

# **Current Status and Future Direction for Thermal Treatment of Wastes in Korea**

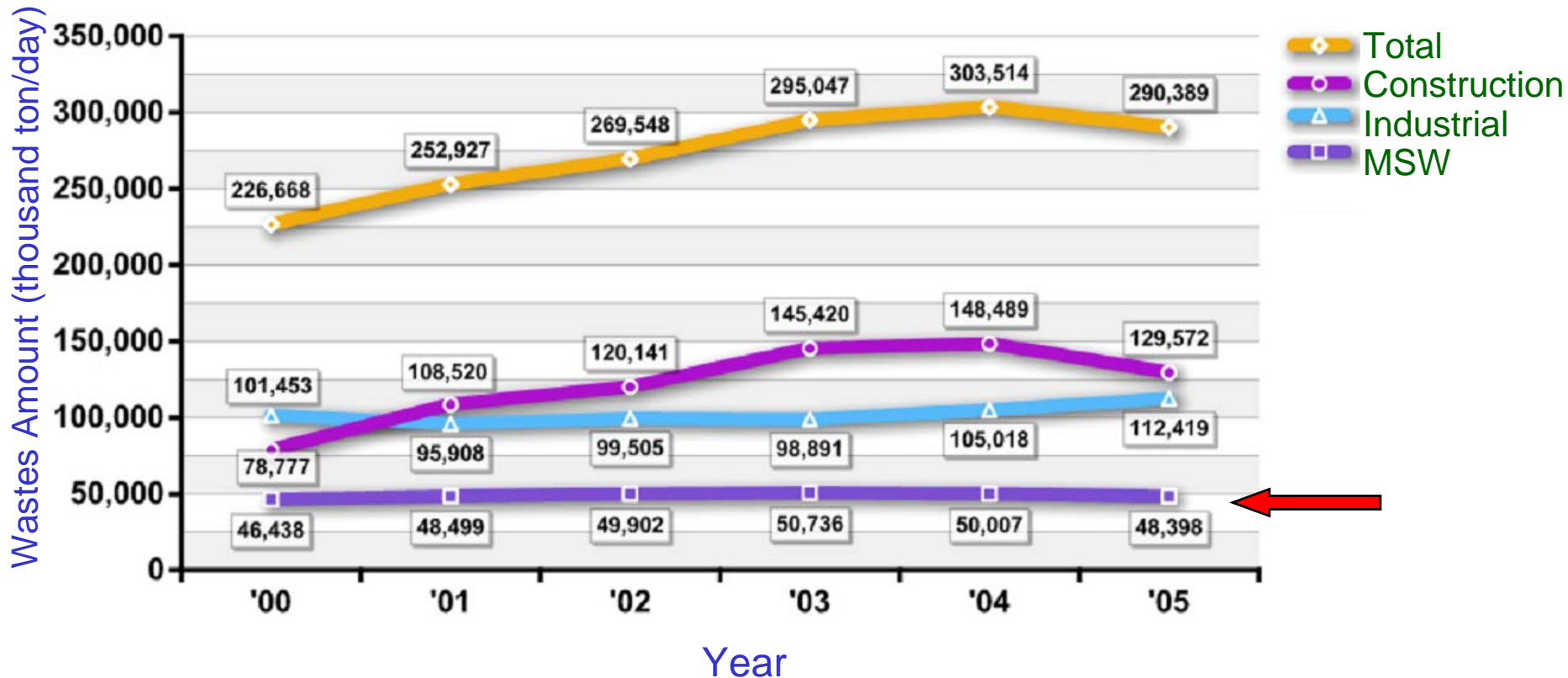
2007. 5. 15.

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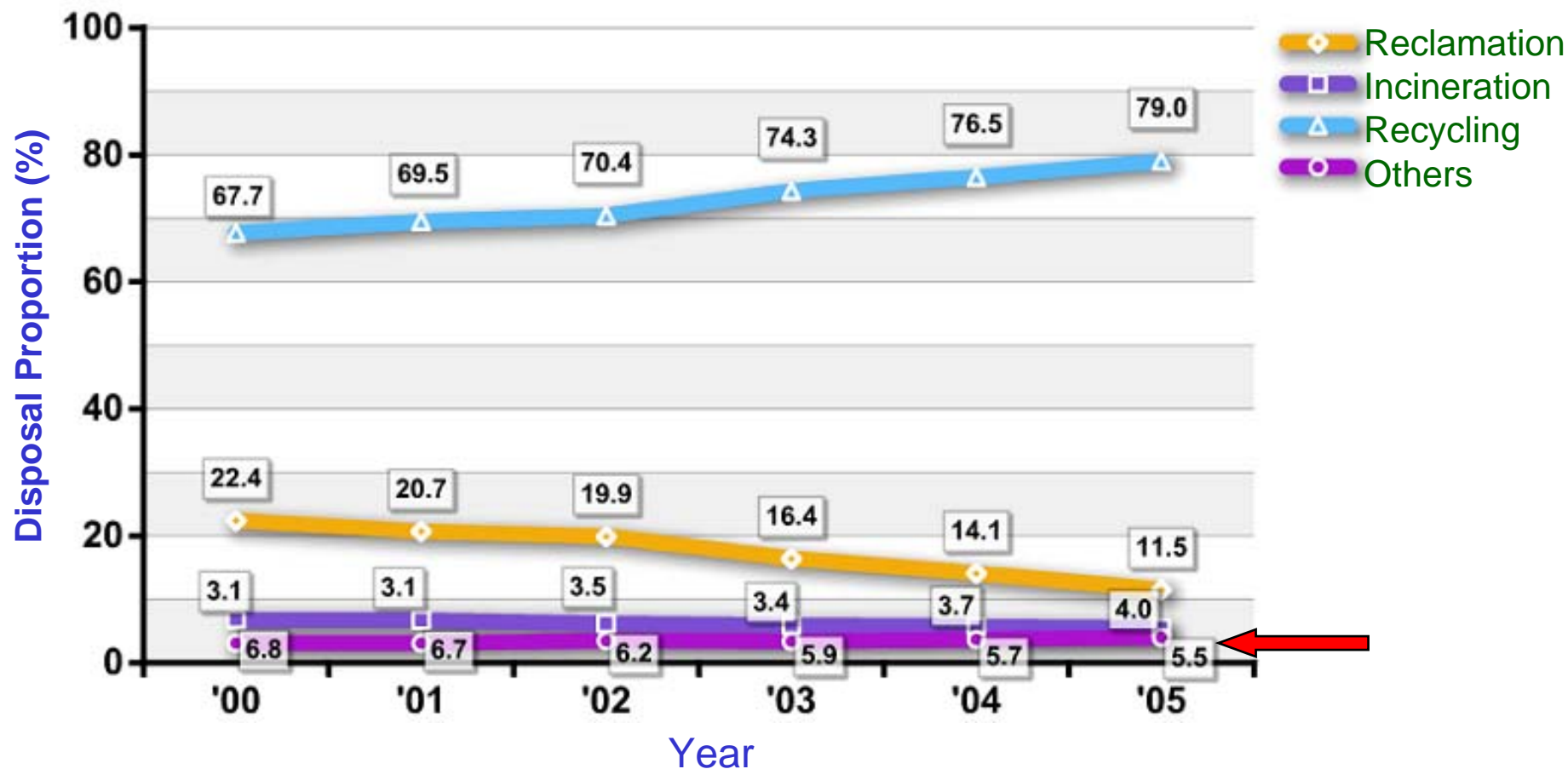
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# Waste Amount Generated in Korea



