Table 3-7 Analytical Sludge Data

Component	Amount Unit	Limit
Dry mass	297 g/kg	
Organic matters	137 g/kg	
pH	7 - 8	
Zn	1,962 mg/kg (max. 2,500) d.m.	3,000 mg/kg 2,000 d.m.
Hg	6.2 mg/kg d.m.	10 mg/kg 15 d.m.
Cd	11 mg/kg d.m.	15 mg/kg
Cr	133 mg/kg d.m.	1,000 mg/kg
Mn	337 mg/kg (max. 150)d.m.	2,000 mg/kg
Ni	98 mg/kg d.m.	200 mg/kg 100 d.m.
Pb	253 mg/kg d.m.	1,000 mg/kg
Cn	273 mg/kg d.m.	800 mg/kg 1,000 d.m.
Cr+Ca+Zn+Ni		4,000

Note: d.m = dry mass

Source: FKFV

Table 3-8 Main Characteristics of TERRA-VITA Compost

Moisture content %	61.40
Organic matter content %	70.72
pH/10% aqueous suspension	7.90
Grain diameter goes through 55 mm sieve %	92.50
Total water soluble salt cont. % d.m.	6.20
Total N content % d.m.	2.51
Total P content P_2O_5 % d.m.	1.01
Total K content K_2O % d.m.	1.39
Ca content % d.m.	4.68
Mg content % d.m.	0.47
Zn mg/kg d.m.	140.00
Fe % d.m.	0.47
Mn mg/kg d.m.	286.00
Cu mg/kg d.m.	138.00
As mg/kg d.m.	0.67
Cd mg/kg d.m.	0.95
Cr mg/kg d.m.	17.00
Hg mg/kg d.m.	0.38
Ni mg/kg d.m.	4.20
Pb mg/kg d.m.	6.80

Note: Sensory qualities: dark brown, friable, and smells of soil.

Density: 0.8 - 0.9 g/cm^3

Granulametry: goes through 5 mm sieves at least 90%

Fractions in %:

- 5 mm 4
- 5-2 mm 89
- 2-1 mm 5
- 1 mm 2

d.m. = dry mass

Source: Gyongyos and Eger Compost Plant

3.6.3 Shredding

Generally shredding is aimed at reducing the size of bulky wastes to facilitate bulky waste combustion by incinerators.

At the present time HHM1 is equipped with one shredding machine. However, due to mixed collection of bulky wastes and an inadequate type of machine the shredding machine has not been in operation for a long time.

As bulky wastes are expected to increase in the future, shredding methods have to be reviewed.

3.6.4 Mechanical Waste Compaction

This method by compaction may be classified as stationary and movable. Stationary type compaction is usually applied at waste transfer stations; the latter may be defined as the type used by collection vehicles.

The Budapest city has no stationary compaction facility because there is no transfer station, but many collection vehicles are equipped with a compaction mechanism.

3.6.5 Incineration

HHM1, put in operation in 1981 as the first plant of its kind in Hungary, was established to combust the MSW and recover the waste heat energy by a boiler system.

(1) The most important features of HHM1 are as follows:

Number of furnaces	4 units
Capacity of each furnace	300 t/day (24 hour/day operation)
Type of combustion	Roller type grate

Capacity	300,000 t/year
Type of boiler	3-Pass, natural circulation type boiler
Steam parameters	
Steam generation	40 t/hour
Originally	40 bar, 445°C
After reconstruction	35 bar, 395°C
Power-generation	24 MW
District heat supply	42 MW

(2) Design basis

Heating values	min. 1400 kcal/kg max. 2300 kcal/kg

(3) Operational data

1) Actual capacity of incineration, steam quantity, power generation and energy supply

Year	Waste m^3/year	Waste t/year	Steam t/year	Power generation KWh/year	Energy supply GJ/year
1982	3,539,939	271,000	431,469	67,800	-
1983	3,597,315	230,900	375,526	64,400	-
1984	3,613,611	234,900	385,520	53,500	27,700
1985	3,707,104	243,600	420,321	58,900	33,700
1986	3,752,678	218,200	371,929	49,400	104,100
1987	3,818,520	243,400	408,406	45,300	226,200
1988	3,881,820	196,600	308,367	43,800	156,300
1989	3,910,986	71,200	128,147	6,600	109,100
1990	3,962,402	149,900	255,371	34,300	71,000
1991		242,766	467,332	48,244	252,061
1992	3,995,353	339,900	615,100	90,992	269,600
Total		2,442,366	4,167,488	563,236	1,249,761

Source: FKFV

2) Operational efficiency

year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
%	75	64	64	68	61	68	55	20	42	67

$$\text{Efficiency} = \frac{\text{actual capacity}}{1200 \text{ t/day} \times 300 \text{ days}} \times 100$$

3) Residue

About 10% of the total volume of the MSW incinerated is residue on average.

3.7 Final Disposal

3.7.1 Operating Final Disposal Sites

There are the four operating final disposal sites, of which capacities were 3,271,000 m^3 in 1992. The above sites will be filled in 1994, if the present disposal situation continues.

At the present time, basically mined holes are used as the final disposal site for the MSW including some harmless industrial wastes.

Mined holes are created after mining the soil out of the original ground.

At most of the sites, a sandwich method has been adopted for the MSW disposal.

But due to an insufficient quantity of covering soil, residues from HHM1 are also used at the final disposal sites. From the view point of environmental protection, the use of residues for covering is not recommended because the residues with fly ash contain some heavy metals.

Locations of the operating final disposal sites are shown in the Figure 3-3.

Table 3-9 Information on the Four Operating Final Disposal Sites

No.	Name of the site	Location of the site	Started operation	Estimated date to get filled up	Free Vol. (1,000m^3)	Machines	Covering material	Landfilling method	Environmental monitoring system
1	AKNA	AKNA street in X-DISTRICT	Since 1958	1993	40	2-compactor of 240 H.P. 1-compactor of 130 H.P. 1-compactor of 100 H.P.	Construction demolish & debris and soil	Open Dumping + covering with soil + sprinkle water	None
2	MICSURIN	Rakosvolgye MGTSZ in XVII-DISTRICT	Since 1987	1994	408	1-compactor of 240 H.P. 1-compactor of 130 H.P. 1-compactor of 100 H.P.	Soil	Sandwich with soil	None
3	PETERI MAJOR Egyetemi Tangazdasag in X-DISTRICT	Kerteszeti	Since 1985	1994	84	1-compactor of 130 H.P. 1-compactor of 100 H.P.	Soil	Sandwich with soil	5 wells were drilled, ground water level is about 1m from bottom
4	DUNAKESZI	Pilisi Allami Parker dogazdasag's (out of Budapest City)	Since 1988	1995	1448	1-compactor of 240 H.P. 2-compactor of 130 H.P.	Soil and incineration residue from HHM1	Sandwich with soil and residues	2 wells were drilled, ground water level is about 50m from bottom

Source: FKFV, 1992

3.7.2 Present Situation of the Operating Final Disposal Sites

The following features are common for the four sites.

(1) Bottom surface condition at the each site.

The bottom liner at each site for preventing ground water contamination consists of a layer of compacted clay and sand. The layer is about 1m thick.

(2) Sloped surfaces at each site.
No liners are laid on.

(3) Leachate collectors.
No leachate collectors are installed.

(4) No leachate treatment facility is installed.

(5) Open channel for superficial water.
No open channel for superficial water is installed.

(6) Truck scale.
No truck scale is installed except at the Akna site.

(7) Basically, the bottoms of the mined holes are formed with coarse sand or fine gravel except at the Akna site.
The bottom and slope of the Akna site are formed with clay.

Generally speaking, when the bottom and slopes of a site consist of coarse sand or fine gravel, the coefficient of permeability will be about 10^{-3} - 10^{-4} cm/s, this value is not enough to prevent ground water contamination.

When a liner is installed on the bottom without a liner on the slopes of the site, the ground water might still be contaminated in heavy rain.

Installation of leachate collectors will help to prevent ground water contamination, due to the leachate drainage effect by reducing the seepage force.

The leachate quantity depends on quantity of rain fall; in Budapest precipitation averages about 550 mm/year.

3.7.3 Legal and Technical Conditions for the Final Disposal Sites

(1) Reuse of mined hole as a final disposal site.

The final disposal sites legally belong to the national government of Hungary; however, the local district council grants permits for use of the land by a third party such as a miner, or FKFV in this case.

The district council gives a permit to a miner for use of the land from the beginning of mining activity to the end of backfilling, or the miner should fill up the mined hole with harmless material such as natural soil or the MSW to the original level.

For this purpose, a waste disposal operator should contract with a miner to dispose of the MSW safely.

Extractions from the law of GENERAL REGULATION ON MINING are attached below.

1) Mining company - in the best interest of the economy, as soon as possible, but not later than the

end of mining activity, is obliged to backfill the mined hole.

2) Backfilling must be carried out gradually according to a backfilling plan prepared by a mining company after being approved by the experts' committee consisting of the Environmental Council and all authorities concerned.

3) Real estate no longer used for mining purposes is to be taken over by the authorities.

4) The mining company must describe the ways of backfilling, and all relevant data and expert's opinions must be attached to the plan. Experts' committee decides on the backfilling method.

5) Design plans for new mines and also technical plans of existing mines must describe the aims and procedure of backfilling.

6) The mining authority is to supervise the actual backfilling operation.

The mining company must create a new surface suitable for further use. Actual reuse of land must be planned by the responsible authority which has taken over the real estates formerly used by the mining company.

In case of dispute regarding this matter, the responsible authority decides who supervises the reuse.

In case no authority is found to take responsibility for reuse, the council of the district, city, county, etc. takes the responsibility automatically.

(2) Technical guide for the MSW disposal activities

Final disposal activities have basically but not fully been carried out in accordance with THE GUIDE FOR SYSTEMATIC DISPOSAL OF MUNICIPAL SOLID WASTE (herein after referred to as the Guide) which was issued in 1978. This Guide gives the regulations for environmental protection as follows.

1) Deleterious affects of non-systematic disposal

The deleterious, harmful affects of non-systematic disposal for public health and environment are summarized as follows:

<u>Air pollution</u>

During the MSW disposal process, from the surface of the uncovered MSW, a great deal of dust is generated by the wind and carries pathogenic microorganisms which are in the MSW. These organisms can directly or indirectly infect humans and animals through food, plants and soil.
These floating substances have low specific weight and large surfaces and can cause air pollution.
After deposit they contaminate the ground surface.
The odorous gases originating from the MSW decomposition can be smelled even at long distances.

<u>Water contamination</u>

Deleterious materials originating from the physical, chemical and biological decomposition of disposed waste enter surface waters directly by means of leaching caused by precipitation, or ground water indirectly by seepage. Physical characteristics, i.e. conductivity and temperature, and chemical characteristics, such as pH, ion concentration and hardness, affect corrosion, and biological characteristics, e.g. BOD_5 and COD, are changed by decomposition products.

The MSW deposited near waters or in surface water contaminates the waters either directly or as decomposition products.

Soil contamination

The self-cleaning ability and permeability of the soil is reduced by the contaminators from the MSW decomposition. Some of the toxic materials kill microorganisms in the soil or at least hinder their activity.

Other adverse affects

- Proliferation of rodents
- Proliferation of insects
- Potential risk of infection
  - Direct: through scavengers
  - Indirect: through animals
- Unsightly

Due to its deleterious and contaminating effects, non-systematic disposal does not meet the health and environment protection regulations, therefore this method of disposal should be stopped, according to the Act II, 1976.

This Guide requires the following data for management of the final disposal sites.

