

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

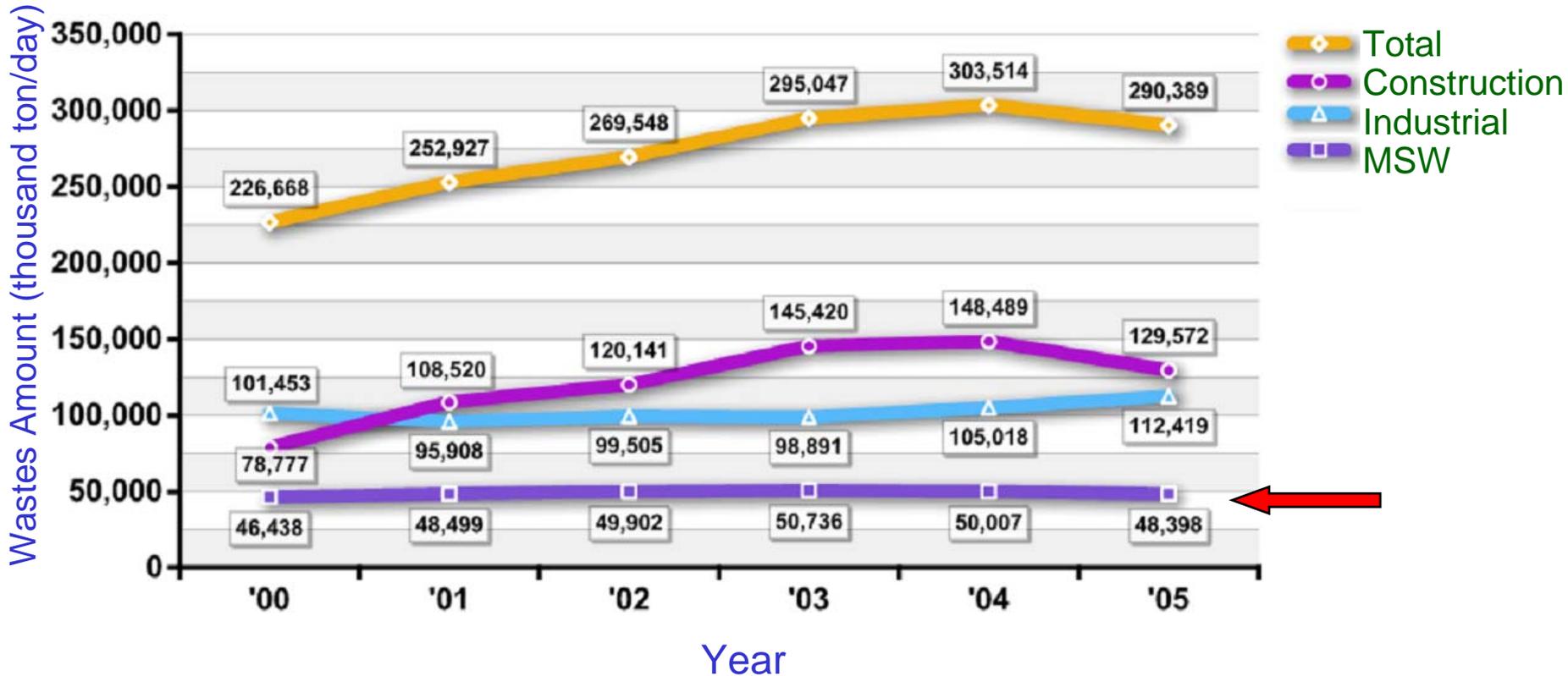
2007. 5. 15.

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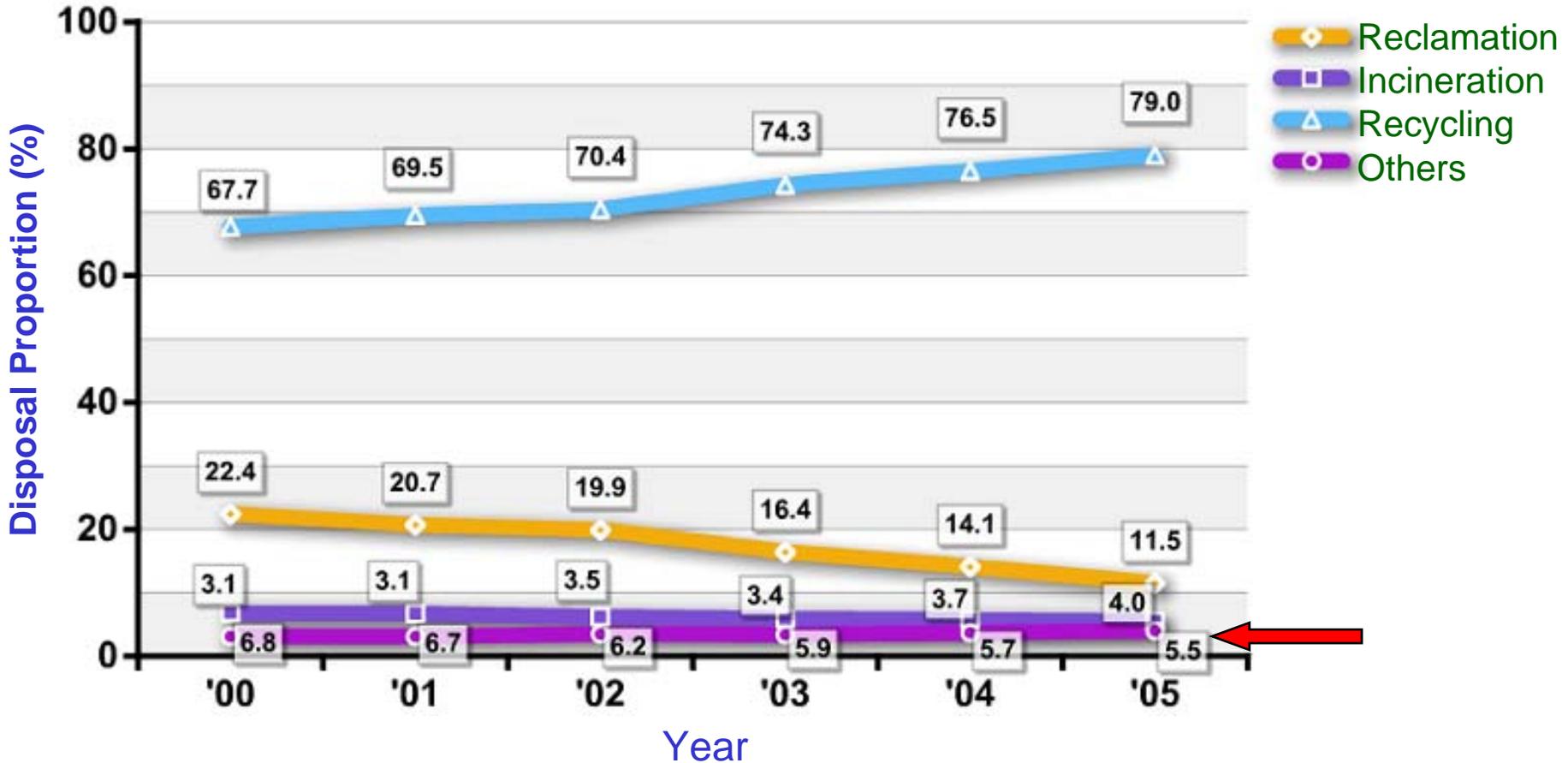
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Waste Amount Generated in Korea