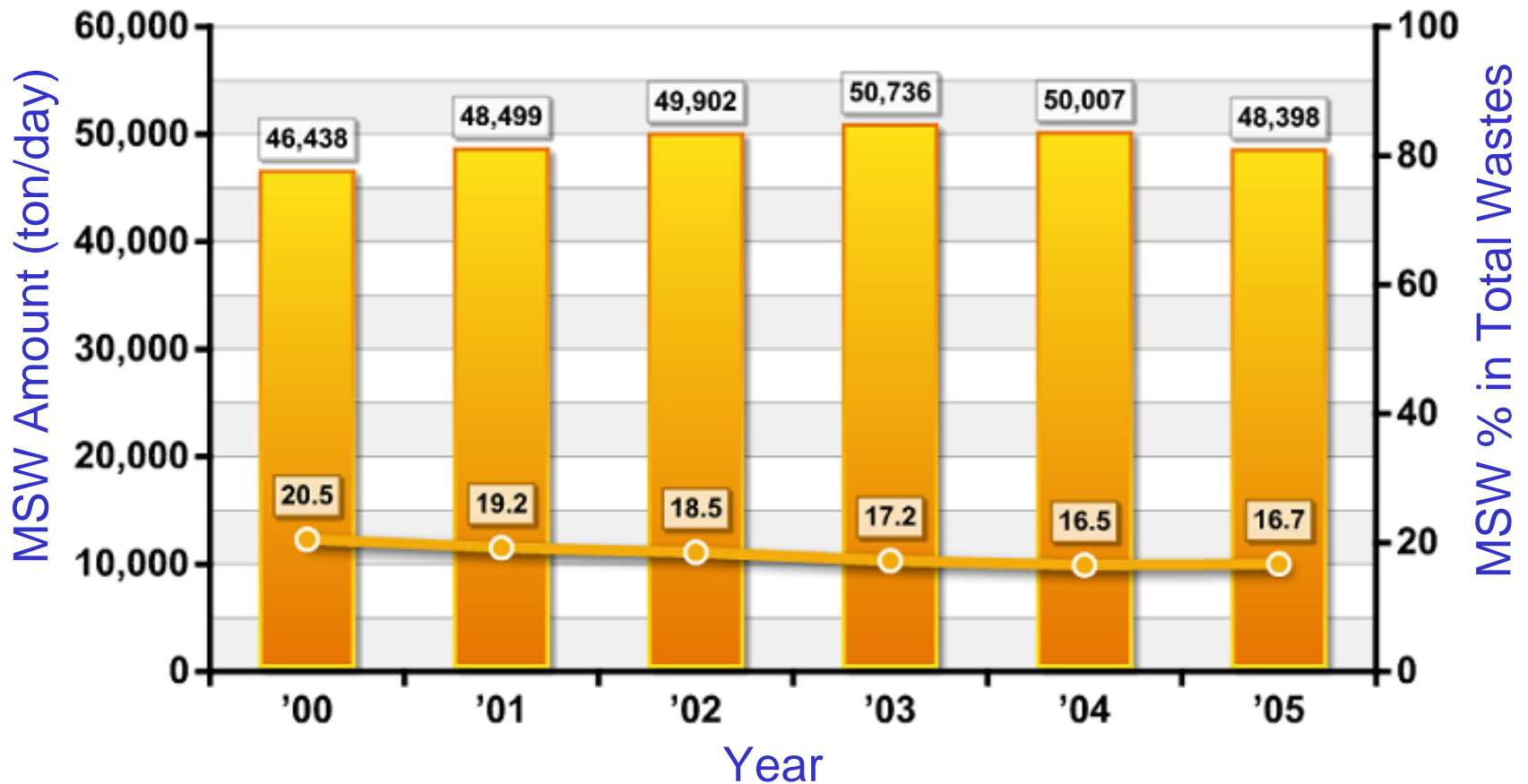
MSW amount is relatively remained constant.

# Trend of Wastes Disposal Methods for Total Wastes



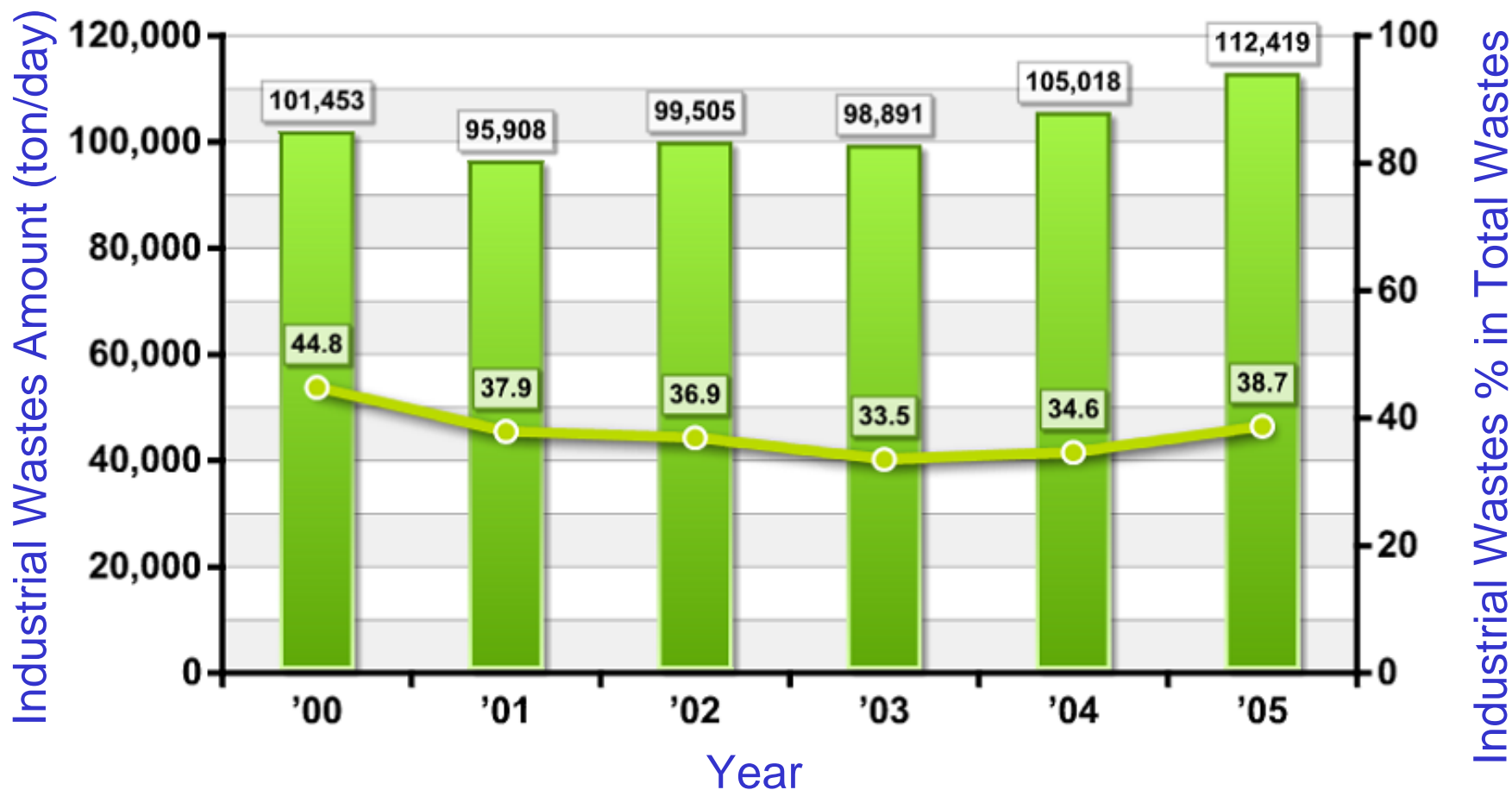
Incineration amount (ton/day) : '02, 16,786 / '03, 17,316 / '04, 17,217 / '05, 15,941