2) Essential data

a) Amount and kinds of wastes
b) Collection area and number of residents

c) Collection vehicles and transport
d) Disposal sites

3) Natural conditions

a) Wind
b) Geological, hydrological and hydrogeological characteristics
c) Topography
d) Ground water

4) Factors to be taken into account when a site plan is formulated.

a) Field and soil preparation
b) Water conservation
c) Reduction of air pollution
d) Covering materials
e) Utilities
f) Facilities

- Road
- Truck scale
- Social welfare and storage building
- Public utilities:
  Electric supply
  Telephone line
  Drinking water
  Street lighting system

3.7.4 Situation of Ground Water at the Final Disposal Sites

The ground water analyses at the Dunakeszi and Peteri major sites, gave the following results.

18 samples were taken. Each sample at the Dunakeszi site and the Peteri major site was analyzed for 41 elements and the result of analysis is presented in the Table 3-10.

(Details in the Appendix 2)

Elements exceeding the Hungarian limits according to the regulation (MI-10-433/3) were:

- Lead,
- Manganese, and
- Nitrate

  at the Peteri major site.

- Arsenic, and
- Lead

  at the Dunakeszi site.

Total hardness and pH at the Peteri major and Dunakeszi sites were respectively very close to the Hungarian limits.

Table 3-10 Result of Ground Water Analysis at the Dunakeszi and Peteri Major Sites

Samples taken from the Peteri-Major site					Samples taken from the Dunakeszi site	
Sample identification		lead	manganese	nitrate	arsenic	lead
NO. OF Well	No. of samp.	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)
1	1/1	0.078	0.790	–	0.080	0.120
	1/2	0.019	0.013	–	<0.05	0.022
	1/3	0.013	<0.01	–	0.064	0.048
	Cal Ave.	0.037	0.271	–	0.065	0.063
	Ctrl meas.	–	–	260	–	–
2	2/1	0.165	2.370		1.510	0.610
	2/2	<0.01	<0.01		1.550	0.098
	2/3	<0.01	<0.01		1.540	0.073
	Cal Ave.	0.062	0.797		1.533	0.260
	Ctrl meas.	–	–	142	–	–
3	3/1	0.780	0.650			
	3/2	<0.01	<0.01			
	3/3	<0.01	<0.01			
	Cal Ave.	0.267	0.223			
	Ctrl meas.	–	–	200		
4	4/1	0.210	0.860			
	4/2	<0.01	<0.01			
	4/3	<0.01	<0.01			
	Cal Ave.	0.077	0.293			
	Ctrl meas.	–	–	180		
Limit according to regulation MI-10-433/3		0.05	0.2	40	0.05	0.05
Limit of Japanese effluent Standards		1.0	10	120	1.0	1.0

Note: Cal Ave = Calculated average,
Ctrl meas. = Control measurement
Source: Investigated by the JICA Study Team, 1992

3.8 Municipal Solid Waste Generation Volume and Composition

The MSW in Budapest is mostly collected by FKFV from 22 districts and hauled to HHM1 and the four final disposal sites in operation.

According to the Figure 3-2, about 91.4% of the total MSW generation is dealt with by FKFV and 8.6% by other companies; and about 49% of the total MSW is incinerated and 50.5% is disposed of at the four disposal sites. Only 0.5% of the 8.6% collected by other companies is recovered for recycling by MEH.

3.8.1 Present Municipal Solid Waste Generation Volume

(1) The MSW generation volume handled by FKFV and other collectors

FKFV has been surveying the MSW generation volume by means of a field measuring method in terms of transported volume per year from 1970 to 1992; the results are presented in the Table 3-11.

(2) The MSW generation weight collected by FKFV

Data of the MSW generation weight collected by FKFV are presented in the Table 3-12. The coefficient of variation of the MSW generation per month can be determined in the following manner.

$$\text{Coefficient of variation per month} = \frac{A}{B}$$

where A: amount of the MSW treated per day during a month (in ton)

$$= \frac{\text{amount of the MSW treated per month (in ton)}}{\text{number of days per month}}$$

B: amount of the MSW treated per day during a year an average (in ton)

$$= \frac{\text{total amount of the MSW treated per year (in ton)}}{\text{number of days per year}}$$

The results are as follows. (refer to the Table 3-12)

$$\text{for 1990} \quad \frac{A}{B} = 1.10$$

$$\text{for 1991} \quad \frac{A}{B} = 1.12$$

$$\text{for 1992} \quad \frac{A}{B} = 1.07$$

$$\text{Therefore, average coefficient} = \frac{1.10+1.12+1.07}{3} = 1.10$$

Table 3-11 MSW Volume Handled by FKFV and Other Companies along with Population

Unit: m^3

Year	Transported by FKFV	Transported by other companies	Total
1970	1,601,646	594,612	2,196,258
1975	2,327,350	637,322	2,998,547
1980	3,246,365	1,061,564	4,332,916
1981	3,363,314	967,801	4,378,693
1982	3,539,939	1,242,911	4,782,850
1983	3,597,315	861,777	4,518,059
1984	3,613,611	873,403	4,487,014
1985	3,707,104	796,006	4,503,110
1986	3,752,678	882,755	4,635,433
1987	3,818,520	831,103	4,649,623
1988	3,881,820	715,427	4,597,247
1989	3,910,986	681,802	4,592,788
1990	3,962,405	460,546	4,422,951
1991	3,901,835	343,924	4,245,759
1992	3,953,000	370,000	4,323,000

Note: 1970-1991 (recorded)
Source: FKFV

Year	MSW Volume (m^3)	Population (person)
1980	4,332,916	2,059,347
1981	4,378,693	2,060,644
1982	4,782,850	2,063,745
1983	4,518,059	2,064,307
1984	4,487,014	2,064,374
1985	4,503,110	2,071,484
1986	4,635,433	2,075,990
1987	4,649,623	2,093,487
1988	4,597,247	2,104,700
1989	4,592,788	—
1990	4,422,951	2,016,300

Sources : FKFV, Hungarian Statistical Yearbook

Table 3-12 MSW Generation Weight Collected by FKFV 1990 - 1992

Year / Month	1990 ton	1991 ton	1992 ton
1	66,106	64,396	55,013
2	54,678	48,127	51,138
3	60,608	62,963	59,378
4	57,400	63,439	59,210
5	63,161	64,493	56,925
6	58,978	56,356	58,022
7	58,919	58,880	58,909
8	58,649	54,478	52,869
9	57,228	58,349	59,041
10	60,134	57,351	54,587
11	54,142	53,710	57,342
12	56,435	43,994	53,121
Total/year	706,438	636,536	675,555

Budapest, 1993, February 19.
Source: FKFV

(3) Results of survey and the MSW analysis by the JICA Study Team

The JICA Study Team analysed the MSW in the Budapest city twice, the first time in June 1992 for the off heating season and the second time in March 1993 for the heating season.

The study on the MSW analysis was performed in such a way that the samples were collected from 12 different zones, they are

- High income areas (2 zones) - A, B
- Middle income areas (2 zones) - C, D
- Low income areas (2 zones) - E, F
- Hotels (2 zones) - H_1, H_2
- Markets and shops (2 zones) - M_1, M_2
- Offices (1 zone) - O
- Parks (1 zone) - P

and prepared for physical and chemical composition analysis by means of a quartering method. Measurements of the MSW generation and heating values were also carried out.

The results of unit rate and specific weight are presented in the Table 3-13 and the MSW generation per capita in the Table 3-14.

Table 3-13 Unit Rate and Specific Weight of the MSW

Zone code	Sample weight (summer test) [kg]	Sample weight (winter test) [kg]	Sample weight (average) [kg/]	Specific weight (summer test) [kg/m³]	Specific weight (winter test) [kg/m³]	Specific weight (average) [kg/m³]
A	310	213	261.5	175.4	118.3	146.9
B	306	235	270.5	98.3	104.4	101.4
C	344	394	369.0	75.1	90.8	83.0
D	224	154	189.0	141.0	102.7	121.9
E	202	277	239.5	122.2	138.5	130.4
F	238	172	205.0	161.4	78.2	119.8
H_1	134	146	140.0	98.5	119.7	109.1
H_2	1,905.1	1,406	1,655.6	148.4	121.4	134.9
M_1	55.5	69	62.3	51.1	40.8	46.0
M_2	212.1	186	199.1	43.5	42.3	42.9
O	824	817	820.5	68.1	69.8	69.0
P	71.5	13	42.3	81.3	24.5	52.9

Source: JICA Study Team investigation

Table 3-14 MSW Generation per Capita

Zone code	Unit rate [kg/capita/day]		
	(summer test)	(winter test)	(average)
A	0.47	0.69	0.58
B	0.42	0.55	0.49
C	0.78	0.68	0.73
D	0.51	0.75	0.63
E	0.68	0.49	0.58
F	0.63	0.87	0.75
H_1	0.81	0.74	0.78
H_2	0.57	0.77	0.67
M_1	0.16	0.13	0.15
M_2	0.12	0.14	0.13
O	0.07	0.07	0.07

Source: JICA Study Team investigation

3.8.2 Present Characteristics of the Municipal Solid Waste

(1) 3-components and physical composition of the MSW investigated by FKFV

The actual measurements of the three components (moistures, incombustibles, combustibles) and the physical composition of the MSW generated in the summer and in the winter during the years 1986 to 1991 are shown in the Table 3-15.

(2) Chemical composition and the heating value of the MSW

The actual measurements of the chemical composition and the heating values of the MSW generated in the summer and in the winter during the years 1982 to 1991 are shown in the Table 3-16.

Table 3-15 Physical Composition and Characteristics of 3 components

Weight(%) 3 components	1986 Winter Season	1986 Summer Season	1987 Winter Season	1987 Summer Season	1988 Winter Season	1988 Summer Season	1989 Winter Season	1989 Summer Season	1990 Winter Season	1990 Summer Season	1991 Winter Season	1991 Summer Season
Moisture	33.36	35.50	42.20	38.45	37.66	40.19	36.40	35.12	34.74	28.92	41.80	43.40
Incombustible	35.96	29.19	29.89	25.08	27.87	26.12	30.40	27.80	30.85	27.36	27.20	24.92
Combustible	30.68	34.53	27.92	36.47	34.37	33.69	33.20	37.08	34.41	43.72	31.00	31.68
Weight(%) Physical composition												
Paper(Cardboad)	19.55	21.51	17.58	17.96	19.31	18.25	18.45	20.65	19.42	19.73	17.86	18.00
Plastic	5.23	5.59	4.93	4.11	4.41	4.29	4.42	4.66	5.11	4.15	4.95	4.17
Textile	5.78	5.38	3.95	4.54	4.83	3.53	2.95	4.10	6.35	7.24	3.10	3.06
Decomposing organic (Kitchen garden)	32.60	37.91	37.27	42.23	37.05	34.09	30.46	33.72	31.06	33.61	38.30	38.46
Glass	5.99	5.91	5.01	4.91	4.73	6.05	4.85	7.23	4.31	6.26	3.40	3.36
Metal	4.52	4.14	5.20	4.18	4.43	5.70	6.62	4.16	6.59	5.29	4.50	4.04
(Inorganic and 16mm fine fraction)	26.33	19.56	26.04	22.02	26.24	29.26	32.25	25.48	27.16	23.72	28.30	28.50

Source: FKFV

Table 3-16 Chemical Composition and Heating Values

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	percentage of each component									
Weight(%)										
Moisture	39.45	39.95	48.88	46.25	34.73	34.25	38.93	35.76	31.83	42.60
Incombustibles	32.94	32.23	24.25	24.95	31.92	29.70	26.99	29.10	29.10	26.06
Combustibles	27.61	27.82	28.80	28.80	33.35	36.05	34.08	35.10	39.07	31.34
	Chemical composition of MSW									
Weight(%)										
Total organic C	17.80	17.74	16.61	17.85	20.66	19.23	21.34	22.61	19.27	17.20
Total N	0.70	0.69	0.69	0.60	1.40	1.24	0.97	1.09	0.76	0.70
	Heating value of MSW in Budapest 1982-1991									
(KJ/kg)										
Heating value(high)	7495	7465	6890	7230	8510	7900	7220	8590	8120	7250
Heating value(low)	6197	6105	5010	5660	7170	6890	6230	7560	6810	6150

Source: FKFV

(3) Result of the JICA Study Team's study and characteristic analysis of the MSW

The JICA Study Team analyzed the MSW in the same manner as stated in the section 3.8.1-(1). The results are presented in the Table 3-17. (Details in the Appendix 1)

According to the Table 3-17, maximum, medium and minimum heating values of the MSW can be determined by the normal distribution method as follows.