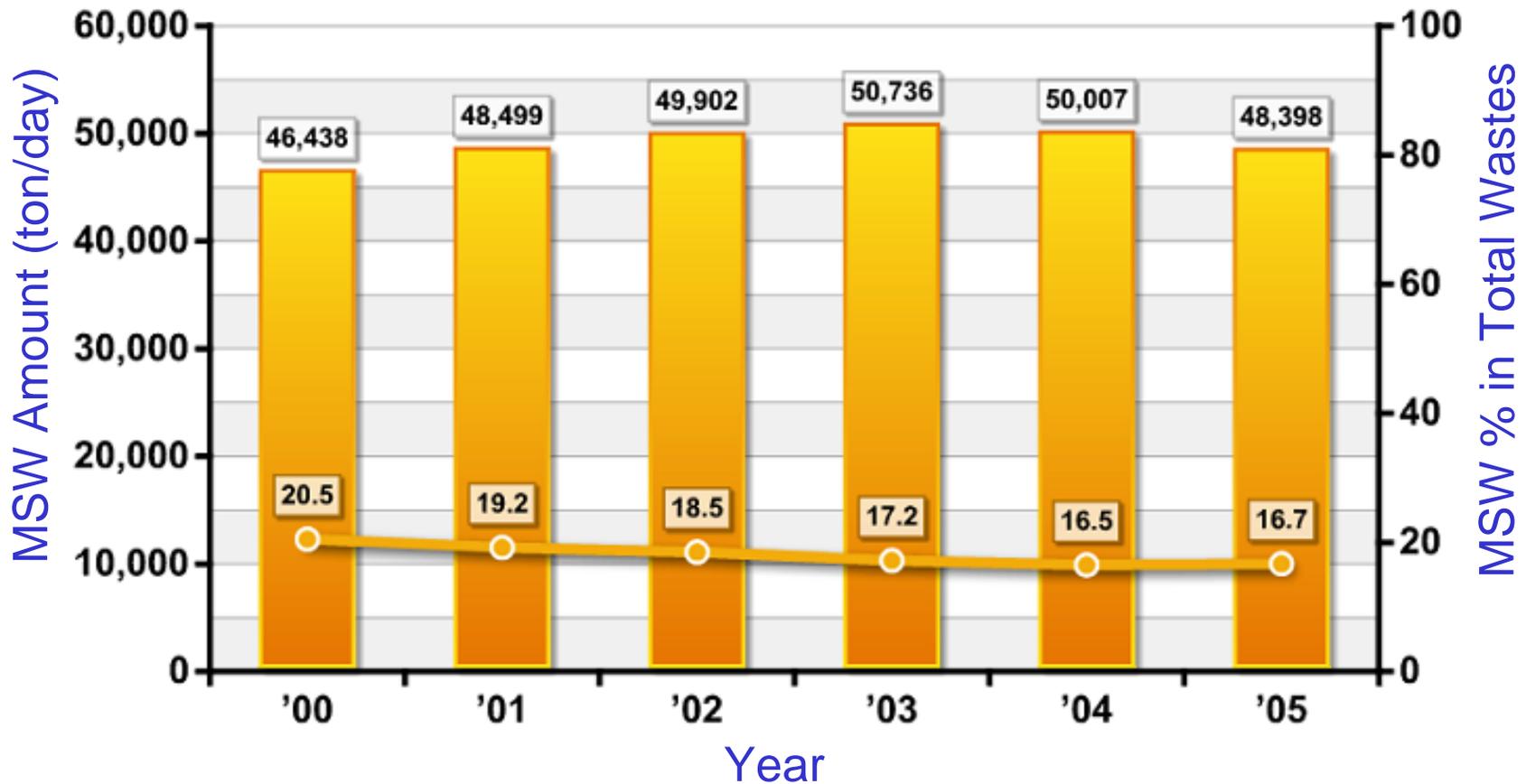
MSW amount is relatively remained constant.