# MSW Generated in Korea (2005)

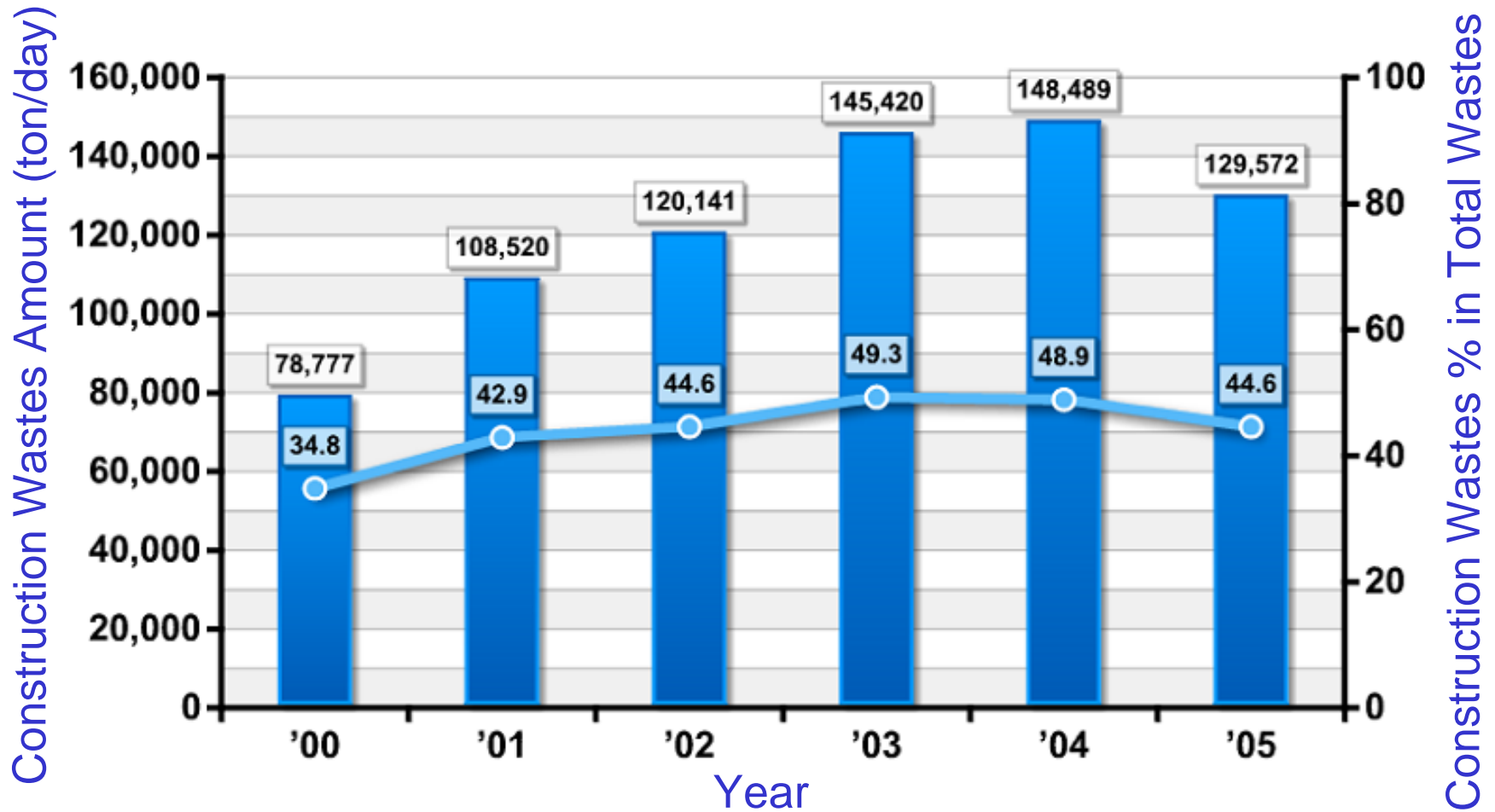


■ '03 : 1.05 kg-MSW/person/day    '04 : 1.03 kg-MSW/person/day  
'05 : 0.99 kg-MSW/person/day

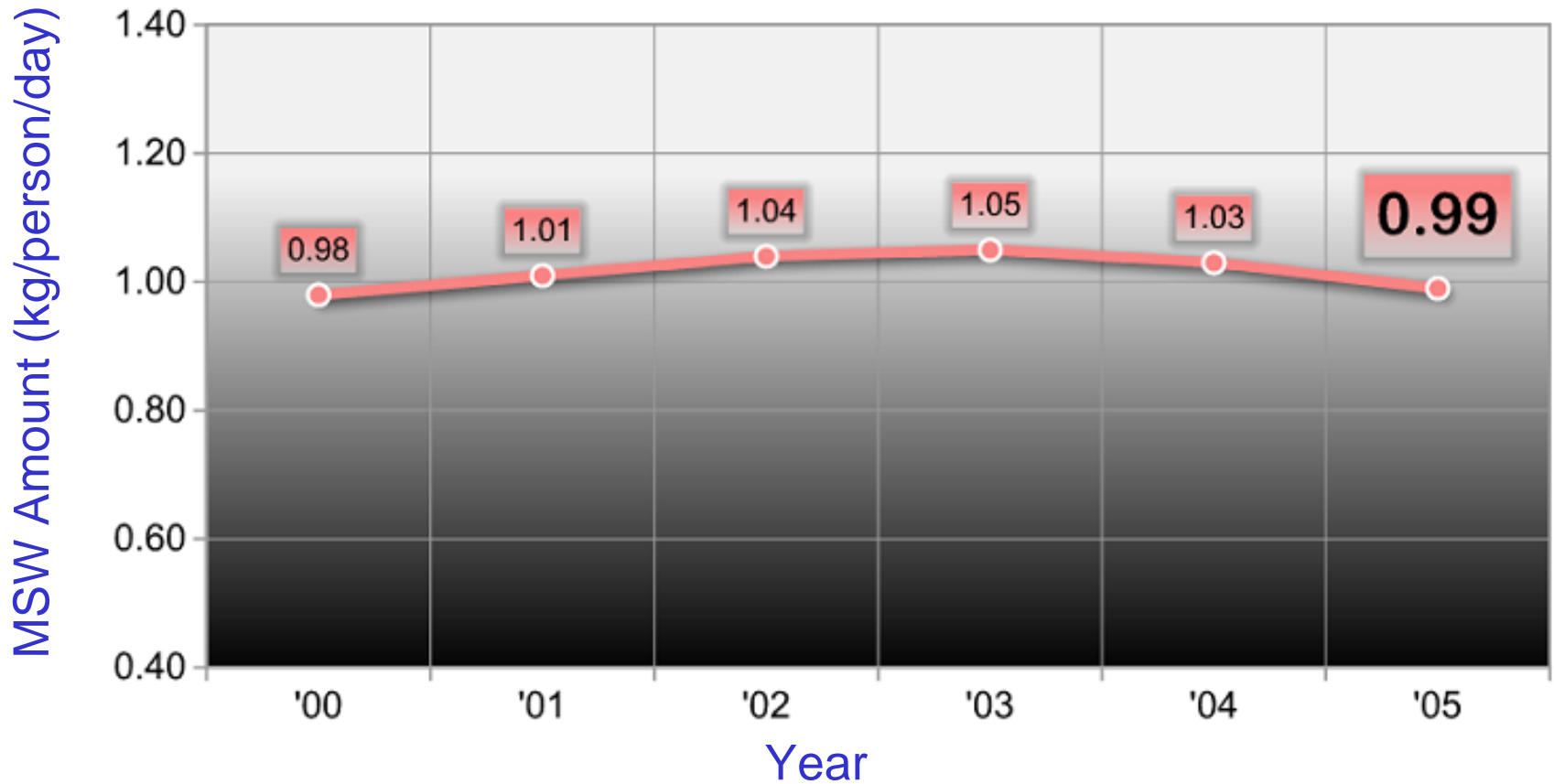
# Industrial Wastes Generated in Korea (2005)



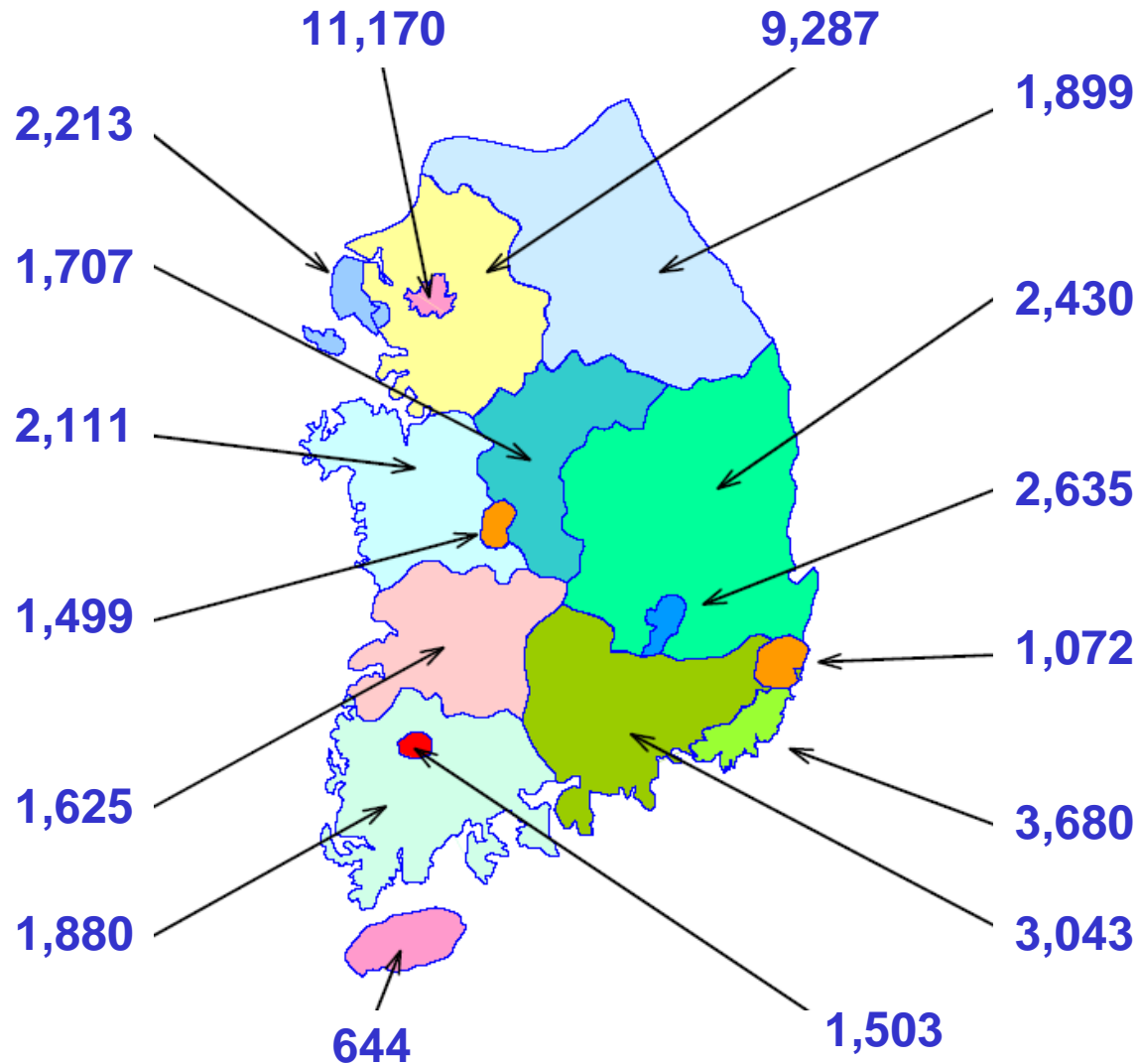
# Construction Wastes Generated in Korea (2005)



# MSW amount generated in Korea (2005) (kg/person/day)



# MSW Amount (ton/day) in Korea ('05)



Seoul, Gyeonggi province are major MSW generating area.