Step 1 $$\overline{X} = \frac{(X_1+X_2+\ldots\ldots+X_n)}{n}$$

Step 2 $$S = (X_1-\overline{X})^2 + (X_2-\overline{X})^2 + \ldots + (X_n-\overline{X})^2 = \sum_{i=1}^{n} (X_i-\overline{X})^2$$

Step 3 $$\sigma^2 = \frac{S}{n-1}$$

Step 4 $$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\Sigma (X_i-\overline{X})^2}{n-1}}$$

where = X_1, X_2, X_3 ····· X_n are measured heating values; S is standard deviation

Step 5 = $\overline{X}$ is determined as the averaged heating value by using all measured heating values in the Table 3-17 for winter and summer. It is 6,378 KJ/kg.

X_1 (maximum) = $\overline{X}$ + 1,645 = 7,616 KJ/kg
X_2 (minimum) = $\overline{X}$ - 1,645 = 5,140 KJ/kg

Conclusion: Maximum heating value = 7,616 KJ/kg
Minimum heating value = 5,140 KJ/kg
Medium heating value = 6,378 KJ/kg

In general practice a ratio of maximum to minimum heating values of 3:1 is acceptable. This case ratio of 1.5:1 is within range, accordingly it is reasonable.

The medium heating values of both the JICA Study Team and FKFV for household waste are relatively close to each other.

Table 3-17 Physical Composition, Characteristics of 3-component and Heating Value

Physical composition (weight %)	Residential zones A..F winter	Residential zones A..F summer	Hotel zones H1+H2 winter	Hotel zones H1+H2 summer	Market zones M1+M2 winter	Market zones M1+M2 summer
paper	17.38	15.64	14.20	16.10	59.88	42.03
textile	4.62	9.12	2.26	0.69	0.00	0.00
plastics	8.80	7.52	4.89	4.92	7.79	11.59
glass	3.96	5.81	7.21	9.69	7.56	3.04
grass, greens	0.23	10.09	0.98	0.09	0.00	0.00
leather	0.00	0.00	0.00	0.00	0.00	0.00
rubber	0.00	0.00	0.00	0.00	0.00	0.00
metals	3.68	2.65	1.02	1.94	3.14	15.94
kitchen garbage	37.29	25.83	57.21	59.31	14.07	9.42
stones, ceramics	3.02	1.54	3.44	0.67	2.33	0.00
other	21.00	21.80	8.79	6.59	5.23	17.98
Total	100.00	100.00	100.00	100.00	100.00	100.00

3 components (weight %)	Residential zones A..F winter	Residential zones A..F summer	Hotel zones H1+H2 winter	Hotel zones H1+H2 summer	Market zones M1+M2 winter	Market zones M1+M2 summer
moisture	47.88	57.87	44.28	54.69	41.07	34.73
incombustibles	9.46	13.80	10.38	6.55	6.18	5.68
combustibles	42.67	28.33	45.34	38.76	52.75	59.59
Total	100.00	100.00	100.00	100.00	100.00	100.00
Bulk density [kg/m³]	105.48	128.90	120.55	123.45	41.55	47.30
Heating value:						
High [KJ/kg]	13,176	14,292	13,285	13,850	16,190	15,500
Low [KJ/kg]	7,508	6,228	7,410	6,585	9,528	10,830

Source: JICA Study Team Investigation

continue

Physical composition (weight %)	Offices, zone O winter	Offices, zone O summer	Parks, zone P winter	Parks, zone P summer	Total of all zones A..P winter	Total of all zones A..P summer
paper	80.00	46.43	25.00	14.63	27.09	20.12
textile	0.47	1.43	0.00	17.46	2.99	4.95
plastics	3.72	3.57	16.67	14.63	6.97	6.73
glass	1.40	2.14	16.67	9.76	5.09	6.83
grass, greens	0.00	1.43	0.00	0.00	0.00	0.00
leather	0.00	0.00	0.00	0.00	0.00	0.00
rubber	0.00	0.00	0.00	0.00	0.00	0.00
metals	6.98	0.71	13.33	5.61	3.22	3.31
kitchen garbage	5.12	7.86	21.67	19.51	37.83	35.33
stones, ceramics	0.00	12.14	0.00	0.00	2.74	1.88
other	2.33	24.29	6.67	18.40	13.63	16.06
Total	100.00	100.00	100.00	100.00	100.00	100.00

3 components (weight %)	Offices, zone O winter	Offices, zone O summer	Parks, zone P winter	Parks, zone P summer	Total of all zones A..P winter	Total of all zones A..P summer
moisture	21.92	41.18	58.13	40.40	42.65	45.77
incombustibles	9.69	15.27	4.70	6.06	7.99	9.47
combustibles	68.40	43.55	37.17	53.54	49.27	44.76
Total	100.00	100.00	100.00	100.00	99.91	100.00

Bulk density [kg/m³]	69.80	68.10	24.50	81.30	72.83	89.81

Heating value:						
High [KJ/kg]	16,370	14,475	12,680		14,340	14,524
Low [KJ/kg]	12,755	9,575	5,095		8,459	8,925

Source: JICA Study Team investigation

3.9 Organization, Institution and Administration

3.9.1 Budapest Capital City Government

In Budapest, all issues related to the MSW management are under the jurisdiction of the Budapest Capital City Government. The 22 District Councils of the city are not directly involved in the MSW management.

The Budapest Capital City Government cooperates, however, with the district councils in research for new sites for the MSW final disposal or incineration plant. During the negotiations concerning the acquisition of new sites the district council imposes certain conditions for the permit such as the examples below.

- Detailed plan of land use and its modification
- Project documentation
- Development of environmental monitoring network
- Participation of district representatives in the tender procedure
- Construction and/or repair of roads
- Economic incentives for the district residents (priority in employment)

3.9.2 Public Service Enterprise /FKFV/

The organization responsible for the MSW management in Budapest is FKFV established by the Executive Committee of the Budapest City Council. FKFV collects and transports the MSW, operates and maintains HHM1, operates and manages the final disposal sites, cleans public facilities, etc. under the supervision of the Budapest Capital City Government. The MSW treatment for industries, institutes and public bodies are undertaken by FKFV on the basis of individual contracts. Approximately 60% of the operation funds for FKFV is covered by income from the FKFV's own collection, transportation, incineration and final disposal activities. The remainder, approximately 40%, is covered by the consignment for the MSW management activities provided by the Budapest Capital City Government.

The organization of FKFV is shown below.

Organization of FKFV

(1) General Manager

- Department of personnel and education
- Legal and administrative department
- Department of internal control
- Department of organization
- Department of maintenance
- Office of public relations and publicity

(2) Technical Deputy General Manager

1) Communal management

- Division of public roads, squares, etc.
- Department of road cleansing
- Communal workshop No. 1
- Communal workshop No. 2
- Communal workshop No. 3
- Communal workshop No. 4
- Division of transport and incineration of waste
- Department of waste transport
- Department of waste disposal
- Unit of transportation
- Chief engineering office of the waste incineration plant
- Thermal workshop
- Electrical workshop
- Workshop of thermal control
- Water softening workshop
- Workshop of maintenance

2) Management of maintenance of public roads

- Deep structure engineering division
- Department of contracting and preparation
- Department of road construction
- Department of material manufacturing
- Traffic-technical management
- Department of bridges
- Technological department

3) Technical department

- Division of developments and investments
- Department of technical developments
- Department of investments
- Department of buildings' maintenance
- Division of maintaining vehicles and equipments
- Department of vehicle maintenance
- Repairing department of building machinery
- Department of component reconditioning
- Department of maintenance and operation
- Group of technical recording and documentation
- Department of environmental protection

4) Department of labor safety

5) Department of energy

6) Department of quality control

(3) Economical Deputy General Manager

1) Manager of commerce and business administration
- Purchasing division

2) Chief accountant

3) Department of planning and statistics

4) Department of labor

FKFV employs about 3,500 persons; the full-time staffs in charge of the MSW management are 1,580 persons.

3.9.3 Hungarian Recycling Company /MEH/

MEH is a company dealing with recycling of materials which are reused in the processing industry. The company is under the supervision of the Hungarian Ministry of Industry and Trade. In addition to the raw materials recovered from the MSW, MEH also collects recyclable industrial wastes. The recycling activities concern iron, steel, non-ferrous metals, paper, textiles and plastic.

Until 1991 MEH operated at a profit of about 10 - 15%. During the year 1992, because of reorganization and reconstruction of the Hungarian industry, the cash flow was negative.

According to the management of MEH some new agreements have been signed with foreign companies for processing of recovered materials which will generate some profits in 1993 and succeeding years.

3.10 Registration, Enforcement and Public Cooperation

The main legal document dealing with the MSW management is the Decree No.1/1986/II/21/ EVM-EUM on the activity of public services and the MSW management. This decree defines the system of collection and transportation of the MSW as well as their proper disposal. The main points concerning disposal and reuse of the MSW are given in the Par. 10 and 11 of the above mentioned decree.

10. Par.

/1/ The MSW can be disposed of at the final disposal sites by establishments assigned by concerned department of the Budapest Capital City Government in accordance with the relevant laws and regulations on public health; water management, environmental protection, building and transportation.

/2/ Some kinds of harmless industrial wastes can be dumped and disposed of together with the MSW.

/3/ Waste can only be imported with special permission given by the concerned Ministry.

11. Par.

/1/ A truck scale must be installed at each of the disposal sites which is in operation at the time this law takes effect or thereafter.

/2/ The truck scale must be installed at the disposal sites which are located at county centers or are expected to operate more than 10 years after this law takes effect.

/3/ The caretaker of the site will be obliged to carry out examinations and surveys of physical and chemical conditions of waste.

/4/ Enclosure of the disposal sites must protect the site from illegal waste dumping and also must protect neighboring areas from pollution and wind transport of waste.

/5/ The dumped MSW must be covered. Operation of the disposal site must not cause harmful noise or air pollution, or affect the health of workers.

Covering of closed sites must be effective enough to make the area suitable for further use and foresting.

/6/ Proper lightning, open air fuel storage, and measures to assure workers' personal hygienic conditions are obligatory at each disposal site.

This decree needs some modification in view of new objectives and tasks of the MSW management. This modification concerns mainly enforcement of the recycling and reuse of materials, reduction of the MSW volume and reduction of environmental risk.

The results of the public opinion survey carried out in the framework of the Study in Budapest in June-July 1992 indicate that public awareness of the separate collection and recycling of the MSW is very high. 92% of questioned persons would be inclined to collect separately some types of the MSW so far as they were ensured of the practical conditions needed.

The majority of those surveyed (77%) consider separate MSW collection justified from both economic and environmental viewpoints. 13% consider it justified only for environmental protection, while only 2% consider separate collection favorable only for its economic importance. 5% has doubts about the necessity of separate collection whatsoever.