Trend of Wastes Disposal Methods for Total Wastes



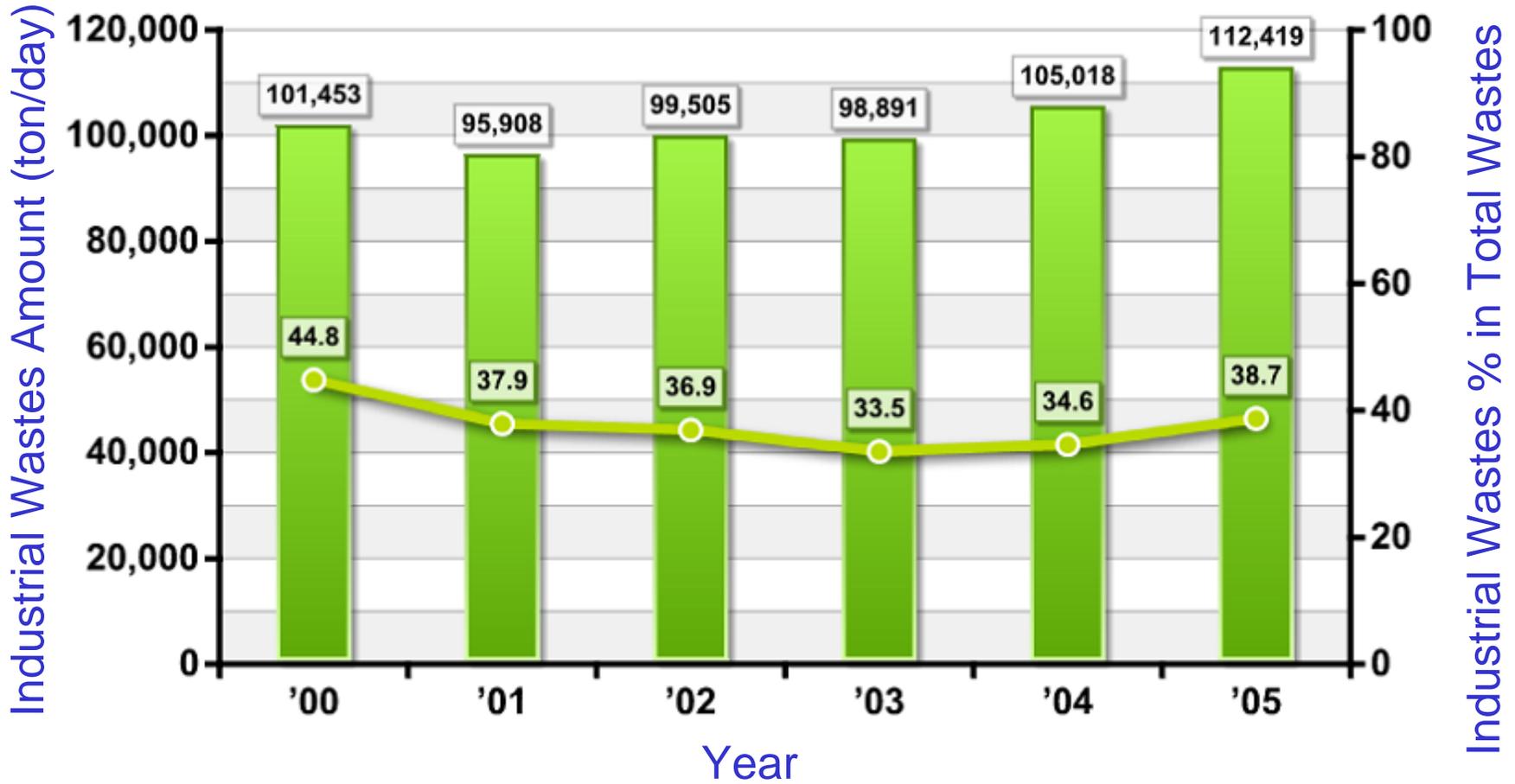
Incineration amount (ton/day) : '02, 16,786 / '03, 17,316 / '04, 17,217 / '05, 15,941

MSW Generated in Korea (2005)

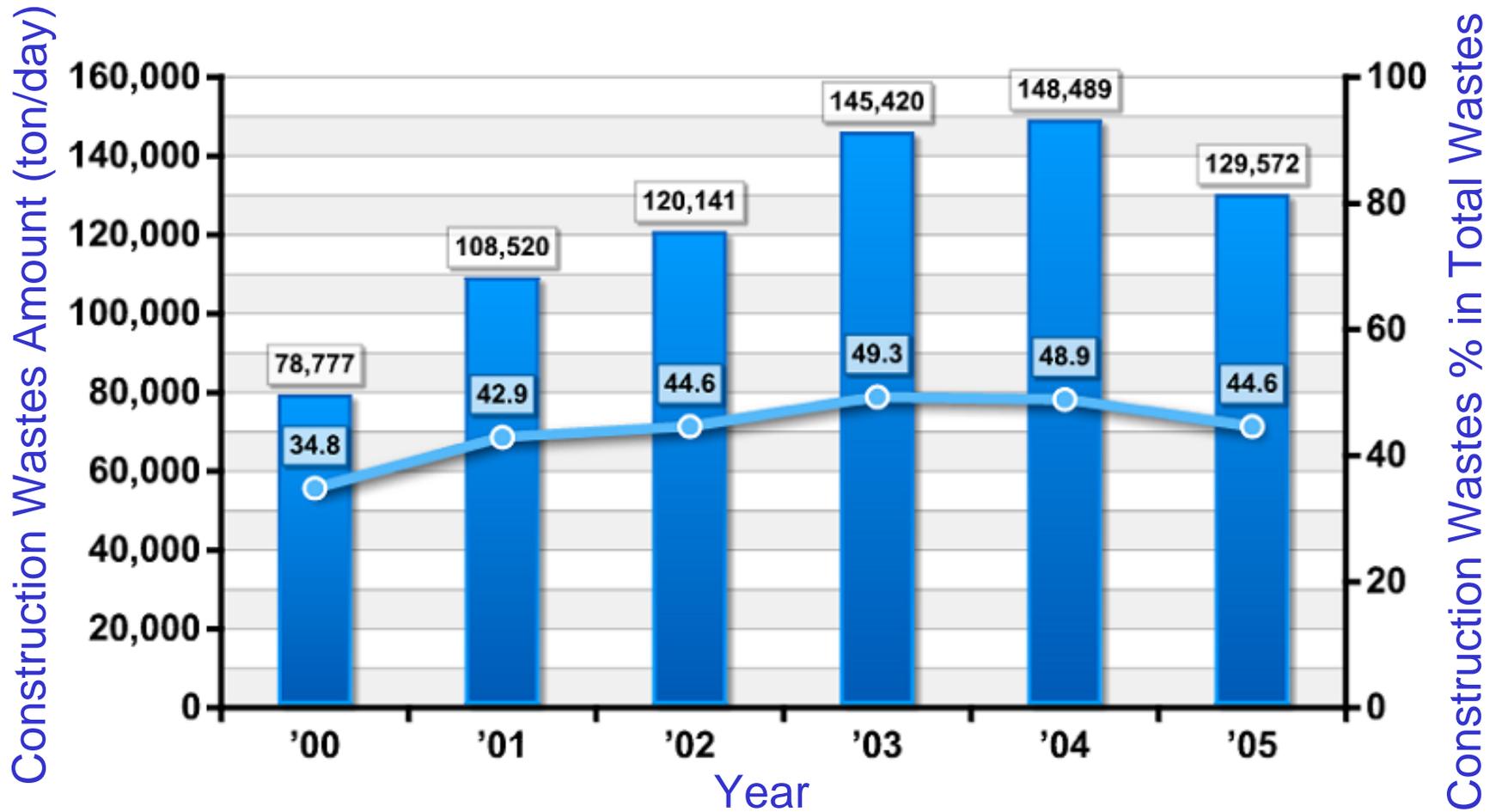


'03 : 1.05 kg-MSW/person/day '04 : 1.03 kg-MSW/person/day
'05 : 0.99 kg-MSW/person/day