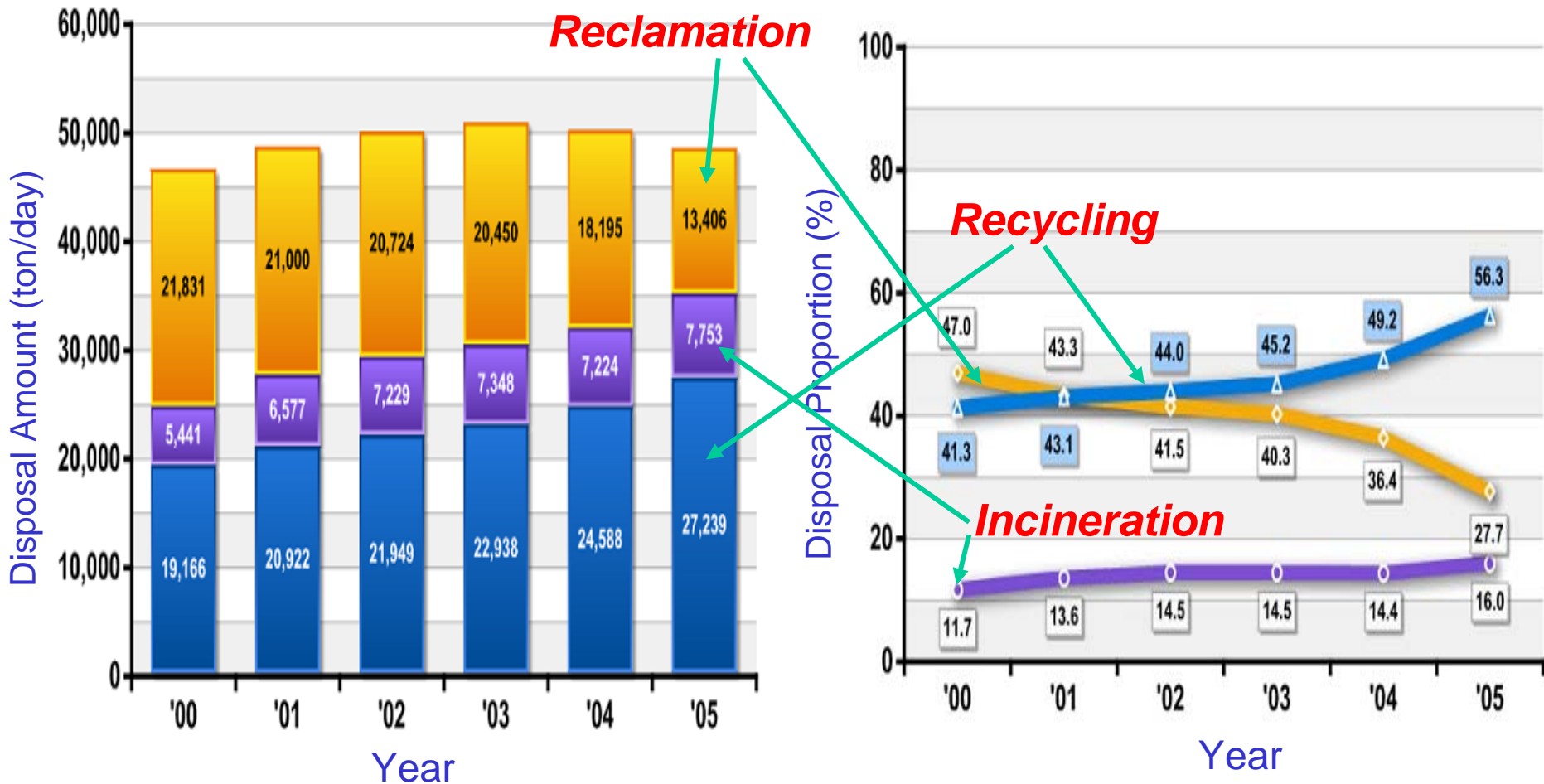
# Yearly Variation of MSW Composition (ton/day)

| Year                    |                                        | '98               | '99               | '00               | '01               | '02               | '03               | '04               | '05               |
|-------------------------|----------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| <b>Total</b>            |                                        | 31,767            | 32,394            | 32,734            | 34,247            | 35,302            | 35,786            | 35,142            | 33,670            |
| <b>Combustibles</b>     | <b>Kitchen food wastes, Vegetables</b> | 11,798<br>(37.1%) | 11,577<br>(35.7%) | 11,434<br>(34.9%) | 11,237<br>(32.8%) | 11,397<br>(32.3%) | 11,398<br>(31.9%) | 11,464<br>(32.6%) | 12,977<br>(38.5%) |
|                         | <b>Papers</b>                          | 5,620             | 5,786             | 5,577             | 5,746             | 5,641             | 5,624             | 5,735             | 5,473             |
|                         | <b>Woods</b>                           | 1,848             | 1,862             | 1,965             | 2,400             | 2,400             | 2,454             | 2,421             | 2,261             |
|                         | <b>Etc.</b>                            | 7,169             | 8,087             | 8,700             | 9,281             | 10,641            | 10,642            | 9,819             | 8,502             |
|                         | <b>Sub-total</b>                       | 26,435            | 27,312            | 27,676            | 28,664            | 30,079            | 30,118            | 29,439            | 29,213            |
| <b>Non-combustibles</b> | <b>Anthracite briquette ash</b>        | 918               | 746               | 648               | 601               | 535               | 595               | 574               | 611               |
|                         | <b>Metal, Glass, Porcelain</b>         | 1,074             | 1,034             | 982               | 954               | 886               | 896               | 845               | 705               |
|                         | <b>Etc.</b>                            | 3,340             | 3,302             | 3,428             | 4,028             | 3,802             | 4,177             | 4,284             | 3,141             |
|                         | <b>Sub-total</b>                       | 5,332             | 5,082             | 5,058             | 5,583             | 5,223             | 5,668             | 5,703             | 4,457             |