85% of those asked mentioned empty bottles, 80% paper, 78% household metal scrap as materials which should definitely be collected separately. Rugs and surplus textile materials were often mentioned also by 57%, 38% mentioned grass and green materials.

89% had already heard about recycling procedures that would be applicable to the reuse of certain type of the MSW. 87% - almost the same number - thinks that recycling of the MSW is equally important from both environmental and economic viewpoints. According to 7%, environmental protection has priority here, while 3% think that cost effectiveness does. 1% takes the position that there is no need at all for reuse of the MSW.

The majority of the surveyed persons support environmentally-friendly solutions to be applied in the MSW management, such as the expansion of separate collection and recycling, as well as the composting of the MSW as a measure for the reduction of the MSW volume. The necessity of construction of a new waste incineration plant was also strongly emphasized.

Infrastructural improvement is also essential, as well as structural change (privatization) and stricter regulations for the MSW disposal; however, these demands appeared only as background requirements for solving the problems.

City residents' knowledge of the MSW management comes mostly from the press. 75% mentioned TV as their main information source, 61% mentioned various papers, 57% mentioned the radio, 17% referred to lectures at school, and 14% referred to specialized books and periodicals.

3.11 Financial Condition of the Present Municipal Solid Waste Management

3.11.1 Outline of FKFV's Budget

In Budapest, all issues related to the MSW management are the responsibility of the municipality. However, actual operations are conducted by FKFV. Most facilities used to support the MSW management activities except for HHM1 are the result of investment by FKFV with the cooperation of the municipality, and FKFV has been managing and maintaining those facilities. FKFV has adopted the independent profit system for the company's accounting, so that so far about 60% of the operating cost for the MSW management has been covered by FKFV's own revenue and the rest has been mainly covered by financial sources from the municipality (payment of consignment fee).

As of the end of 1991, FKFV's total assets were 5,138,359,000 Ft and the assets' structure is characterized by a high proportion of fixed assets and low current assets, so that depreciation cost and loan interest greatly harm FKFV's profitability and have the potential of hampering the MSW management activities in Budapest. The Table 3-18 shows FKFV's financial conditions in terms of revenue and expenditure since 1988. The MSW management is one of the services provided by the FKFV and it is the largest one; its share is 56.5% of all FKFV's activities (other activities consist of construction activity, road sweeping, etc.). There has been a net surplus during 1988-91, but it is estimated that there will be a 94.3 million Ft deficit in 1993 following a 78.4 million Ft deficit in 1992.

A total of FKFV's books in 1992 showed a deficit but it was smaller than planned, due to the contribution of the MSW management activities. FKFV accepted a much bigger volume of solid waste than expected, so the total consignment fee as well as the total service charges were increased, while expenditures for the MSW management activities fell short of expectation.

Table 3-18 Profit and Loss Statement of FKFV

Unit: Thousand Ft.

Activities	1988	1989	1990	1991	1992	1993
I. Total FKFV						
Revenue	2.282.435	2.492.489	3.158.489	3.747.165	4.526.774	4.474.580
Expenditure	2.126.215	2.375.724	3.064.315	3.587.822	4.605.198	4.568.903
Balances	156.220	116.765	94.174	159.343	-78.424	-94.323
thereof:						
II. Total of Solid Waste Management Activities						
Revenue (II/I)	1.151.486	1.121.307	1.478.481	2.117.707	2.600.111	2.626.275
	50.4%	45.0%	46.8%	56.5%	57.4%	58.7%
Expenditure (II/I)	988.364	1.022.689	1.320.222	1.869.203	2.230.723	2.297.962
	46.5%	43.0%	43.1%	52.1%	48.4%	50.3%
Balances	163.122	98.618	158.259	248.504	369.388	328.313
III. Consignment fee paid by Municipality for All FKFV's Activities	636.090	702.837	918.588	1.406.966	1.698.893	1.702.466
IV. Covering Ratio by Municipality's Consignment Fee *2	27.9%	28.2%	29.1%	37.5%	37.5%	38.0%

Notes: *1 Estimate

*2 Covering Ratio = $\frac{\text{Municipality's Consignment Fee}}{\text{Total Revenue}}$

Source: FKFV

Only for the MSW management activities, its balances exceeded other FKFV's activities by a great margin since 1990. Surplus of the MSW management activities in 1993 is estimated at about 329 million Ft. The financial structure of each MSW management process can be characterized as follows.

(1) The cost proportion of solid waste management is commonly in the ratio of 60:30:10%, Collection & Transportation : Incineration : Final Disposal. The last five years (1988 - 1992) average ratio in FKFV's solid waste management has been almost identical with this tendency, with the proportion being 66:26:8 (Table 3-19).

(2) The covering ratio of the municipality's consignment fee in FKFV's total revenue has been gradually increasing. The ratio in 1993 will be 38.0% (Table 3-18).

(3) The Waste Incineration Department has the second largest budget share in all the MSW management activities and is the only department that suffers a loss (Table 3-19).

(4) Compared with the budget growth rate of the Final Disposal Department, the other two departments show the growth more than 2.5 times greater.

(5) In terms of a ratio of gross profit to revenue, however, the Final Disposal Department achieves the highest ratio. In the total MSW management balance, that ratio shows only small growth despite increases of profit and revenue amounts.

Besides the above, HHM1 was built by FKFV with the financial support of the national government and the Budapest Capital City Government. The finance for construction was as follows;

Table 3-19 Revenue and Expenditure of the Solid Waste Management Activities by Process

Unit: Thousand Ft.

Activities	1988	1989	1990	1991	1992	1993 *1
I. Collection and Transportation						
Revenue	758.249	795.233	1.090.633	1.568.073	1.848.446	1.892.716
Expenditure	582.886	664.623	946.546	1.273.233	1.443.229	1.496.039
Balances	175.363	130.610	144.087	294.840	405.217	396.677
II. Incineration						
Revenue	165.914	90.738	165.753	299.418	522.692	490.264
Expenditure	268.556	254.079	252.338	513.875	697.259	698.218
Balances	-102.642	-163.341	-86.585	-214.457	-174.567	-207.954
III. Final Disposal						
Revenue	227.323	235.336	222.095	250.216	228.973	243.295
Expenditure	136.922	103.987	121.338	82.095	90.235	103.105
Balances	90.401	131.349	100.757	168.121	138.738	140.190
IV. Total						
Revenue	1.151.486	1.121.307	1.478.481	2.117.707	2.600.111	2.626.275
Expenditure	988.364	1.022.689	1.320.222	1.869.203	2.230.723	2.297.362
Balances	163.122	98.618	158.259	248.504	369.388	328.913
V. Consignment Fee paid by Municipality for Sold Waste Management	358.657	350.099	519.867	797.228	978.508	1.027.240
VI. Covering Ratio by Municipality's Consignment Fee *2	31.1%	31.2%	35.2%	37.6%	37.6%	39.1%

Notes : *1 estimated figures

*2 Covering Ratio = $\frac{\text{Municipality's Consignment Fee}}{\text{Total Revenue}}$

Source: FKFV

	Thousand Ft
Subsidy by the Government (Grant)	82,000
Subsidy by the Budapest municipality (Grant)	700,000
Other Subsidies by Governmental Organizations (Grant)	300,000
FKFV's own funds (Loan)	1,118,000
Total	2,200,000

3.11.2 Budget Structure of Each Municipal Solid Waste Management Activity

The breakdown of management cost by each process is stated in the Tables 3-20 to 3-22. Some distinctive features are summarized as follows.

(1) The Waste Collection and Transportation Department has the largest budget share of all FKFV activities. Within the cost items, the maintenance cost for the collection vehicles and fuel costs show high proportions, and especially rising fuel (gasoline) cost, it is feared, will further adversely affect the profitability of the department.

(2) Annual maintenance cost for collection vehicles is about 17% of the total cost. This percentage is higher than in standard cases. The main reason is that FKFV uses old vehicles as long as possible by replacing parts and doing repairs instead of purchasing new vehicles.

(3) Depreciation cost shows the high proportion. Especially, depreciation for the restoration cost of HHM1, that amounted to 1.7 billion Ft, added much to costs, and the depreciation will be increased further due to the use of the new accounting system from fiscal 1992.

Table 3-20 Operation Costs of Waste Collection and Transport

Unit: Thousand Ft.

	Year 1991	Year 1992	Year 1993 (projected)
Direct Costs			
- Wages	111.120	137.936	150.232
- Social Security	47.780	60.692	66.102
- Fuel Costs	104.332	120.758	131.633
- Depreciation (transport vehicles)	115.522	137.657	138.000
- Container Purchases	67.109	146.338	51.605
- Maintenance Costs - Collector vehicles	213.901	246.254	246.254
- Containers	4.849	4.820	5.000
- Leasing Fee for Vehicles	123.337	-	82.636
- Collection Costs of Rental Fees for Containers	-	75.271	58.554
- Other Direct Costs (workers' house, transport charges)	15.552		
Total direct cost	803.502	929.726	930.016
Indirect Costs			
- Wages	28.835		
- Social Security	12.399		
- Maintenance Costs of Buildings	1.228		
- Depreciation (buildings, equipments)	2.384		
- Fees for Public Utility Services	1.242		
- Material Costs (work clothes, protective clothes, tools, etc.)	8.413		
- Other Expenses	1.300		
- Comprehensive Costs for Maintenance	80.645		
Total indirect cost	136.446	188.056	183.923
- Direct + Indirect costs	939.948	1.117.782	1.113.939
- Administrative costs of the head-office	333.285	325.447	382.100
Total prime costs	1.273.233	1.443.229	1.496.039
Revenues	1.568.073	1.848.446	1.892.716
Profit	294.840	405.217	396.677
Quantity of waste transported by FKFV (in compacted m3)	3.901.825	3.995.573	3.788.000

Source: FKFV

Table 3-21 Operation Costs of the Incineration Plant

Unit: Thousand Ft.

	Year 1991	Year 1992	Year 1993 (projected)
Direct Costs			
- Wages	43.946	58.662	62.295
- Social Security	18.897	25.811	27.410
- Public Services (operation, gas, electrical supply, water and sewerage system)	84.449	66.978	136.250
- Maintenance and chemicals (water softener)	25.130	66.999	
- Equipment, machines, for technology			
- Depreciation	137.679	197.370	197.370
- Maintenance costs (done by other companies)	23.662	48.818	40.000
- Repair of other machines	676	32.751	34.805
- Slag transport	15.139		
- Costs of workers' hostel	1.495		
Total direct cost	351.073	497.389	498.130
Indirect Costs			
- Wages	8.967	12.605	
- Social Security	3.865	5.546	
- Maintenance costs of buildings	6.624	6.804	
- Depreciation (buildings, real assets)	9.104		
- Material Costs (work clothes, protective clothes)	3.171	20.270	
- Other costs (cleaning, laundry for work clothes, sewage cleansing, telephones, books, fees for experts, etc.)	17.079		
Total indirect cost	48.810	45.225	45.230
- Direct + Indirect costs Total	399.903	542.614	543.360
- Contribution to administrative costs of entire company	113.972	154.645	154.858
Total Cost	513.875	697.259	698.218
Revenues			
from incineration	151.968	273.088	275.264
from sales (electrical, heat energy)	147.450	249.604	215.000
Total revenue	299.418	522.692	490.264
Total Balance	-214.457	-174.567	-207.954

Source: FKFV

Table 3-22 Operation Costs of the Final Disposal Sites

Unit: Thousand Ft.