Industrial Wastes Generated in Korea (2005)



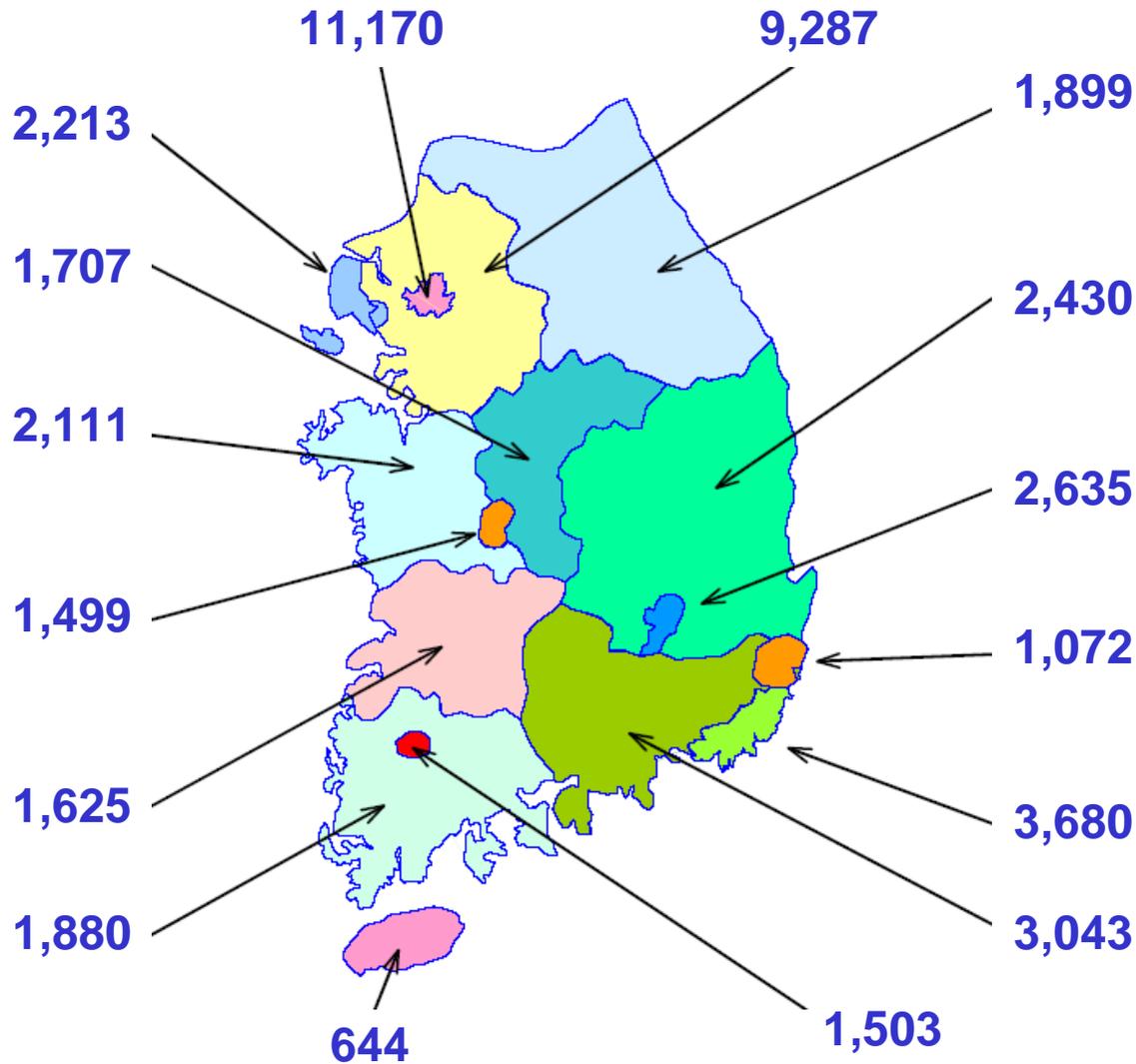
Construction Wastes Generated in Korea (2005)



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



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



□ Seoul, Gyunggi province are major MSW generating area.