# Typical MSW Pictures (S city , Gyunggi Province)



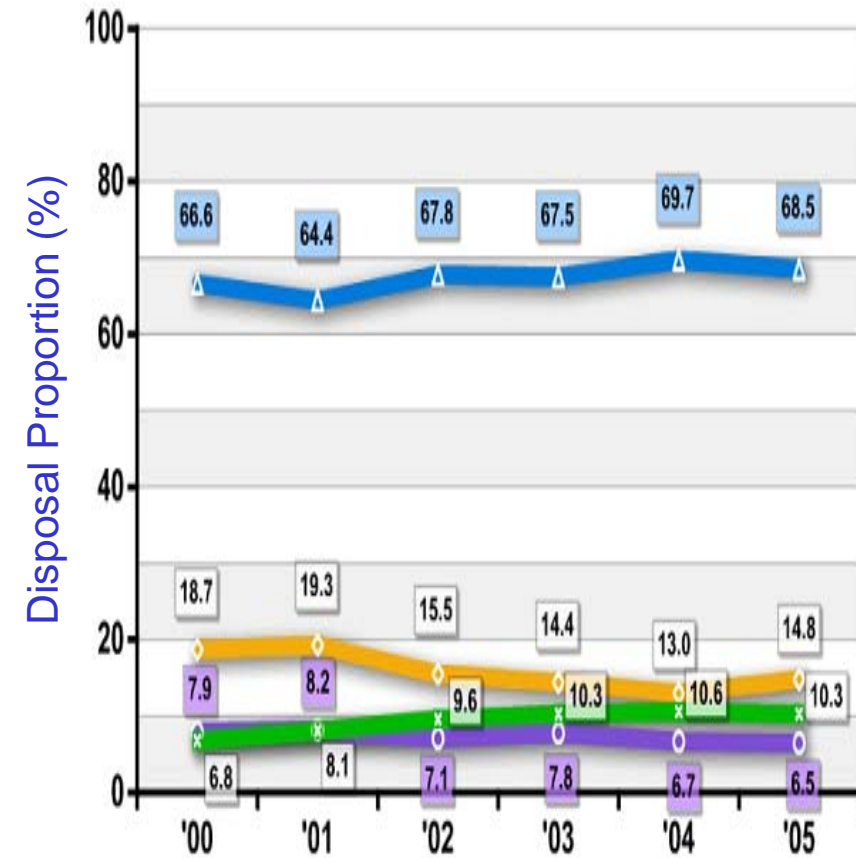
# Trend of MSW Disposal Methods



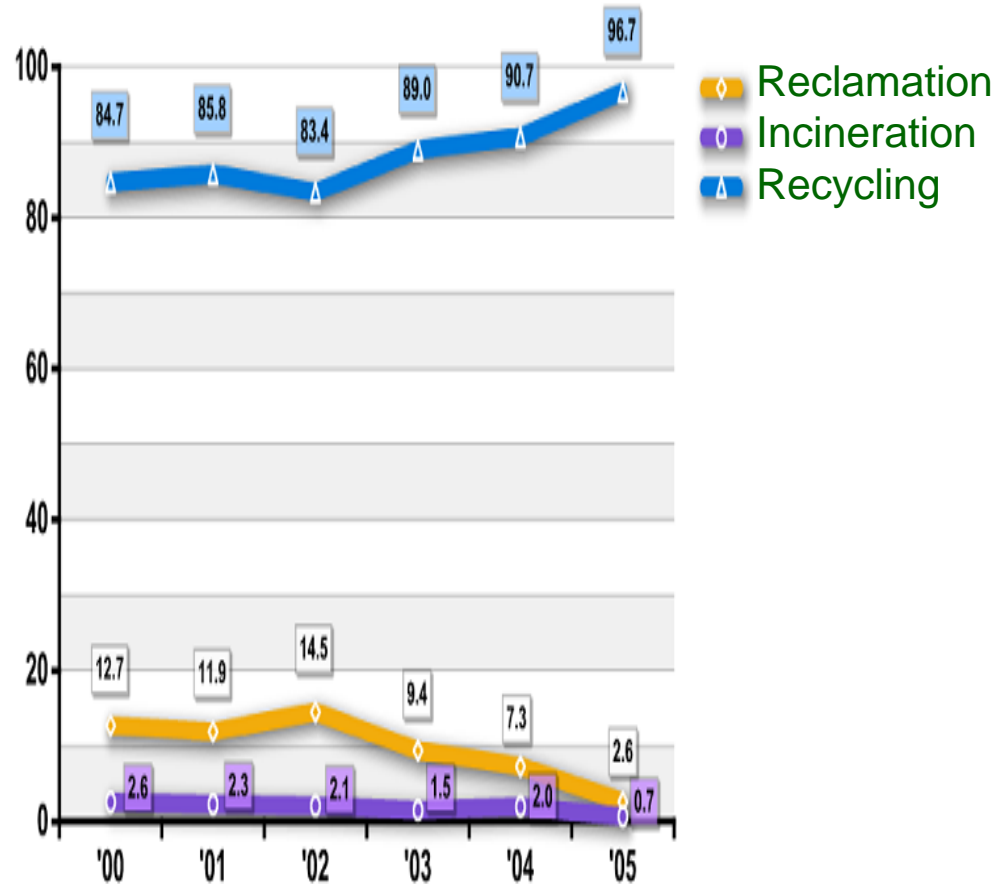
- Government intends to increase the incineration rate to 30% by 2011, but resistance by NGO and others persists.

# Trend of Disposal Methods

## Industrial Wastes



## Construction Wastes



# Status of Large-scale MSW Incineration Plants in Korea (1/2)

| Name        | Province Location | Capacity |    | MSW Heating Value (kcal/kg) | Composition |              |       |
|-------------|-------------------|----------|----|-----------------------------|-------------|--------------|-------|
|             |                   | T/D      | ea |                             | Moisture    | Combustibles | Ash   |
| Suwon       | Gyeonggi          | 300      | 2  | 2,006                       | 50.74       | 41.86        | 7.40  |
| Daesangdong | Gyeonggi          | 300      | 1  | 2,787                       | 40.49       | 52.85        | 6.66  |
| Samjungdong | Gyeonggi          | 200      | 1  | 2,377                       | 42.52       | 47.75        | 9.73  |
| Gwangmyung  | Gyeonggi          | 150      | 2  | 2,551                       | 37.28       | 52.50        | 10.22 |
| Nowon       | Seoul             | 400      | 2  | 2,582                       | 33.99       | 56.63        | 9.38  |
| Pyungchon   | Gyeonggi          | 200      | 1  | 2,898                       | 30.14       | 56.66        | 13.20 |
| Dadae       | Busan             | 200      | 1  | 2,306                       | 47.38       | 45.38        | 7.24  |
| Yangcheon   | Seoul             | 200      | 2  | 2,790                       | 31.46       | 53.07        | 15.47 |
| Mapo        | Seoul             | 250      | 3  | 2,603                       | 33.23       | 51.05        | 15.72 |
| Sungnam     | Gyeonggi          | 300      | 2  | 2,554                       | 33.54       | 56.41        | 10.05 |
| Ilsan       | Gyeonggi          | 300      | 1  | 3,023                       | 35.55       | 56.37        | 8.09  |
| Changwon    | Gyeongnam         | 200      | 2  | 2,649                       | 47.76       | 42.72        | 9.52  |
| Sungseo     | Daegu             | 200      | 3  | 2,874                       | 34.44       | 53.98        | 11.58 |
| Haewoondae  | Busan             | 200      | 2  | 2,409                       | 43.44       | 48.43        | 8.13  |
| Yongin      | Gyeonggi          | 100      | 3  | 2,527                       | 33.79       | 58.41        | 7.80  |
| Gwacheon    | Gyeonggi          | 80       | 1  | 1,927                       | 44.03       | 46.29        | 9.68  |

- ❑ Total 59 incinerators are operating at 33 sites.
- ❑ MSW heating values are increasing above 3,000 kcal/kg at some sites.



# Status of Large-scale MSW Incineration Plants in Korea (2/2)

| Name      | Province Location | Capacity |    | MSW Heating Value (kcal/kg) | Composition |              |       |
|-----------|-------------------|----------|----|-----------------------------|-------------|--------------|-------|
|           |                   | T/D      | ea |                             | Moisture    | Combustibles | Ash   |
| Woolsan   | Woolsan           | 200      | 2  | 2,293                       | 43.73       | 44.84        | 11.43 |
| Ansan     | Gyeonggi          | 200      | 1  | 2,715                       | 34.11       | 58.28        | 7.61  |
| Sangmoo   | Gwangju           | 200      | 2  | 2,987                       | 35.30       | 51.00        | 13.70 |
| Suji      | Gyeonggi          | 35       | 2  | 2,119                       | 35.47       | 54.56        | 9.98  |
| Gonghang  | Incheon           | 70       | 2  | 2,249                       | 45.42       | 47.58        | 7.00  |
| Gunpo     | Gyeonggi          | 200      | 1  | 2,934                       | 33.86       | 59.64        | 6.50  |
| Gimhae    | Gyeongnam         | 200      | 1  | 3,262                       | 25.55       | 63.33        | 11.12 |
| Chonan    | Chungnam          | 200      | 1  | 1,976                       | 44.39       | 49.84        | 5.77  |
| Guri      | Gyeonggi          | 100      | 2  | 3,139                       | 32.58       | 61.58        | 5.85  |
| Chungra   | Incheon           | 250      | 2  | 2,195                       | 39.96       | 45.36        | 14.68 |
| Gangnam   | Seoul             | 300      | 3  | 2,946                       | 30.33       | 56.30        | 13.37 |
| Euljungbu | Gyeonggi          | 100      | 2  | 2,501                       | 36.64       | 46.00        | 17.36 |
| Paju      | Gyeonggi          | 100      | 2  | 3,033                       | 33.52       | 61.69        | 4.79  |
| Myungji   | Busan             | 200      | 2  | 2,239                       | 47.85       | 42.21        | 9.95  |
| Daejeon   | Daejeon           | 200      | 2  | 2,047                       | 38.33       | 51.09        | 10.58 |
| Sanpuk    | Jeju              | 100      | 2  | 1,858                       | 41.10       | 47.45        | 11.45 |
| Sannam    | Jeju              | 70       | 1  | 1,831                       | 44.20       | 46.33        | 9.47  |

# Current Perception for Thermal Treatment of Wastes in Korea

## □ Nearby residents

- NIMBY continues.
- Want more stringent dioxin reduction in medium-size industrial wastes incinerators.
  - Regulation standards : 1 ng-TEQ/Nm<sup>3</sup>
  - Typical agreement with residents : 0.1 ng-TEQ/Nm<sup>3</sup>
- For MSW incinerators, sometimes want below 0.01 ng-TEQ/Nm<sup>3</sup>
- But, if new thermal technology is applied, acceptable with conditions.