	Year 1991	Year 1992	Year 1993 (projected)
Direct Costs			
- Wages	10,182	11,679	13,332
- Social security	4,378	5.139	5.866
- Fuel costs	7,652	7,167	7.834
- Machines - depreciation	3.201	2.937	2.940
- maintenance costs	2,617	9.777	9.731
- Charges (watering, desinfection of mines)	6,141	15,777	7.100
- Mine's rental fees	17.600	-	15.688
Total direct cost	51.771	52.476	62.491
Indirect Costs			
- Wages	1.174		
- Social security	505		
- Maintenance costs of buildings	324		
- Depreciation (buildings, real assets)	363		
- Public Services	983		
- Material costs (protective drinks and clothes, fuel)	376		
- Other costs (laundry for work clothes, minges guards, freight, sewage cleansing, rental fee for the area, extermination of vermin, etc.)	8.391		
Total indirect cost	12.116	17.746	17.746
- Direct + Indirect costs	63.887	70.222	80,237
- Contribution to administrative costs of entire company	18.208	20.013	22.868
Total prime cost	82.095	90.235	103,105
Revenues			
- from disposal activities	250.216	228.973	243.295
Balances	168.121	138.738	140.190

Source: FKFV

(4) Contribution to the administrative cost of the entire company is approximately 22% of the total cost in 1992 and this ratio is uniform in FKFV irrespective of each department's profitability. This item shall be allotted for administration cost of FKFV's head office and also covers investment costs.

(5) The main revenues of HHM1 are composed of the consignment fee from the municipality, an incineration fee collected directly from the companies who bring the MSW to the plant, and the revenues from the sales of electric power and heat energy. The proportion of these revenues are roughly 30:20:50% respectively. Part of the consignment fee is to cover final disposal management cost.

(6) The sale of surplus energy which is generated in HHM1 is the one of the sources of revenue. Especially, supplying heat energy makes up for supply shortages in the region.

(7) Land rental is the biggest cost factor, because FKFV has been renting all sites for final disposal. Each final disposal site is effectively operated by only a few workers and depreciation cost is also small because the sites were originally mines and can be used without any new construction.

3.11.3 Municipal Solid Waste Management Service Charges and Electric Power Tariff

(1) MSW management service charges

FKFV's revenue in the MSW management activities is mainly composed of three items, namely the consignment fee, the container leasing fee and the service fee. Relevant aspects of each fee are summarized as follows.

1) Consignment fee

As a result of FKFV's performing its duties on the basis of the Budapest City Council's Decree, FKFV received the municipality's consignment fee at a certain amount per cubic meter for the total MSW management. The tariff of charges for 1993 has not been decided as of March 30, 1993, but according to FKFV, the increase will be within the range of Value Added Tax. The consignment fee of the municipality is FKFV's main revenue now.

2) Container leasing fee

Several sizes of container are leased to residents and companies in Budapest to collect the MSW. FKFV has charged a leasing fee based on the size of the container. This amount covered about 10.6% of the MSW management's revenue in 1991.

3) Service fee

FKFV received the MSW collected and transported by private companies for a fee. Also FKFV itself collects extra solid waste from factories or offices on a fee basis. FKFV charges 480 Ft/m^3 for total management of the MSW in 1991.

FKFV has two methods of bill collecting for container leasing fees. One is IKV-FSZDV route; IKV (City Dwelling Service Co.) pays a leasing fee to FKFV for residents of state of the municipality-owned apartments through FSZDV (Service Charge Collecting Co.). The second is direct collecting of bills by FKFV, that directly charges companies (office or factory) as well as households which keep individual leasing containers.

Apart from the present revenue structure, a new "Fee Collection System" is now under examination by FKFV and the municipality. This concept is based on the "Polluter Pays Principle" whereby management expenses including the cost for the MSW management facilities should be shared by the polluter who generates the wastes and the authorities who are in charge of the MSW management. If this viewpoint is adopted, a new "Fee Collecting System" will be applied for all beneficiaries of FKFV's MSW management service. Under the present fee system, a fee for the commercial waste is directly charged only by FKFV, while the household waste charges are case by case.

The Tables 3-23 and 3-24 show the waste management cost per household in terms of gross cost and substantial cost, since 1988. The cost has increased every year, to 1,655 Ft in 1992 and 1,732 Ft estimated in 1993. In the case of 1993, the household cost per month is about 150 Ft. This is estimated as only 0.34% of the average household income in Budapest based on 1990 income data, but to the household cost should be added FKFV's administrative cost, some margin and Value Added Tax (VAT).

The settlement of reasonable tariff charges and fee collecting methods still need further discussion and explanation; especially, the relevancy of the municipality's consignment fee is one of the biggest questions which should be cleared both for the authorities that are in charge of the MSW management and for all beneficiaries (households, commerce etc.). Because the present financial source of the consignment fee is tax paying by all citizens.

Table 3-23 Waste Management Cost per Household (Gross)

	Collection and transportation	Incineration	Final disposal	Total waste weight (tons)	Cost/ton (Ft.)	No. of households	Cost/ household (Ft.)
	Total SWM Cost (1,000 Ft)						
1988	582.866	268.556	136.922				
		988.344		699.054	1.414	823.296	1.200
1989	664.623	254.079	103.987				
		1.022.689		703.978	1.453	789.177	1.296
1990	946.546	252.338	929.338				
		2.128.222		706.438	3.013	795.284	2.676
1991	1.273.233	513.875	89.095				
		1.876.203		686.536	2.733	803.807	2.334
1992	1.436.351	697.259	90.235				
		2.223.845		661.000	3.364	807.826	2.753
1993*	1.534.870	709.783	93.986				
		2.338.639		648.450	3.607	811.865	2.881

Note: *1993 figures are based on the JICA Study Team's estimation
SWM Cost = MSW management cost

Source: FKFV
Fovarosi Onkormanyzati Kezikonyv, 1992

Table 3-24 Actual Waste Management Cost per Household

	Actual SWM Cost for Household Waste (1,000 Ft.)	Total waste weight (tons)	Cost/ton (Ft.)	No. of households	Cost/ household (Ft.)
1988	593.006	419.432	1.414	821.649	722
1989	613.613	422.387	1.453	787.599	779
1990	1.276.933	423.863	3.013	793.693	1.609
1991	1.125.722	411.922	2.733	802.199	1.403
1992	1.334.307	396.600	3.364	806.210	1.655
1993*	1.403.183	389.070	3.607	810.241	1.732

Note: coefficient of total cost and total waste is 0.6
No. of household is 0.998 respectively
SWM Cost = MSW management cost

Source: FKFV
Fovarosi Onkormanyzati Kezikonyv, 1992

(2) Electric power tariff

Regarding energy recovery, FKFV has been selling electric power and heat energy which are generated in HHM1 to the Hungarian Electric Works Co., (Magyar Villamos Muvek Rt) and the Heat Distributing Co. (FOTAV).

The sale price of the recovered energy is decided by the Price Authority (A'RHATOSA'G), which is an independent third party, so that FKFV cannot set the price by itself. Sold amount and prices of the recovered energy in 1991 are as follows.

	Total Sold Amount of HHM1	Sale Price of HHM1	Market Price (for reference)
Electric Power	38,430 MWh	2.93 Ft/kWh	3.70 Ft/kWh
Heat Energy	252,061 GJ	180 Ft/GJ	323 Ft/GJ

Market prices of both energy forms have been increasing since 1991, however the sale price by HHM1 has been kept almost constant.

In a quite unusual way compared to international practice, for a long period 25 to 30% of the annual electric power demand in Hungary was met by imports. Last year electricity consumption was 34.8 TWh, a decrease of 5.9% from 1991 following a drop of 13.8% from the 1989 peak consumption of 40.3 TWh. The share of imported electric power has decreased, but it is still significant.

Besides electric power supply, the heat energy from HHM1 is also available for sale. However, the saleable quantity is not so much, because the Hungarian Electric Works Co. also provides heat energy in some power plants at low prices. So, it seems to be difficult to sell the heat energy from HHM2 to the domestic market.

3.12 Major Issues in the Present Municipal Solid Waste Management of Budapest

(1) Insufficient capacity of the final disposal sites

(2) Insufficient incineration capacity of HHM1 due to technical and superannuated issues

(3) Insufficient measures for the reduction of the generated MSW volume

(4) Difficulty in obtaining the new final disposal sites for the future

(5) Necessity of countermeasures for environmental protection at the final disposal sites and HHM1

1) Ground water contamination likely due to dumping of incineration residue and ash at the final disposal sites
2) Necessity of sufficient quantity of covering soil and compaction effect
3) Necessity of management using truck scale for final disposal operation
4) Installation of new flue gas treatment system satisfying the national emission and immission standards for HHM1

(6) Insufficient number of collection vehicles

(7) Necessity of strengthening management capability of the Budapest Capital City Government for the MSW management

1) Lack of information and data control
2) Necessity of strengthening capability for organizing related companies and organizations and following up new technologies

(8) Weak of financial base

1) Revenue shortage of the municipality due to the decline of subsidy from the central government
2) Inflexibility of municipal finance
3) High inflation rate
4) Lack of funds allotted for investment

CHAPTER 4 EXAMINATION OF THE MASTER PLAN COMPONENTS AND SYSTEM ALTERNATIVES

4.1 Introduction

This Chapter is aimed at establishing the basis for the formulation of system alternative (M/P) analyzing the present situations, issues which were summarized in the Chapter 3.

At the same time, the forecasting of future situations, the MSW generation volume and its characteristics and technical trends in connection with the organizational aspects in the Budapest Capital City Government is performed.

Results of this Chapter will be related to the establishment of goals and targets which should be placed prior to formulation of the M/P in the next Chapter.

4.2 Forecast of the Future Municipal Solid Waste Generation Volume and Its Composition

In order to obtain basic data for the formulation of an MSW management system in 2005, the following physical elements and chemical compositions must be forecast.

- MSW generation volume until the year 2005
- MSW generation unit in the year 2005
- Heating value of the MSW in the year 2005
- Chemical composition of the MSW in the year 2005

4.2.1 Municipal Solid Waste Generation Volume Until the Target Year 2005

In order to determine the MSW generation volume until the year 2005, two methods were applied.

The first method is based on population and the MSW generation units which were estimated by using the collected data of 10 years as presented in the Table 3-11.

The second method is based on an increasing MSW ratio which will be predicted from the correlation between the growth rate of GDP and increasing MSW ratio in the past.

In a consequence the MSW generation volume in the future will be forecast by comparing the results obtained by both methods.

<u>First method</u>

First it is necessary to forecast the increase of population for the future based (refer to the Figure 4-1) on the records of population from 1980 to 1990 with the exception of 1982 and 1990. By using a least squares method the following regression line was obtained.

$P = \{0.0053\ (Y - 1980) + 2{,}053\} \times 10^6$

where: P is population

Y is the year

in case of 2005, $P = \{0.0053\ (2005 - 1980) + 2{,}053\} \times 10^6$

$= 2{,}185{,}500$

Secondary the MSW generation unit has to be calculated based on the results of investigation by FKFV (refer to the Table 3-11 and the Figure 4-1).

According to the graph (Figure 4-1) of trends of the MSW generation unit the following formula is obtained by the least squares method.