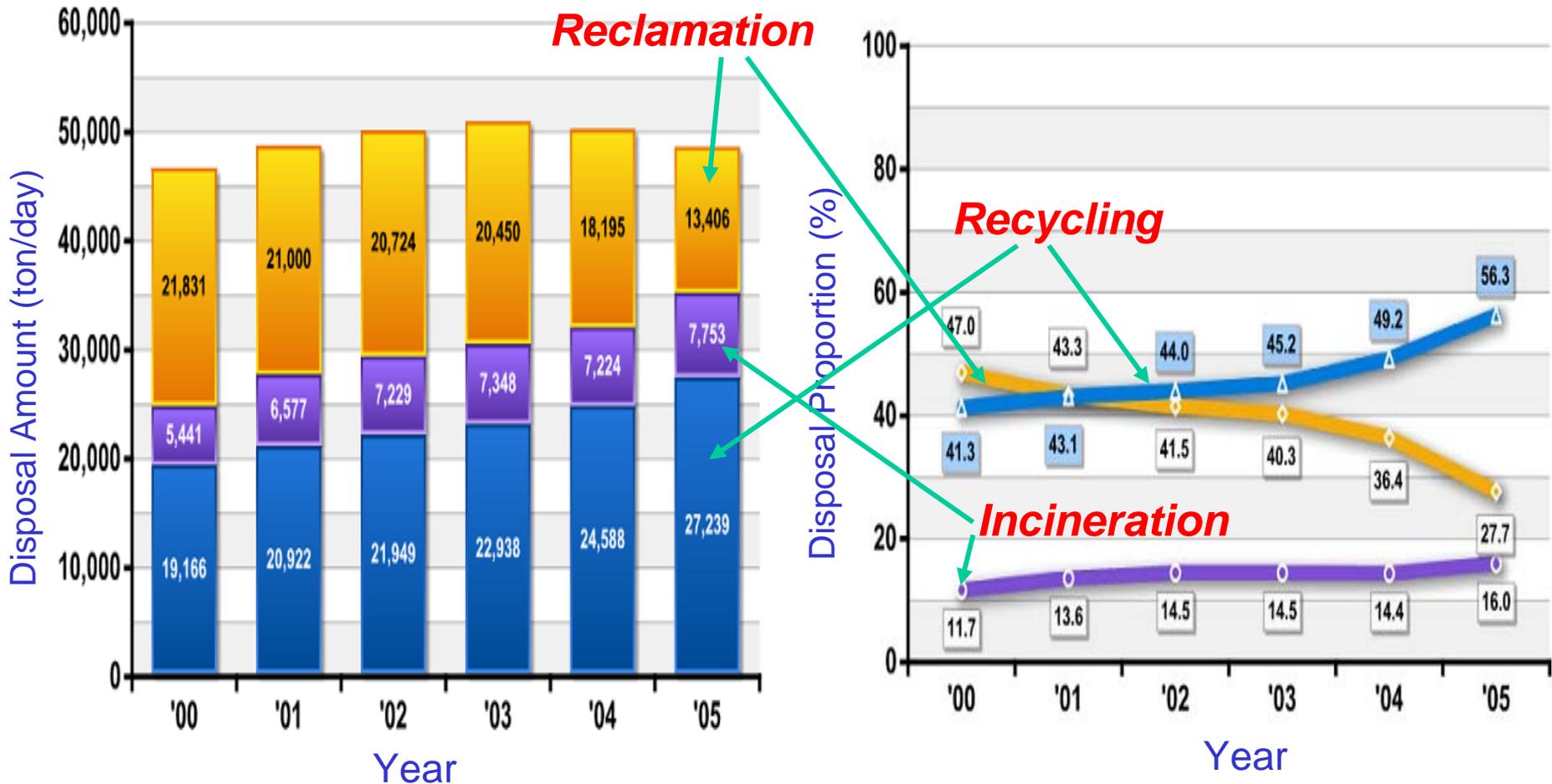
Yearly Variation of MSW Composition (ton/day)

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

Typical MSW Pictures (S city , Gyunggi Province)