## □ Korean Government

- Maximize recycling. For this purpose, wants to expedite MBT.
- Policy to shut-down small incinerators due to high dioxin generation.
- Policy to push for co-use of installed large-size MSW incinerators among nearby municipalities.
- Incentives in construction cost share of Government (30% → 50%) for new incinerators when co-use among nearby municipalities.

## □ Environmental NGO's

- Prefer MBT and full-recycling.
- Minimum thermal treatment.

# Effects of Stockholm Convention for thermal treatment of wastes in Korea

- ❑ Korea officially joined the Stockholm Convention on Persistent Organic Pollutants in January 25, 2007.
- ❑ More strong regulation in dioxin from incineration of industrial wastes is inevitable.
- ❑ Official policy of Ministry of Environment
  - includes the reduction of total dioxin production in Korea to meet the requirement of the Convention.
  - by enforcing more stringent regulation in incineration of wastes, particularly industrial wastes.

## ◆ Dioxin produced amount in Korea (2001)

| Facility                        | Incineration     |                   |                         | Non-incineration |                 |           |          |                   |                  |                         | Total  |
|---------------------------------|------------------|-------------------|-------------------------|------------------|-----------------|-----------|----------|-------------------|------------------|-------------------------|--------|
| Area                            | MSW              | Industrial Wastes | Sum                     | Steel            | Non-steel metal | Non-metal | Chemical | Energy Combustion | etc. (crematory) | Sum                     |        |
| Dioxin produced amount (g-ITEQ) | 163.5<br>(16.0%) | 728.16<br>(71.4%) | 891.6<br><b>(87.4%)</b> | 96.4             | 15.0            | 3.1       | 0.6      | 9.8               | 4.1              | 128.9<br><b>(12.6%)</b> | 1020.5 |



# Dioxin emission standards for incinerators in Korea

## ◆ Dioxin emission standard for incinerators in Korea

| Capacity       | New Plant | Existing Plant        |                  |
|----------------|-----------|-----------------------|------------------|
|                |           | 2001.1.1 – 2005.12.31 | After 2006. 1. 1 |
| above 4 ton/hr | 0.1       | 20                    | 1                |
| 2-4 ton/hr     | 1         | 40                    | 5                |
| 0.2-2 ton/hr   | 5         | 40                    | 10               |

Note: excluding medical wastes and above 2 ton/hr MSW incinerators

## ◆ Dioxin emission standard for large (above 2 ton/hr) MSW incinerators

| New Plant | Existing Plant built before 97. 7. 19 |                  |
|-----------|---------------------------------------|------------------|
|           | till 2003. 6. 30                      | after 2003. 7. 1 |
| 0.1       | 0.5                                   | 0.1              |

(Unit : ng-TEQ/Nm<sup>3</sup>)

# Trend in Waste Pyrolysis Combustion/Gasification Technologies

## ❑ Current status :

- **Europe** Stalled – lots of interest, but no action
- **USA** None (except for a very few States/companies)
- **Canada** Interest is picking up
- **Australia** Interest is dying down
- **Japan** Very active

## ❑ Bottleneck issues in each country :

- **Europe** Process risk
- **USA** Cheap disposal (in most States), delays to RCRA (Resource Conservation and Recovery Act)
- **Canada** Increased costs
- **Australia** Cheap disposal, disillusionment with suppliers
- **Japan** State of the economy (economics)

# Construction Status of MSW Pyrolysis/Gasification Melting Plants in Korea

| Site                     | Capacity               | Company Name                           | Technology Supplier | Type          | Project Start Year |
|--------------------------|------------------------|----------------------------------------|---------------------|---------------|--------------------|
| Yangsan City             | 100 ton/day<br>2 units | POSCO Construction Co.                 | Nippon Steel        | Shaft         | 2003               |
| Yangju City              | 100 ton/day<br>2 units | Dongbu Construction Co.                | R21                 | Rotary kiln   | 2005               |
| Koyang City              | 150 ton/day<br>2 units | POSCO Construction Co.                 | Nippon Steel        | Shaft         | 2006               |
| Eunpyung New Town, Seoul | 48 ton/day<br>1 unit   | GS Construction Co.<br>+ Hyosung Ebara | EBARA               | Fluidized-bed | 2006               |
| Pangyo, Sunghnam City    | 45 ton/day<br>2 units  | Halra Industrial Develop. Co.          | KOBELCO             | Fluidized-bed | 2006               |
| Hwasyng City             | 150 ton/day<br>2 units | GS Construction Co.<br>+ Hyosung Ebara | EBARA               | Fluidized-bed | 2007               |
| Dalsung, Daegu City      | 70 ton/day<br>1 unit   | Hyosung Ebara                          | EBARA               | Fluidized-bed | 2007               |

# Technical Issues for Thermal Treatment in Korea

## 1) Issues by high heating value in MSW

- Way of maintaining the design capacity of incinerators
- Grate material, refractory problems and new grate design

## 2) Waste-To-Energy Issue

- Practical applicability of RDF, RPF
- System design with steam turbine and steam distribution
- Applicability of combined cycle
- Government incentives as a renewable energy

## 3) Introduction of MBP (Mechanical-Biological Pretreatment)

- Introduction timing and scale
- Verification with Korean MSW
- Adaptation of existing incinerators
- Whole new design of incinerator

## 4) Property of MSW in Korea

- High moisture content by food wastes

# Technical Issues *(continued)*

## 5) Dioxin Issues

- Inherent removal of dioxin
- Cheap and reliable after-treatment in flue gas
- Way of changing concept in NGO and other environmental groups
- Bad impression of people, although technically dioxin is not a problem anymore in large-scale incinerators :  
**Prejudice** : Incineration = Dioxin producer = Environment polluter
- Increased people's expectation in MSW treatment

## 6) Introduction of Pyrolysis Combustion/Gasification Melting technologies

- In construction at 7 sites
- Need a good operation performance

# Trend of Heating Value in Korean MSW

| Year | Heating Value (kcal/kg) |         | Composition (wt%) |              |     | No. of plant sites for data collection |
|------|-------------------------|---------|-------------------|--------------|-----|----------------------------------------|
|      | Average                 | Maximum | Moisture          | Combustibles | Ash |                                        |
| 1997 | 1,496                   | 2,001   | 54                | 35           | 11  | 10                                     |
| 1999 | 1,511                   | 2,019   | 53                | 36           | 11  | 15                                     |
| 2001 | 1,578                   | 2,981   | 50                | 40           | 10  | 27                                     |
| 2002 | 1,945                   | 3,403   | 47                | 43           | 10  | 29                                     |
| 2003 | 2,243                   | 3,892   | 42                | 46           | 12  | 33                                     |
| 2004 | 2,302                   | 3,340   | 41                | 49           | 10  | 32                                     |
| 2005 | 2,541                   | 3,611   | 38                | 52           | 10  | 33                                     |

□ Mainly due to :

- Lower moisture, food wastes
- Higher content of vinyls, plastics, papers, woods/leaves, textiles

□ Clear trend in moisture, combustibles

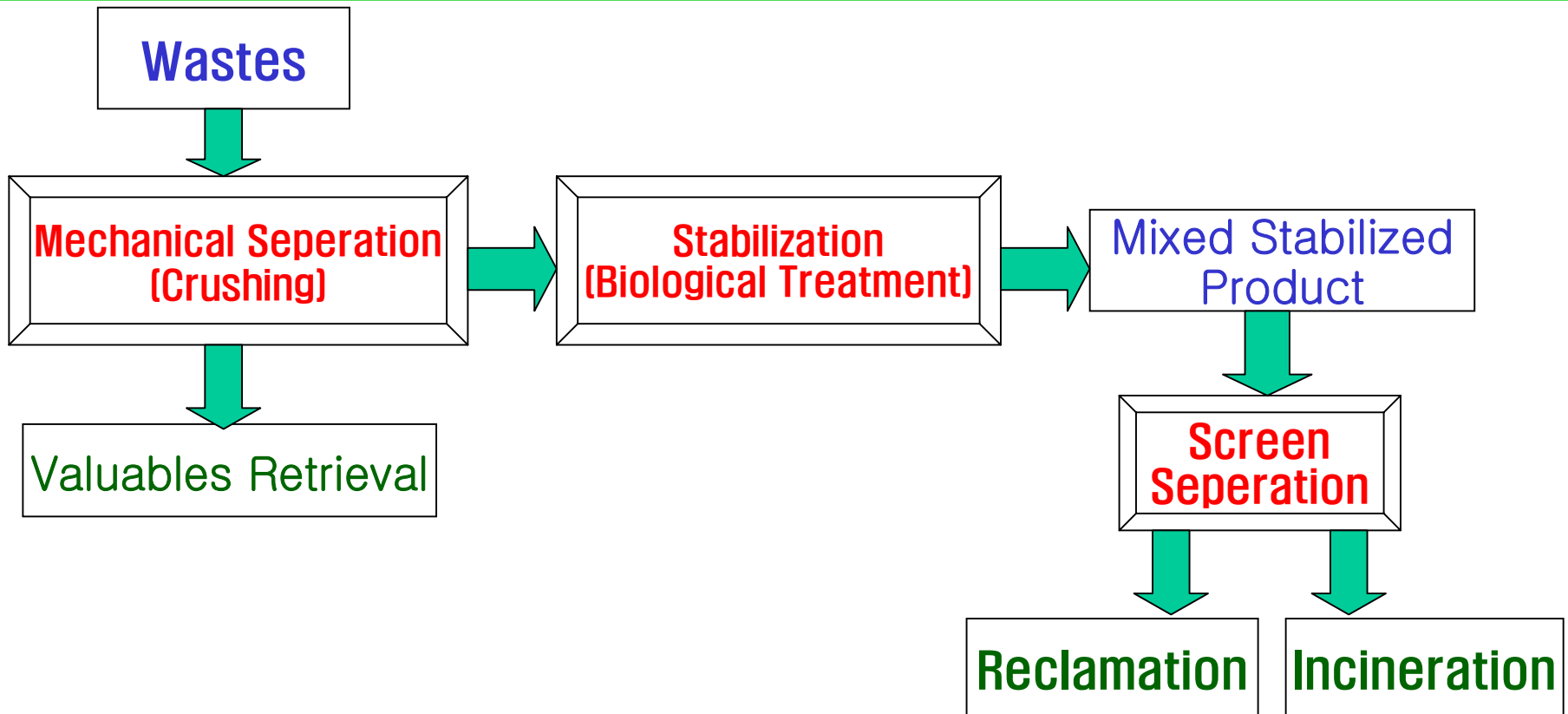
# Electricity Price Incentive for New & Renewable Energies in Korea (2006. 9.)