$U = 0.011\ (Y - 1980) + 2.143$

where: U is the MSW generation unit m^3/capita·year

Y is the year

in case of 2005, $U = 0.011\ (2005 - 1980) + 2.143$

$= 2.418$

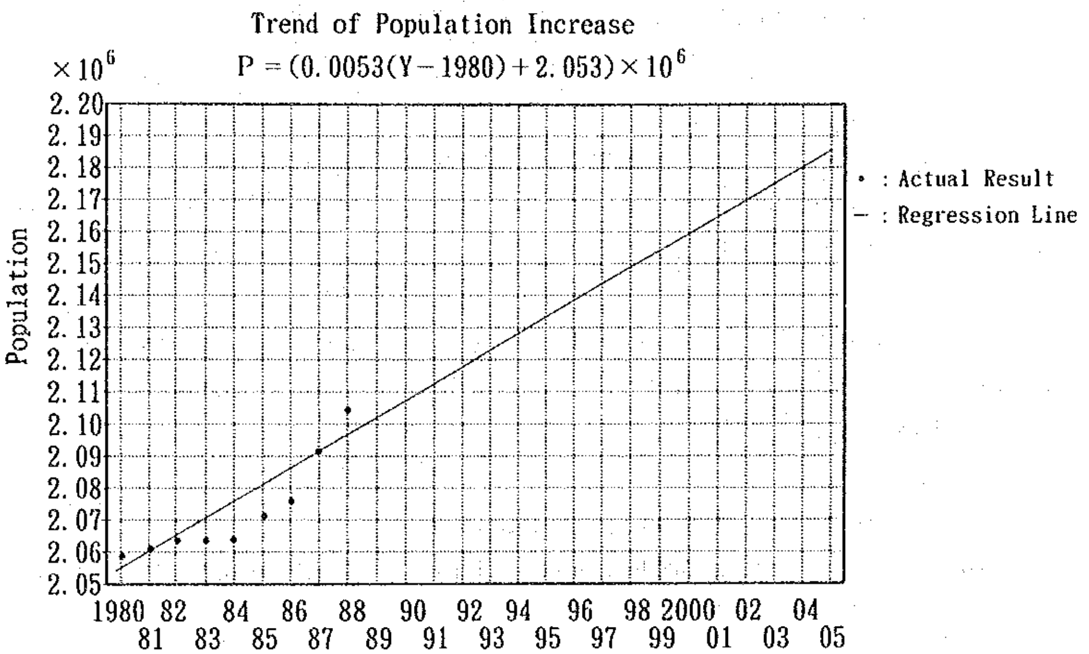
Estimate of the MSW generation volume in 2005:
Population x the MSW generation unit m^3/capita·year
= 2,185,500 x 2.148 = 5,284,539 m^3/year

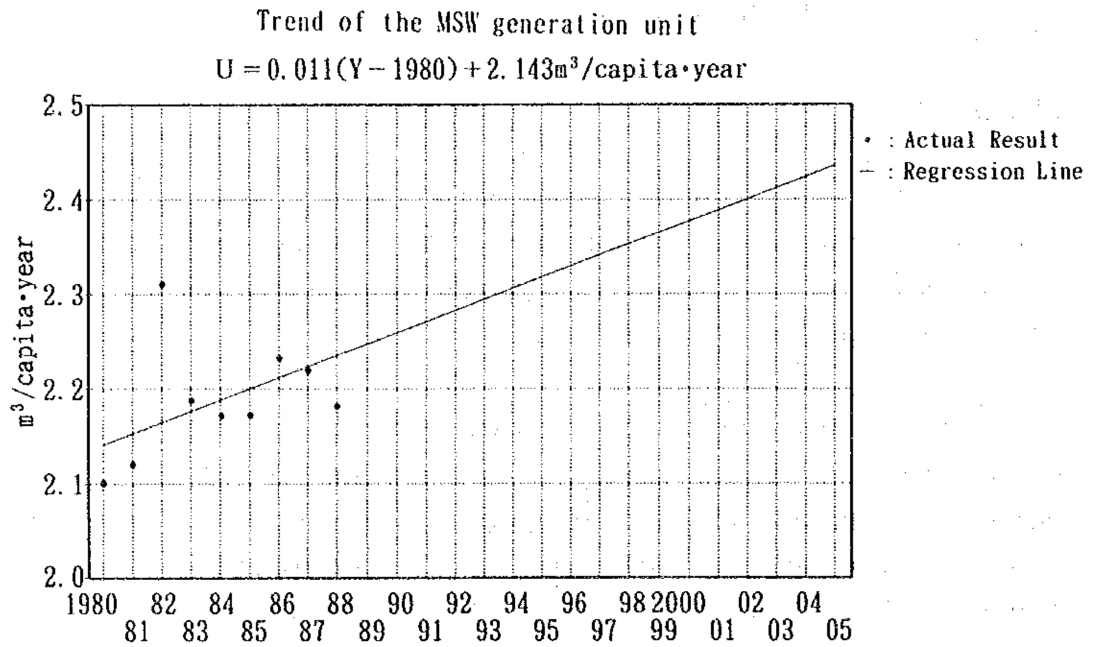
Second method

Instead of the ordinary method forecasting the MSW generation volume in the future, the MSW generation volume can be multiplied by the estimated increasing ratio of the MSW generation volume per year.

The increasing ratio of the MSW generation volume can be estimated from the correlation between GDP of the past 9 years in Hungary and the actually generated MSW generation volume in the Budapest city (refer to the Table 4-1 and the Figure 4-2). The case of Japan, indicating a correlation through the past 15 years, is shown in the Figure 4-3.

Figure 4-1 Trend of Populational Increase and Trend of the MSW Generation Unit





In the Figure 4-2 the correlation between increasing ratio of GDP and the MSW generation volume can be obtained.

According to the Figure 4-2, after examination of several possible methods of calculation, the regression function presented in the following figure is selected.

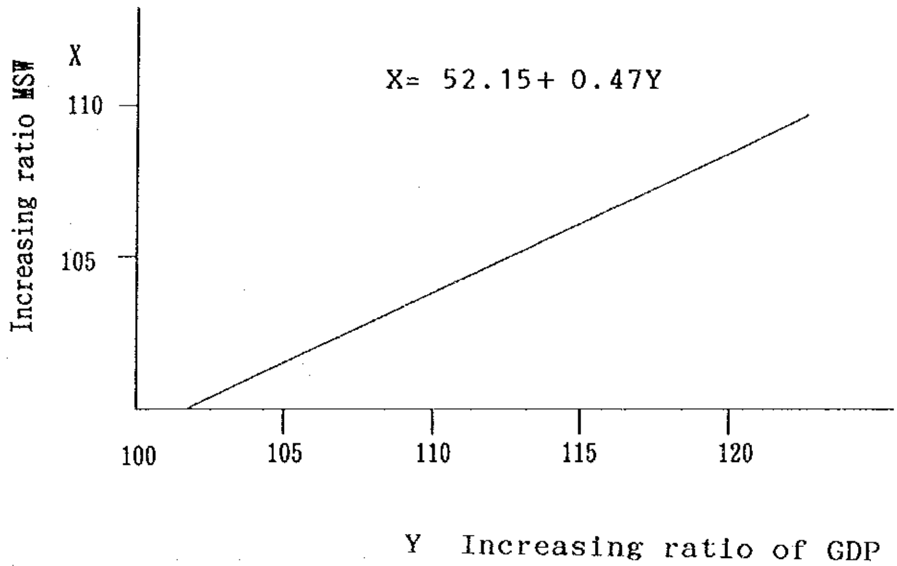


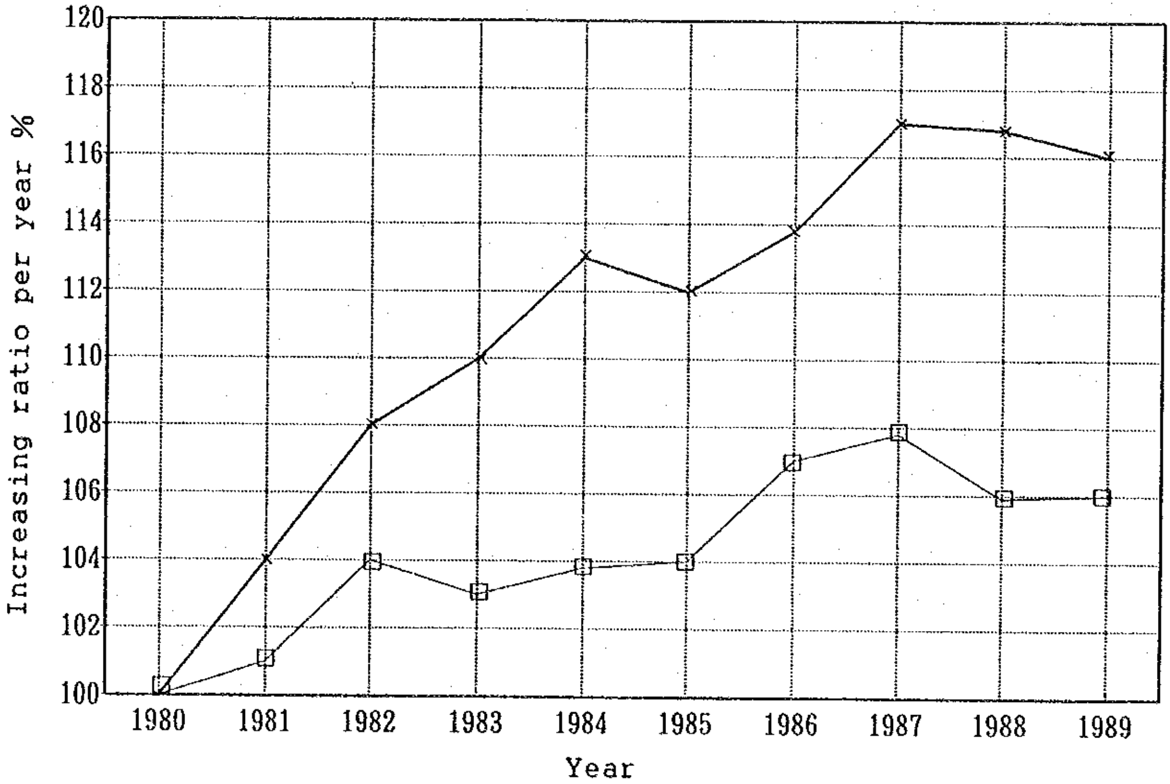
Table 4-1 GDP and the MSW Generation Volume

GDP = Billion Ft, Waste: x 1000m³

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Increasing ratio	670.0	696.1	726.1	737.6	756.3	748.6	760.6	784.7	782.5	778.8	***
(without inflation)	100.0%	103.9	108.4	110.1	112.9	111.7	113.5	117.1	116.8	116.2	0.0
MSW generation	4,333	4,379	4,783	4,518	4,487	4,503	4,635	4,650	4,597	4,593	4,423
volume	100.0%	101.1	110.4	104.3	103.6	103.9	107.0	107.3	106.1	106.0	102.1

source: Hungarian Statistic Book (GDP)

Figure 4-2 Relationship between Both Increasing Ratios of GDP and the MSW

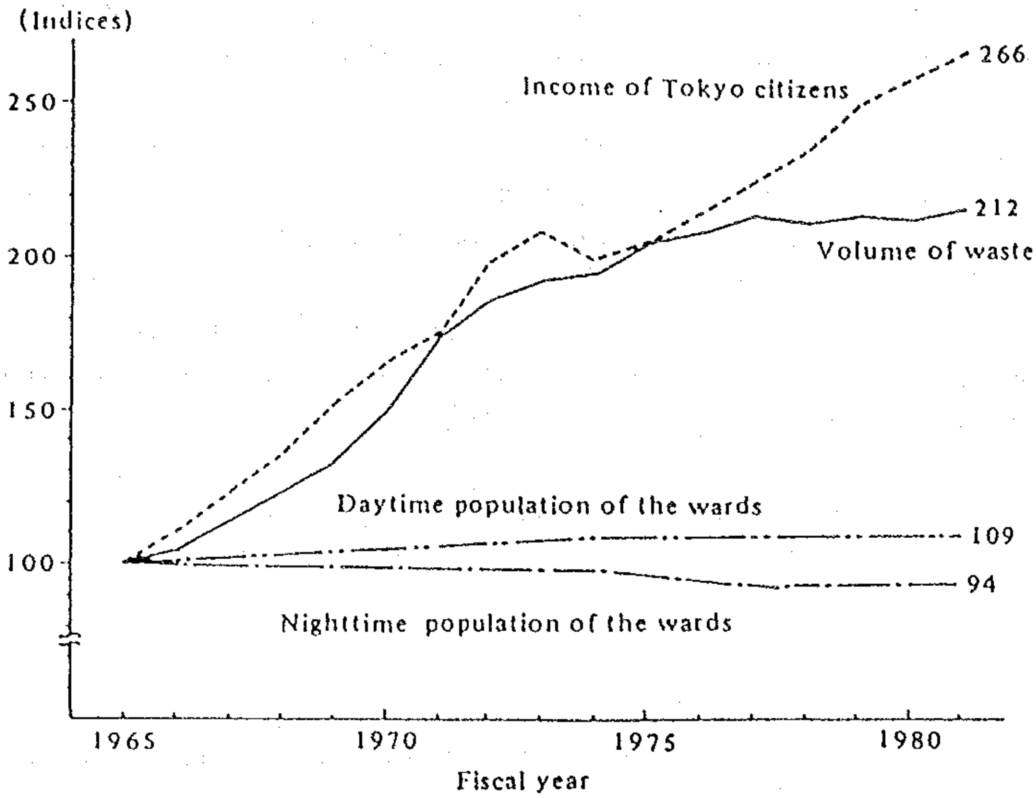


Note: □ MSW + GDP(const.)