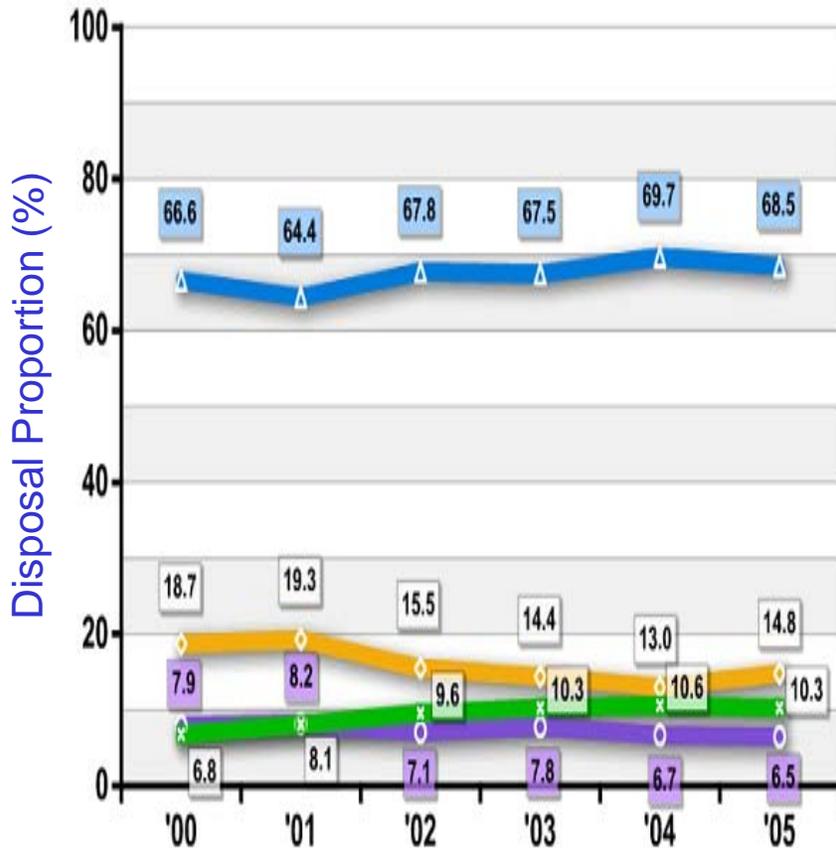
Trend of MSW Disposal Methods



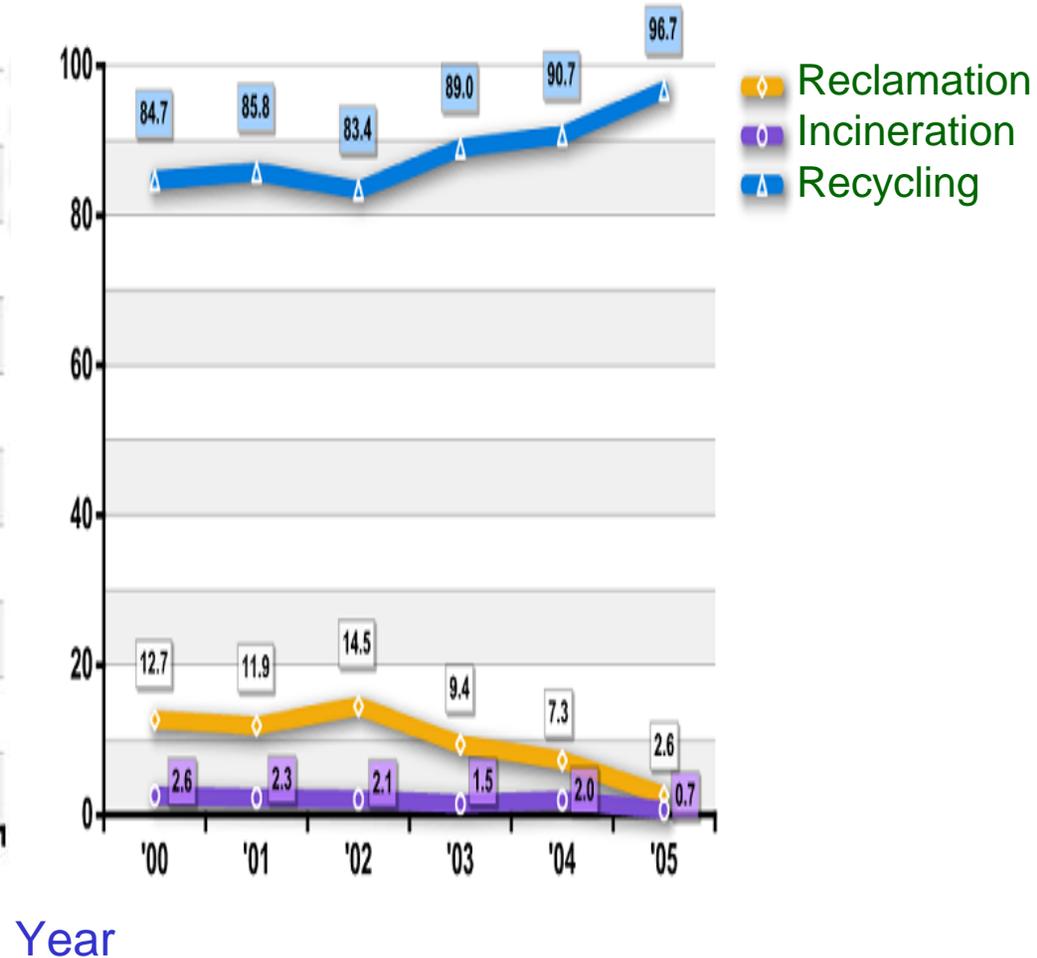
❑ Government intends to increase the incineration rate to 30% by 2011, but resistance by NGO and others persists.

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	Inchon	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	Inchon	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/Nm³
 - Typical agreement with residents : 0.1 ng-TEQ/Nm³
- For MSW incinerators, sometimes want below 0.01 ng-TEQ/Nm³
- 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 (16.0%)	728.16 (71.4%)	891.6 (87.4%)	96.4	15.0	3.1	0.6	9.8	4.1	128.9 (12.6%)	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/Nm³)

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 2 units	POSCO Construction Co.	Nippon Steel	Shaft	2003
Yangjoo City	100 ton/day 2 units	Dongbu Construction Co.	R21	Rotary kiln	2005
Koyang City	150 ton/day 2 units	POSCO Construction Co.	Nippon Steel	Shaft	2006
Eunpyung New Town, Seoul	48 ton/day 1 unit	GS Construction Co. + Hyosung Ebara	EBARA	Fluidized-bed	2006
Pangyo, Sunghnam City	45 ton/day 2 units	Halra Industrial Develop. Co.	KOBELCO	Fluidized-bed	2006
Hwasyng City	150 ton/day 2 units	GS Construction Co. + Hyosung Ebara	EBARA	Fluidized-bed	2007
Dalsung, Daegu City	70 ton/day 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.)

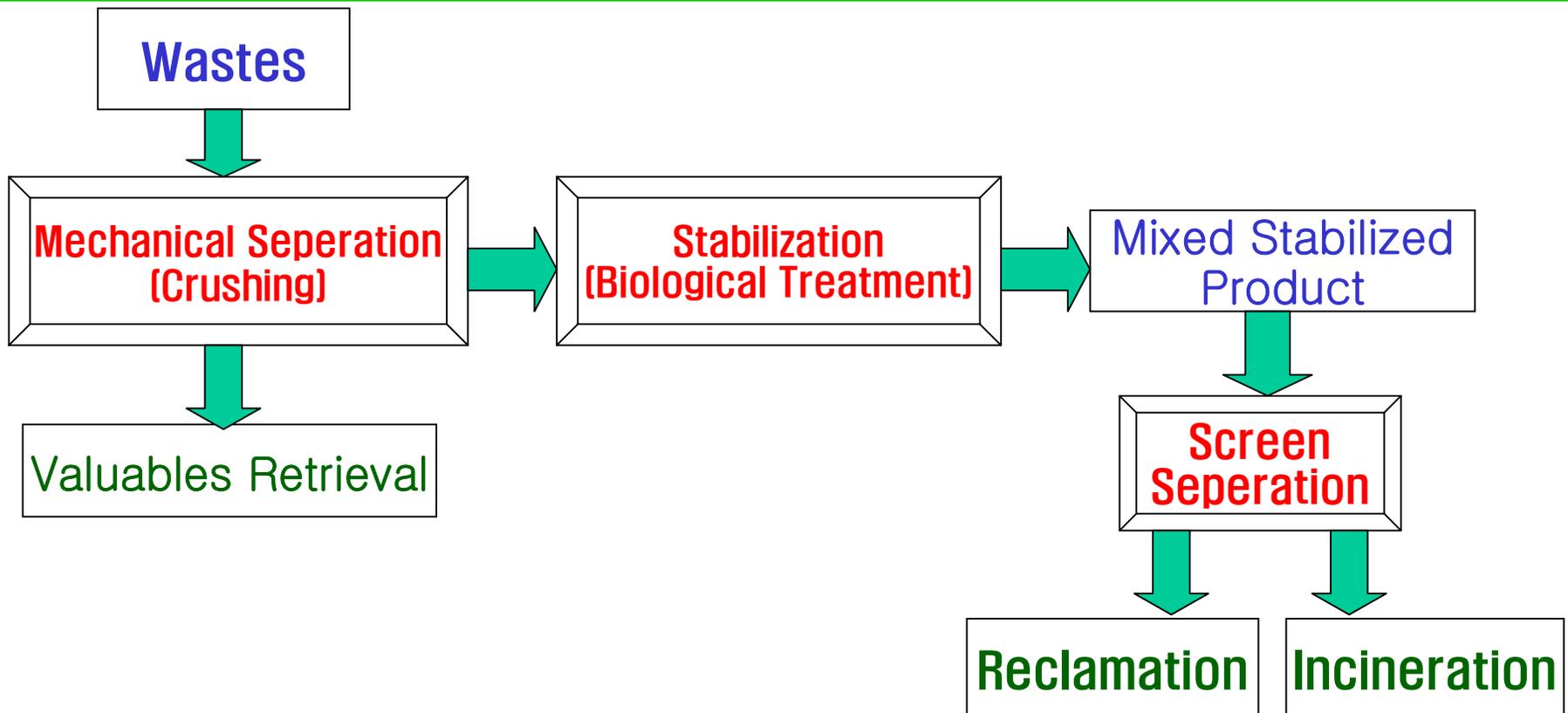
Source	Eligible Capacity	Apply Zone	Base price (Won/kWh)		Current Price (Won/kWh)	Remarks	Foreign Cases
			Fixed price	Variable Price			
Sun-light	Above 3 kW	Above 30 kW	677.38	-	716.40	Reduction rate 4% (after 3 years)	183~689 Won
		Below 30 kW	711.25	-			
Wind	Above 10 kW		107.29	-	107.66	Reduction 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)

