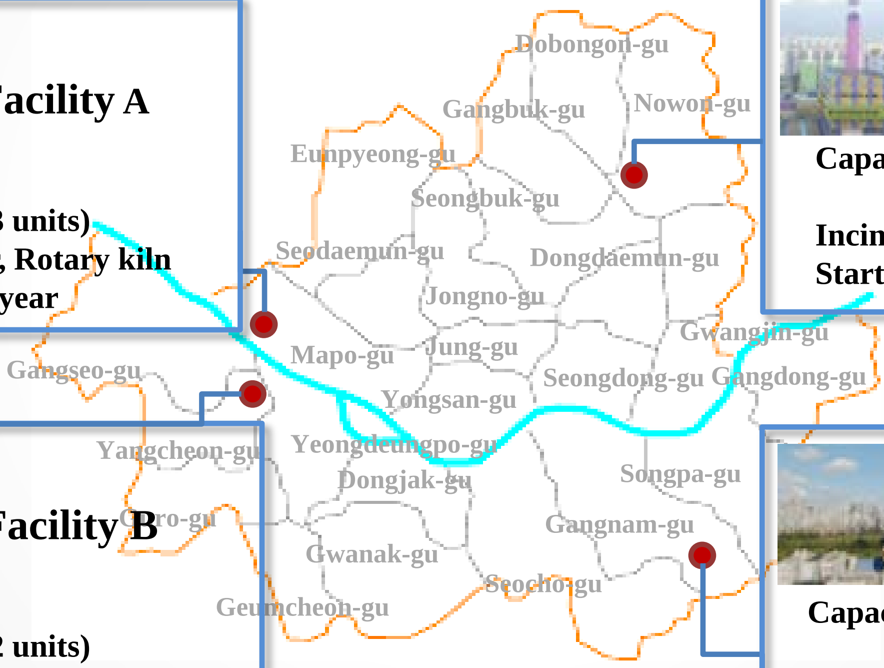
- **Waste heat increase supplied into District heat**
- **Since 2011, electricity production and sales have grown rapidly**

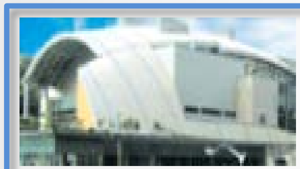
  - Self consumption was about 50% of electricity production in 2013

3. Energy Efficiency Analysis of WtE Plants in Seoul

Subject facilities (WTE Plants in Seoul)

- **4 Waste-to-Energy plants in Seoul area were studied.**





Facility A

Capacity : 750 ton/day
(250 ton/day × 3 units)
Incineration type : Stoker, Rotary kiln
Starting operation : 2005 year

Facility B

Capacity : 400 ton/day
(200 ton/day × 2 units)
Incineration type : Grate stocker
Starting operation : 1996 year