Source: GDP- Hungarian Statistic Book

MSW- FKFV

Figure 4-3 Comparison of the Volume of Waste and the Population and Income of the Citizens of Tokyo



According to this formula, X = 52.15 + 0.47Y

The increasing ratio of the MSW per that of GDP is approximately calculated as 0.5; taking into account possible fluctuation by 20%, gives 0.6%.

According to the Ministry of Finance of Hungary, the GDP ratio in the future is estimated from 1994 to 2005 to be 3.0% per year without inflation. Consequently the possible increase ratio of the MSW from the previous calculation will be about 1.8% per year (0.6 x 3 = 1.8), it is approximately 2.0% which is the same as estimated by FKFV.

If we assume 2.0% to be the rate of increase of the MSW generation per year, the total amount of the MSW generation volume in 2005 will be 5,375,000 m^3/year.

The results of the study corresponded well with the following FKFV's forecast for the M/P target year, 2005 shown below.

Unit; 1,000m^3

Year	1990	1991	1992	1993	1994	1995	1996	1997
Generation Volume	4,423	4,246	4,323	4,323	4,323	4,409	4,498	4,588

Year	1998	1999	2000	2001	2002	2003	2004	2005
Generation Volume	4,679	4,773	4,808	4,966	5,065	5,166	5,270	5,375

Note: The values in this table were forecasted by FKFV under the assumption that the quantity of the MSW generated will increase at an annual rate of 2% from 1994 in correspondence with the forecasted economic growth of Hungary.

4.2.2 Physical Characteristics of the Municipal Solid Waste

As for the physical characteristics of the MSW the following three compositions should be considered in formulating the intermediate treatment system in terms of heat balance.

- 3 major components
  - . Moisture (weight %)
  - . Combustibles (ignition loss, weight %)
  - . Ash (residue after burning, weight %)
- Approximate the MSW composition
- Heating value of the MSW (kJ/kg)

(1) 3 major components

According to the data given in the Table 3-15, the following linear formulas can be derived by a least squares method (Figure 4-4).

$$W = 41.49 - 0.398\ (Y - 1982)$$
$$A = 29.81 - 0.235\ (Y - 1982)$$
$$C = 28.70 + 0.633\ (Y - 1982)$$

where: W is moisture content (in %)
A is ash content (in %)
C is combustibles content (in %)
Y is the year

For the year 2005

$$W = 41.49 - 0.398\ (Y - 1982)$$
$$= 32.34$$
$$A = 24.40$$
$$C = 43.26$$

For the year 1993

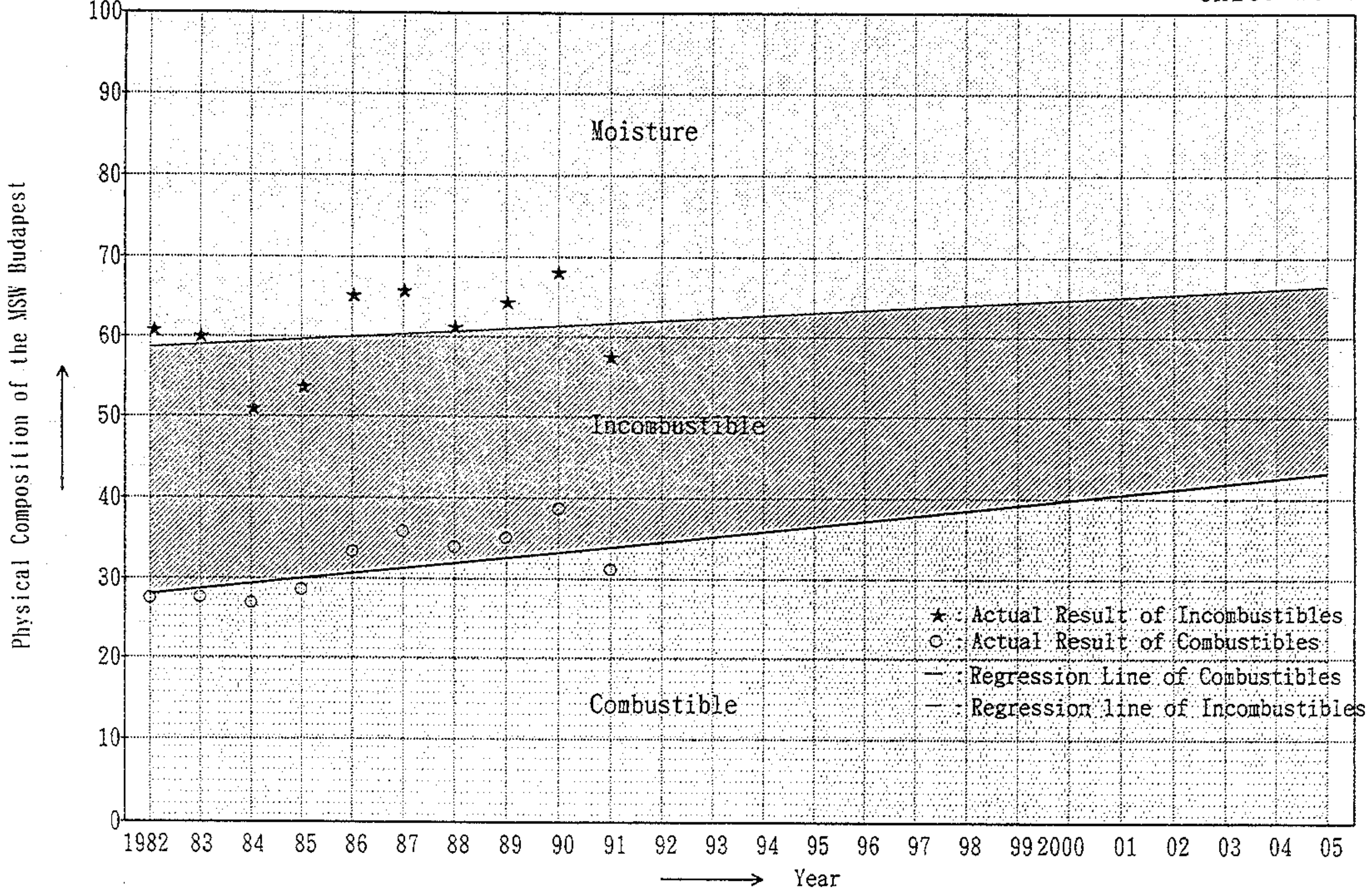
$$W = 41.49 - 0.398\ (1993 - 1982)$$
$$= 37.11$$
$$A = 27.23$$
$$C = 35.66$$

In comparison with similar figures obtained in the JICA Study Team's survey, the moisture content is almost the same, but contents of ash and combustibles are considerably different.

In this sense FKFV's long-term data are considered to be realistic to use.

Figure 4-4 Physical Composition of the MSW in Budapest
(from 1982 upto 1992)

Unit: wt %



(2) Plastic content of the MSW

According to the data accumulated during the past 10 years by FKFV, a statistical curve is presented in the Figure 4-5. By using the least squares method, the following formula is obtained for forecasting the plastic content in the MSW.

$$P = 2.886 + 0.0425\ (Y - 1982)$$

where: P is plastic content (%)
Y is the year

In the year 2005

$$P = 2.886 + 0.0425\ (2005 - 1982)$$
$$= 3.886$$

(3) Heating value of the MSW

In order to forecast the heating values of the MSW in the future, two methods are applied. The first method is to use a formula which considers three elements, such as combustibles, plastics and water content (%) in the unit weight (kg) of the MSW.

The second method is merely to predict the future heating values by using a linear equation derived statistically from the annually measured heating values.

1) First method

The following formula is used:

$$H_L = \{45(C-P) + 80P - 6W\} \times 4.186 \text{ kJ/kg}$$

where: H_L is Low heating value kJ/kg
C is combustibles content (%)
P is plastic content (%)
W is water content (%)