| Source             |         | Eligible Capacity | Apply Zone       | Base price (Won/kWh) |                | Current Price (Won/kWh) | Remarks                           | Foreign Cases |
|--------------------|---------|-------------------|------------------|----------------------|----------------|-------------------------|-----------------------------------|---------------|
|                    |         |                   |                  | Fixed price          | Variable Price |                         |                                   |               |
| Sun-light          |         | Above 3 kW        | Above 30 kW      | 677.38               | -              | 716.40                  | Reduction rate 4% (after 3 years) | 183~689 Won   |
|                    |         |                   | Below 30 kW      | 711.25               | -              |                         |                                   |               |
| Wind               |         | Above 10 kW       |                  | 107.29               | -              | 107.66                  | Reduction rate 2% (after 3 years) | 37~109 Won    |
| Bio-energy         | LFG     | Below 50 MW       | Above 20 MW      | 68.07                | SMP+ 5         | 61.80                   |                                   | 59~138 Won    |
|                    |         |                   | Below 20 MW      | 74.99                | SMP+10         | 65.20                   |                                   |               |
|                    | Bio-gas | Below 50 MW       | Above 150 kW     | 72.73                | SMP+10         | New                     |                                   |               |
|                    |         |                   | Below 150 kW     | 85.71                | SMP+15         |                         |                                   |               |
|                    | Biomass | Below 50 MW       | Woody biomass    | 68.99                | SMP+5          | New                     |                                   |               |
| Waste Incineration |         | below 20 MW       | -                | -                    | SMP+ 5         | SMP+CP                  |                                   |               |
| Fuel Cell          |         | above 200 kW      | Biogas usage     | 234.53               | -              | New                     | Reduction rate 3% (after 2 years) |               |
|                    |         |                   | Other fuel usage | 282.54               | -              |                         |                                   |               |

\* Most of recovered energy from waste incineration is used as heat energy rather than to generate electricity. No incentive for recovered heat energy.

SMP (System Marginal Price), Average SMP in '05: 61.55 Won/kWh, CP (Capacity Payment)

# MBT (Mechanical Biological Treatment)



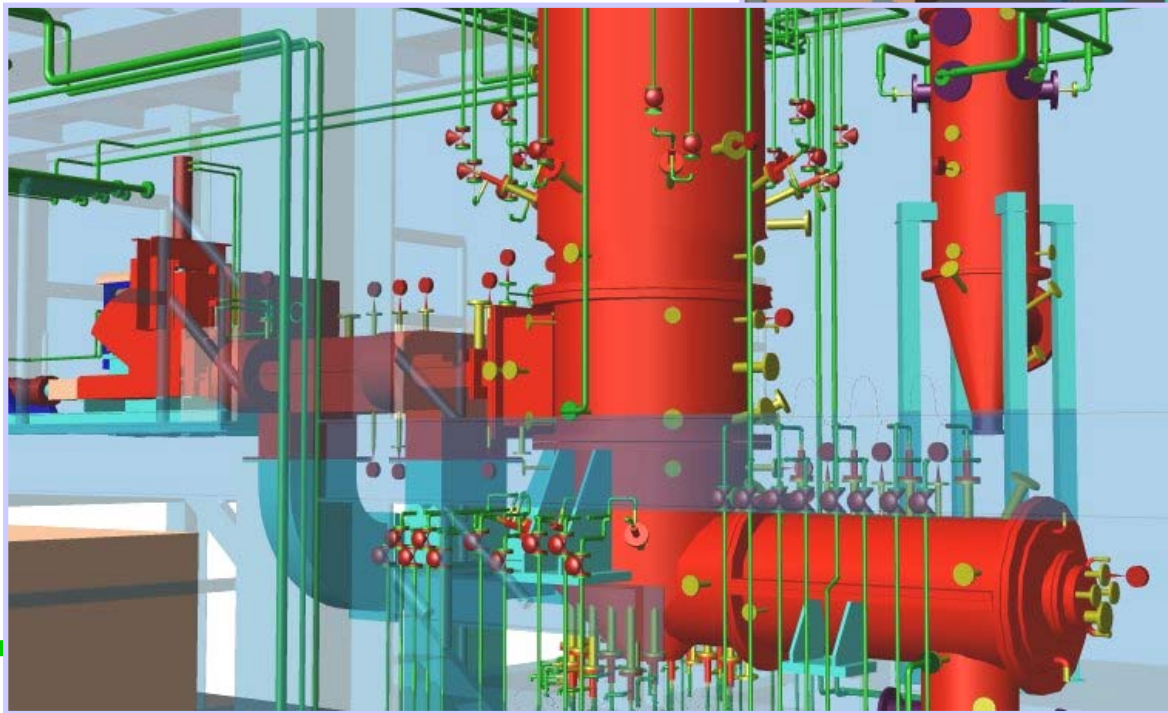
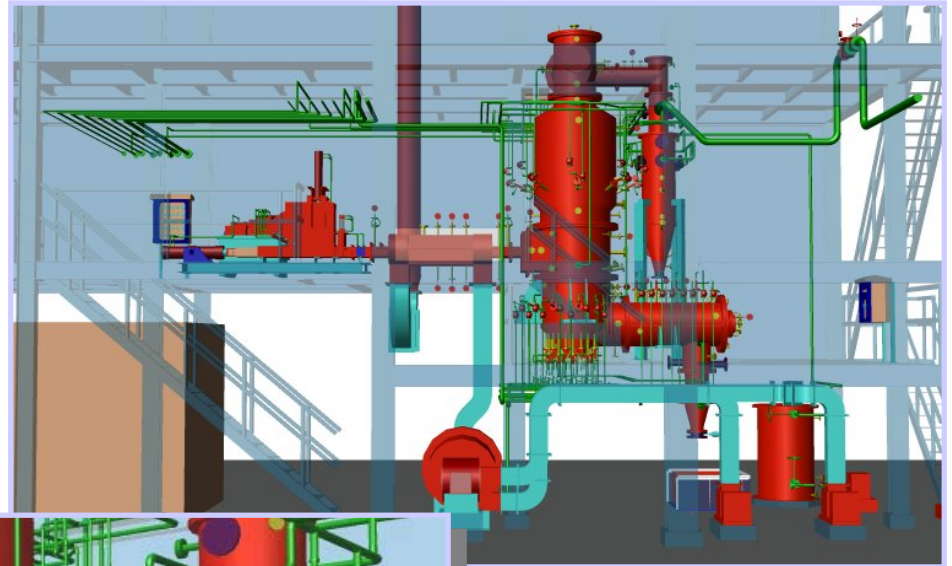
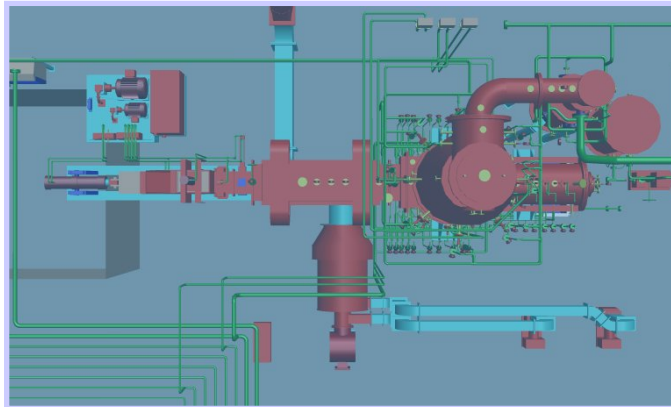
- ☐ Conceptually, best practice in MSW treatment
- ☐ Wide acceptance to NGO's and environmental groups
  - Maximizing retrieval of recycleables
  - Minimizing incineration/reclamation (minimizing of pollutants generation)
- ☐ However, many technical / economical issues to be solved