Facility C

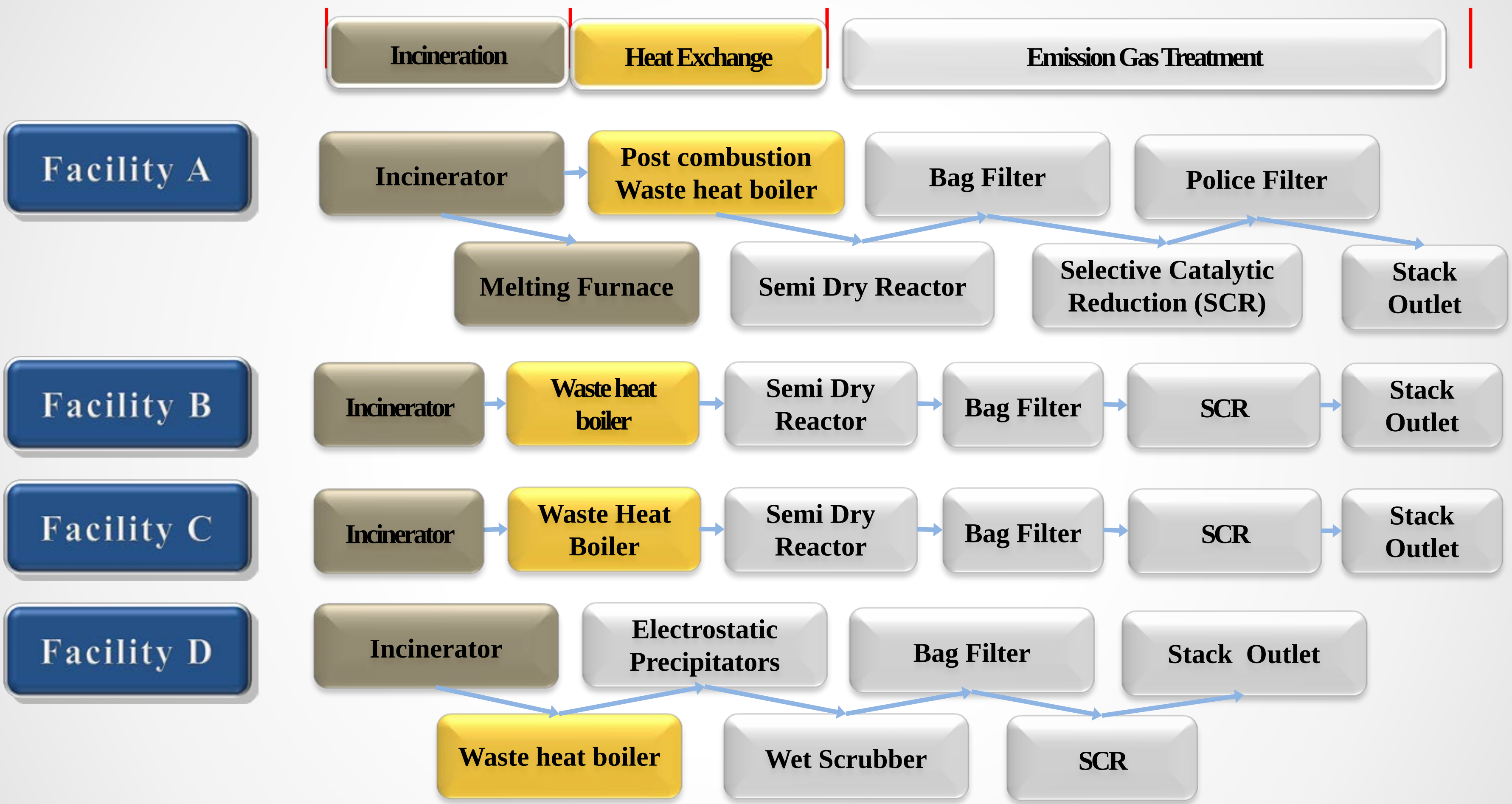
Capacity : 900 ton/day
(300 ton/day × 3 units)
Incineration type : Horizontal stocker
Starting operation : 2002 year

Facility D

Capacity : 800 ton/day
(400 ton/day × 2 units)
Incineration type : Rotary stoker
Starting operation : 1997 year

3. Energy Efficiency Analysis of WtE Plants

Subject facilities (WTE Plants in Seoul)



Energy Recovery at WtE Plants

- **It was carried out in terms of MSW process, operation status and utilization of waste heat during 2011 ~ 2013.**

<The Utilization Status of Waste Heat at Subject Facility (2013)>

Incineration facility		A	B	C	D
Steam	Inside	21.4	24.2	4.5	24.4
	Outside	13.6	70.8	95.5	75.6
Electricity	Inside	4.5	3.3	-	-
	Outside	2.5	1.7	-	-
Warm water	Inside	-	-	-	-
	Outside	58	-	-	-
Total		100	100	100	100

Remark] Inside denotes energy utilization inside the plants, etc.