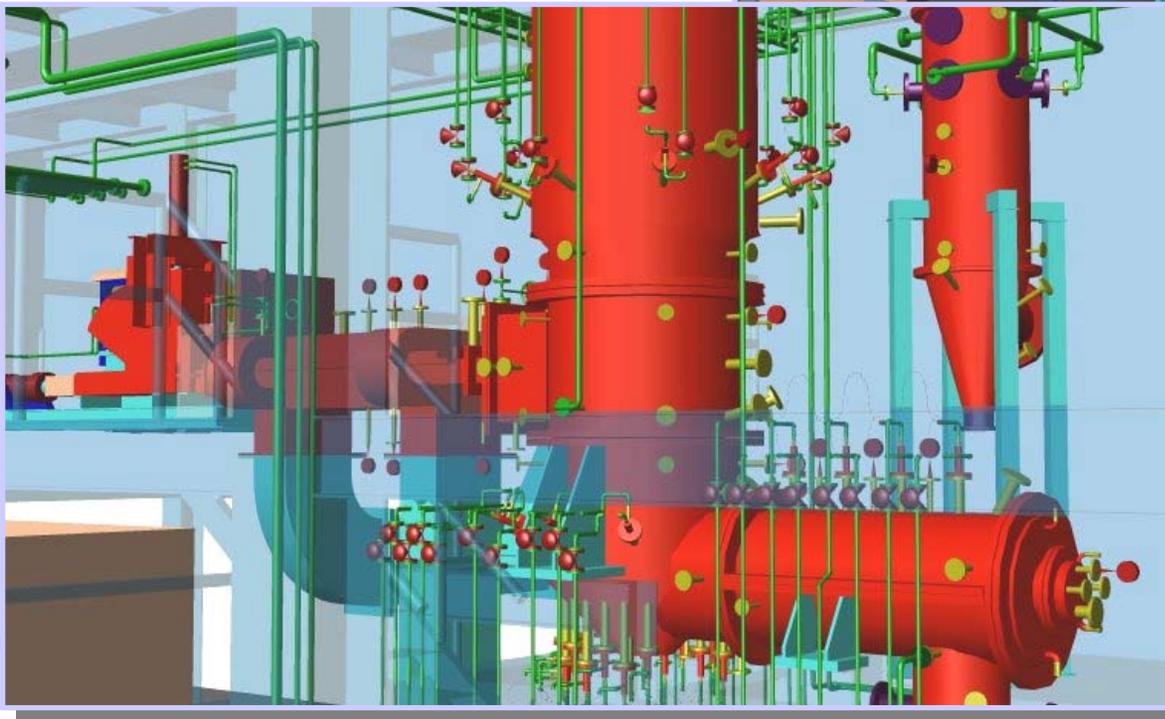
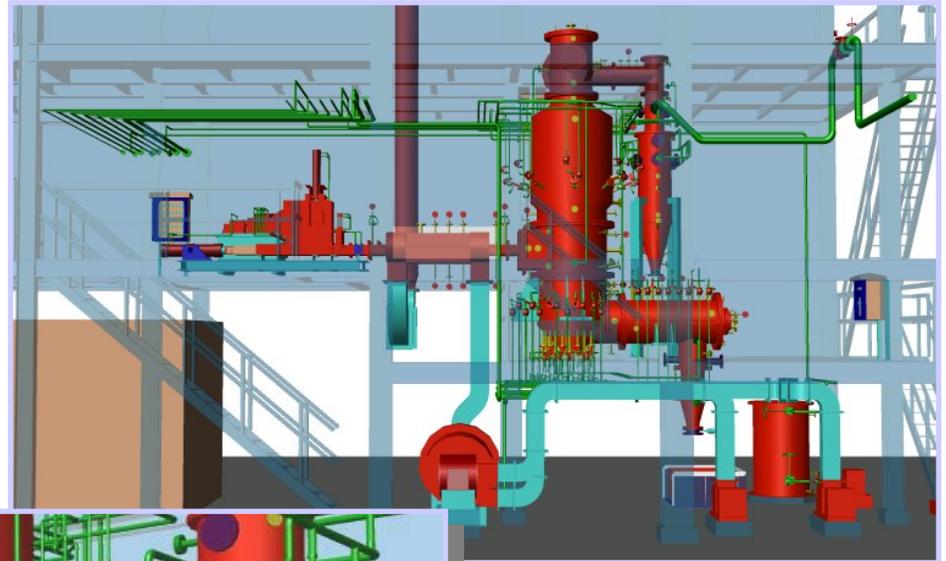
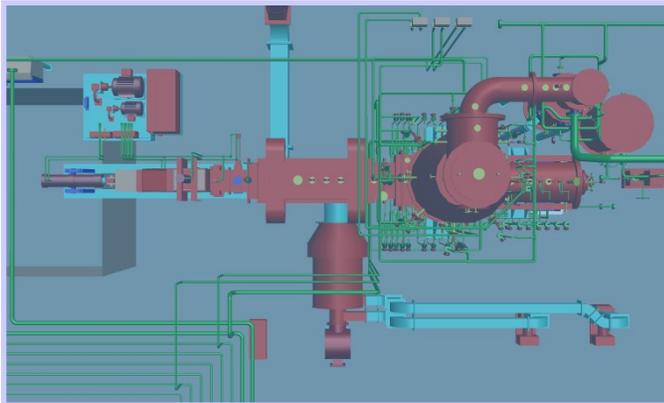