# Current Status on MBT in Korea

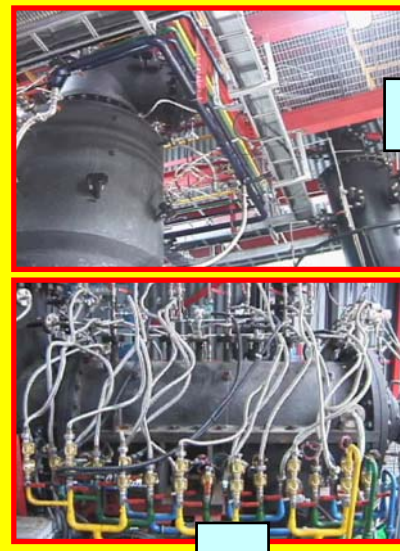
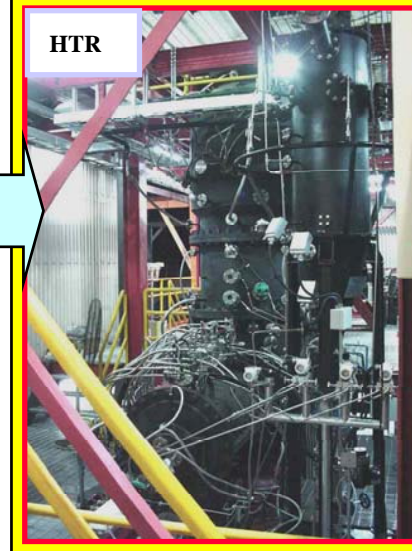
- ❑ Follow the trend of European countries
- ❑ Start 4 demonstration plants in 2007 by Government for different cases
  - Major city 200 ton/day, Medium city 90 ton/day, City in rural area 150 ton/day, Rural area 30 ton/day
- ❑ By 2010,
  - Construct 8 MBT plants (average 150 ton/day)
  - Pre-treat 15% (1,200 ton/day) of MSW reclamation amount (8,000 ton/day)
  - 3-4 plants configure as MBT + RDF cogeneration plant
- ❑ Long-term plan
  - Over 200 ton/day MBT plants for each major areas with a co-use concept by nearby municipalities

# MSW Pyrolysis Gasification Melting Pilot Plant at IAE

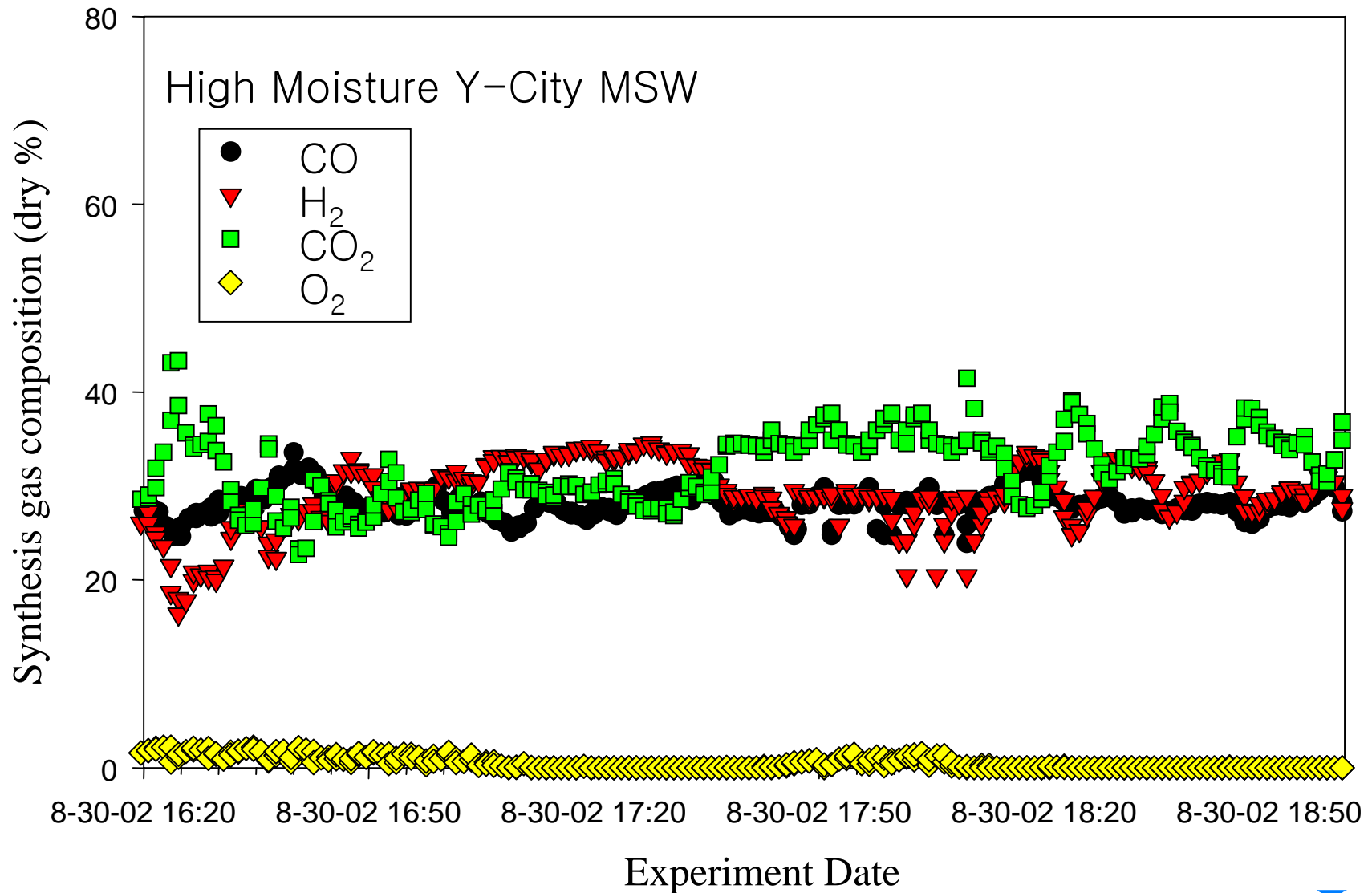


❑ Based on  
Thermoselect<sup>®</sup>  
process,  
modified for  
Korean MSW

# 3 Ton/Day MSW Gasification Pilot Plant at IAE



# Syngas Composition from High Moisture Korean MSW (55.8 wt% Moisture)





# Current Dioxin Reducing Techniques applied in Korea

- Reducing Cl-containing materials entering incinerators
  - Minimizing PVC, other Cl-containing plastics
  - Pre-screening
- Maintaining constant feeding rate of MSW into incinerators
- Control of incineration temperature at  $850 \sim 950^{\circ}\text{C}$ , residence time inside incinerator above 2 seconds
- Quick quenching of flue gas
- Sustaining MSW thickness above grate at  $50 \sim 100\text{cm}$
- Operation practice : flue gas quick quenching  $\rightarrow$  Boiler exit temperature ( $< 220^{\circ}\text{C}$ )  $\rightarrow$  Bag filter inlet temperature ( $< 180^{\circ}\text{C}$ )
- Applying SNCR or SCR (Use of de-dioxination catalysts)
- Lime mixed combustion (in study)
- Increasing incineration temperature (High temperature incineration)

# Conclusions

- ❑ Incinerated ratio of MSW in Korea is remained at 16% range with a minor increasing trend. To reach 30% incineration ratio, there are many barriers by people's preconception and very tight dioxin emission requirements that cannot be reached without further investment.
- ❑ More cheap and inherently reliable technology for dioxin reduction and removal is in great demand to increase the incineration rate for MSW as high as 30% in Korea.
- ❑ MBT is conceptually best candidate for future MSW treatment. However, more detailed pre-study is required regarding the technical suitability for Korean MSW and economics in Korean situation. Korean Government embarked the path for MBT with demonstration plants in 2007 and will have an impact on future incineration path.
- ❑ Interest is picking up for generating electricity from wastes by government incentives. But, the incentive is not high enough compared to other renewable energies.
- ❑ People accept the new thermal technology for wastes treatment right now and thus 7 new plants using new technologies are in construction in Korea. To maintain the acceptance trend, reliable operation data and construction experience for the pyrolysis combustion/gasification technologies are required.
- ❑ Pyrolysis/Gasification pilot plant using Korean MSW yielded a gas compositions in the range of 25-35% CO and 20-35% hydrogen, which is a good feedstock for the C1 chemistry.