3. Energy Efficiency Analysis of WtE Plants

Energy Recovery Equation

- **Energy recovery efficiency was calculated using the following equations.**

1) Korea's Energy Recovery Method
2) R1
3) Heat Loss Equation

Korea's Energy Recovery Method

$$\text{Energy Recovery Efficiency (\%)} = \frac{\text{Total Recovery Energy}}{\text{Total Input Energy}} \times 100$$

Total Input Energy

- Waste input heat
- Fuel input heat
- Combustion gas

Incineration facility

Total Recovery Energy

- Steam
- Warm wind
- Warm water

Heat Loss Equation

$$\text{Heat Recovery Efficiency (\%)} = \frac{\text{Total Heat Loss}}{\text{Total Input Heat}} \times 100$$

Input Heating Quantity + Auxiliary Fuel Quantity = Heat Loss + Recovery Heat

2. Materials and Methods

Energy Recovery Equation

R1

$$R1 = \frac{E_P - (E_f + E_i)}{0.97 \times (E_w + E_f)}$$

- 0.60 for installations in operation and permitted in accordance with applicable Community legislation before 1 January 2009.
- 0.65 for installations permitted after 31 December 2008.

- **MSW definition is not clear**
- **The factors of 1.1 and 2.6 have a lack of scientific basis**
- **Although it is different to use recovery energy in Each country, energy efficiency is set to identical guideline**

$$E_P = 1.1 \times E_{th} + 2.6 \times E_{fuel}$$

$$E_f = \sum m_{fuel} \times NCV_{fuel}$$

$$E_w = m_{waste} \times NCV_{waste}$$

E_P : The energy produced by the electricity (Gcal/year)

E_f : Total quantity contributed Steam production (Gcal/year)

E_i : exclude E_w and E_f of annual input energy (Gcal/year)

0.97 : Energy loss factor

E_{th} : Energy quantity of produced heat (Gcal/year)

E_{el} : Energy quantity of produced electricity (Gcal/year)

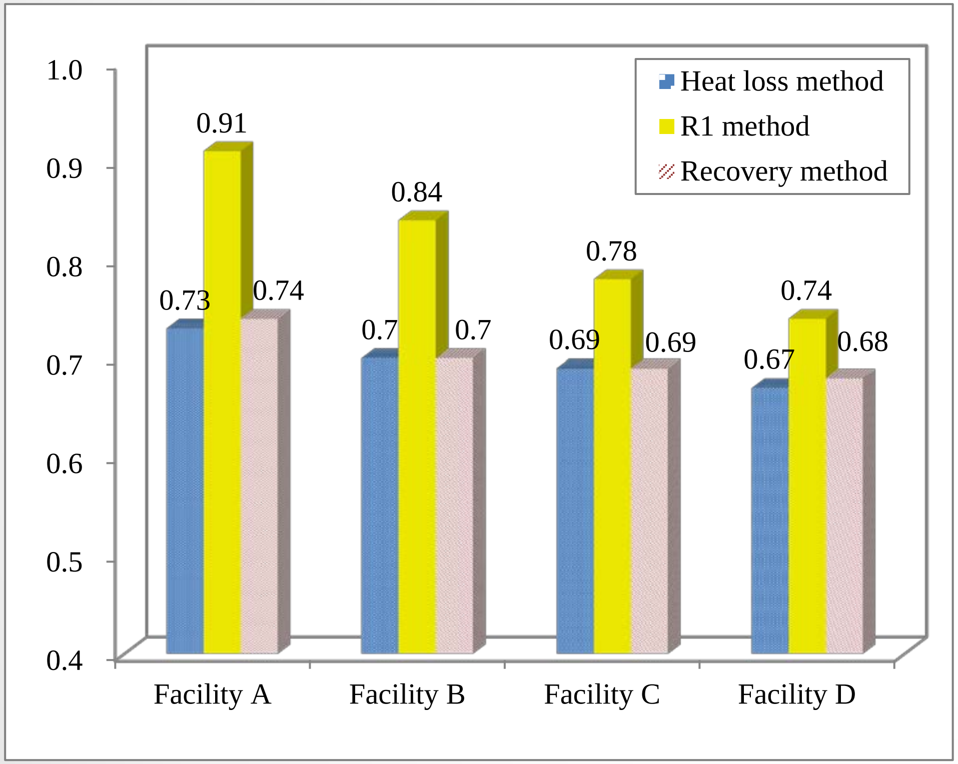
* Source : EU (2008) Guidelines on the R1 energy efficiency formula in Annex II of Directive 2008/98/EC