- Conceptually, best practice in MSW treatment
- Wide acceptance to NGO's and environmental groups
 - Maximizing retrieval of recycleables
 - Minimizing incineration/reclamation (minimizing of pollutants generation)
- However, many technical / economical issues to be solved

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

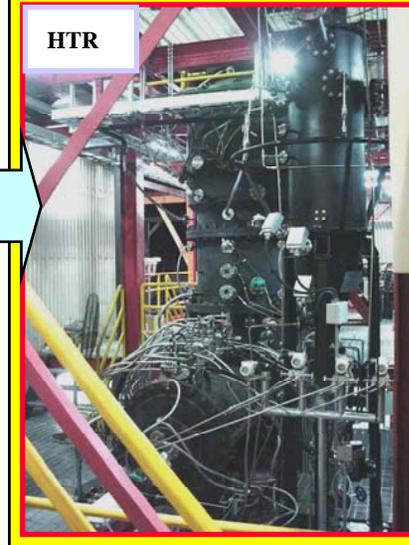


- Based on Thermosteect[®] process, modified for Korean MSW

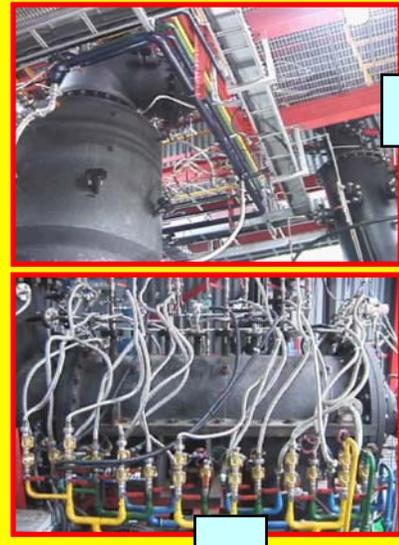
3 Ton/Day MSW Gasification Pilot Plant at IAE



Degassing channel



HTR



Shocking cooling and gas cleaning



Press



Control room

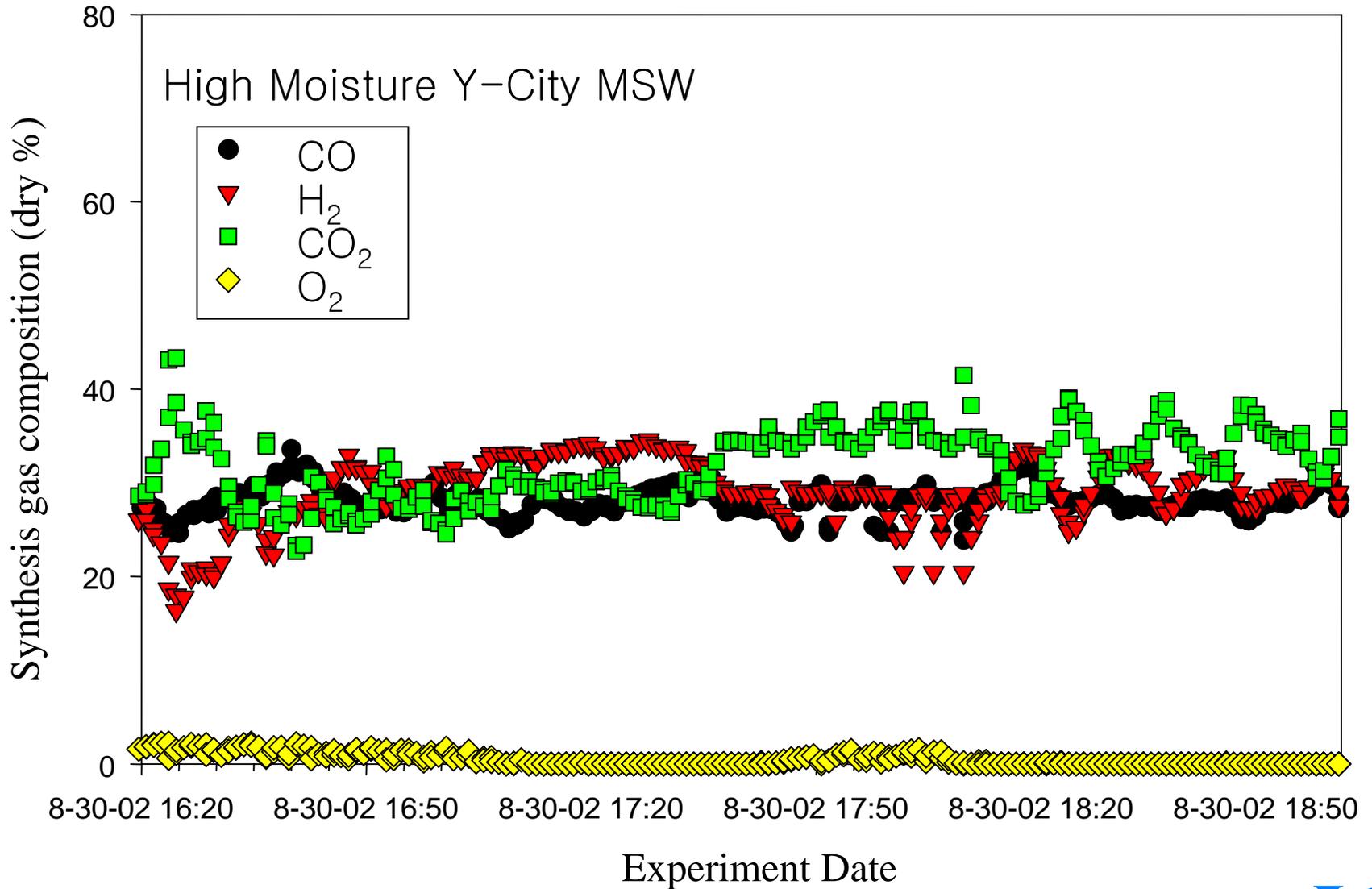


Slag removal



Combustor

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 → Boiler exit temperature ($< 220^{\circ}\text{C}$) → 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.