4. Results & Discussion

The Comparison of Energy Recovery Efficiency

Different Energy Recovery Efficiency by each formula

Optimization of Treatment Process

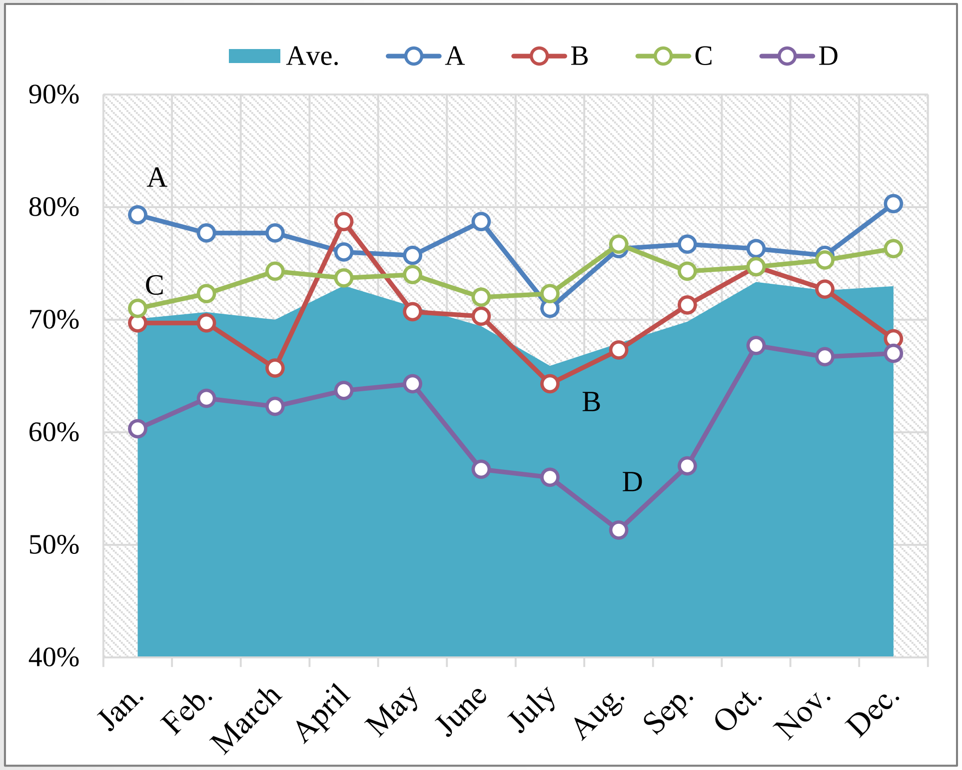


<The Comparison of Energy Recovery Efficiency (2013)>

- Heat loss method and recovery method showed similar values
- R1 method is showing the highest value
  - ➡ R1 is made by EU, it is difficult to reflect domestic(Korea) situation
- High energy loss in facility D
  - ➡ Mismatch between pollution control facilities

Seasonal Change of Energy Utilization

Energy Utilization Changes depending on Seasonal Variation



Recovery Efficiency (%)	
Except in summer	In summer
71.2 ~ 76.1	63.4 ~ 68.9

- Low energy utilization in summer
- ➡ Low heat demand and steam wasted

<Seasonal Variation of Energy Utilization Efficiency(2013)>

5. Conclusions

5. Conclusions

To raise recovery energy…

- In summer, energy utilization efficiency was relatively low because heat demand is relatively small and steam is wasted.

  ➡ **Various approaches like district cooling needs to be considered to improve energy efficiency**

- Korea's Energy Recovery Method is considered only output except actual energy consumption

  ➡ **Energy efficiency estimation method should be reconsidered to reflect the actual energy application situations.**

Thank you for your attention!

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