Figure 4-5 Plastic Content

Unit: wt %

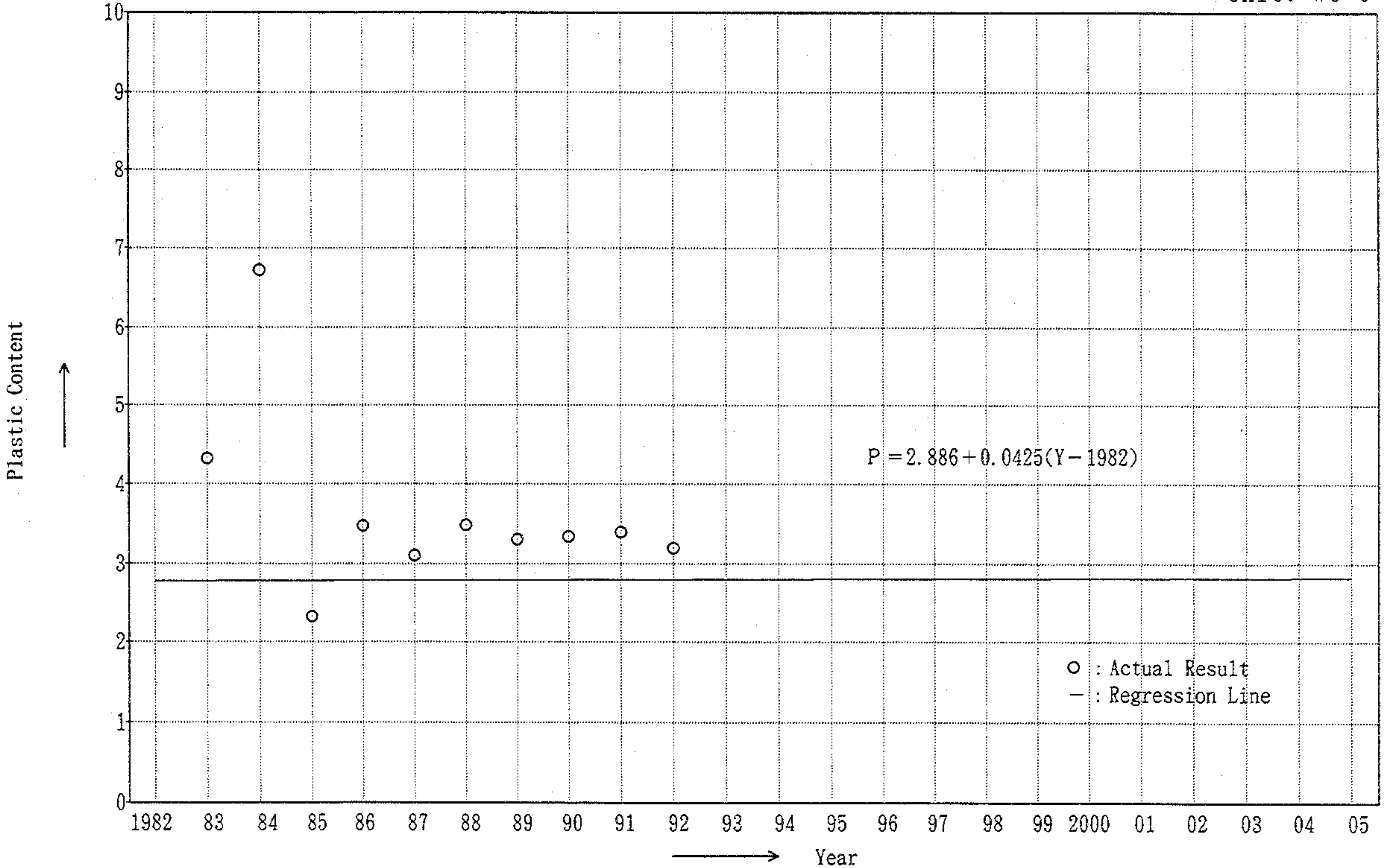
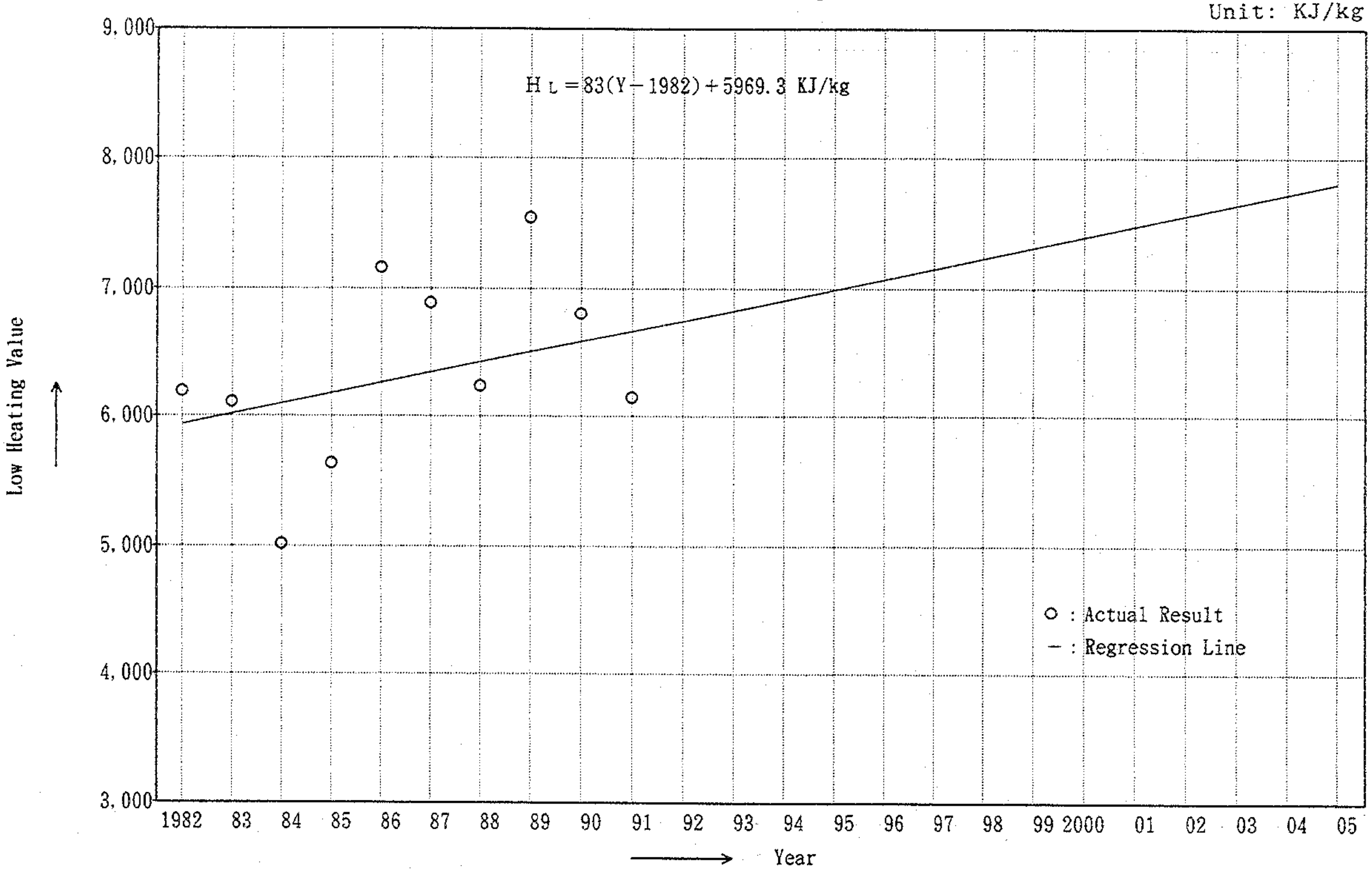


Figure 4-6 Low Heating Value



These elements can be obtained from the linear equations for the three components of the MSW.

This leads to the result:

H_L = {45(C-P) + 80 x P-6W} x 4.186 kJ/kg
where: C is combustible content (%)
P is plastic content (%)
W is water content (%)

In the year 2005
H_L = {45(43.26-3.886) + 80 x 3.886 - 6 x 32.34}
x 4.186 = (45x39+311-194) x 4.186
= 1872 x 4.186 = 7,836 kJ/kg

2) Second method

Heating values from 1982 to 1992 obtained by FKFV are plotted and the least squares method applied to obtain the following equation. (Figure 4-6)

H_L = 83(Y- 1982) + 5969.3 kJ/kg
where: H_L is low heating value kJ/kg
Y is the year

In the year 2005
H_L = 83 (2005- 1982) + 5959.3
= 7,868 kJ/kg

Evaluation

Comparing heating values calculated by the first and second methods, almost the same heating values are obtained.

The second method is preferable because plastic content changes over time with change of life style.

(4) Specific weight of the MSW

Specific weights of the MSW found by FKFV (Figure 4-7 and Table 4-2), decreased rapidly from 1965 to 1985 and more slowly after 1986.

The latter trend, being more current, is used for future prediction. In terms of geometric series the following formula is derived from the curve plotted in the Figure 4-7.

$$Ws = Ws_1 \{1 + (\frac{Ws_2}{Ws_1})^{1/4} - 1\}^x$$

where: Ws is specific weight kg/m^3

Ws_1 is 0.159 kg/m^3 in 1986 (fixed)

Ws_2 is 0.156 kg/m^3 in 1990 (fixed)

X is a number for the year, 1, 2 ...X, starting from 1991

In the year 2005

$$Ws = 0.159 \times \{1 + (\frac{0.156}{0.159})^{1/4} - 1\}^x$$

$$= 0.159 \times 0.99525^x$$

$$= 0.159 \times 0.99525^{15} = 0.152$$

Evaluation

In consideration of the present relatively high content of incombustibles in the MSW and 5% allowance, Ws of 0.150 would be more realistic than 0.148 in 2005. FKFV also estimated 0.150 as the specific weight in 2005.

Figure 4-7 Specific Weight of the MSW

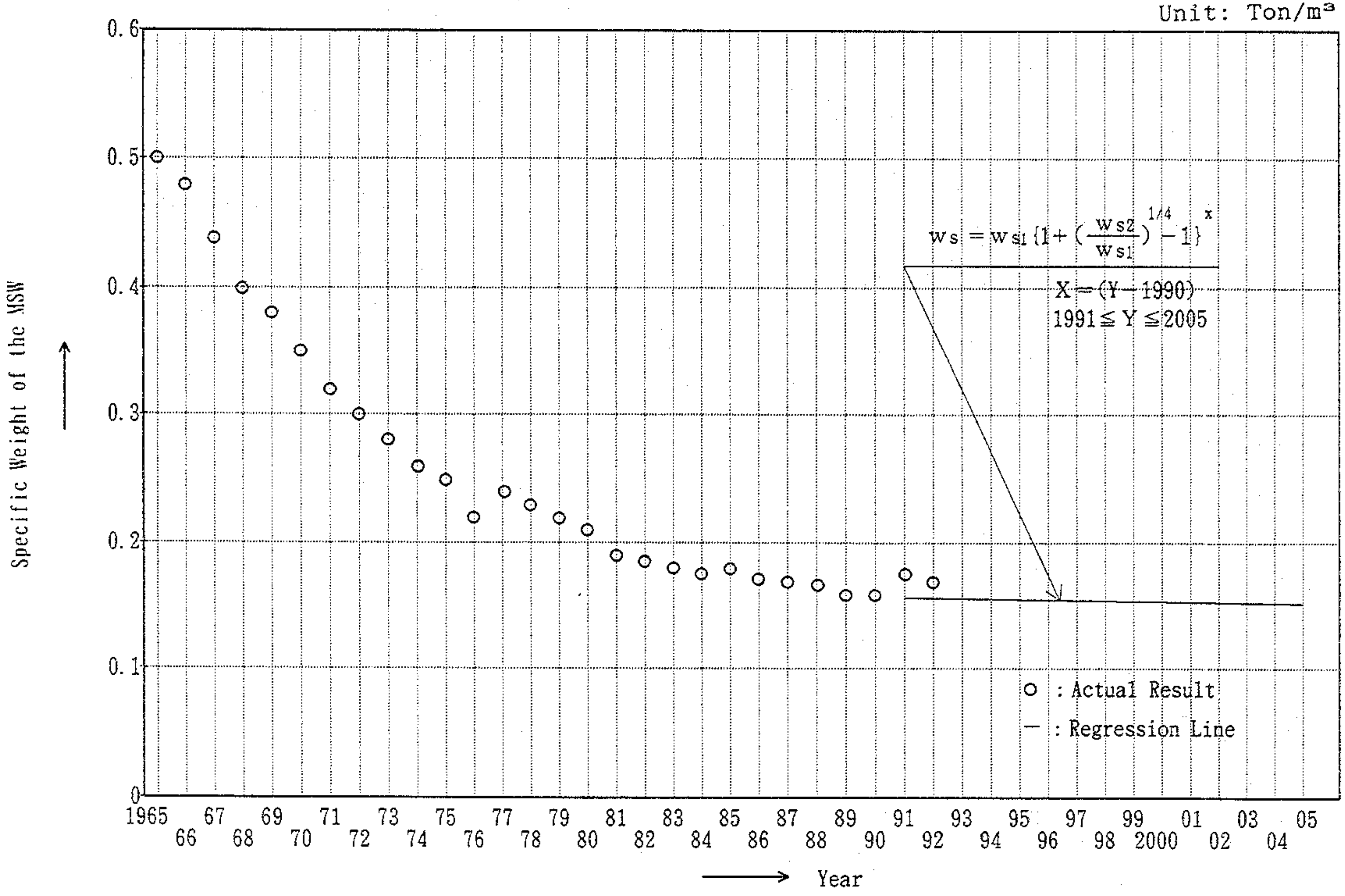


Table 4-2 Data of Specific Weight of the MSW

Unit: Ton/m^3

Year	Data 1	Data 2	Data 3	Data 4	Mean value
1965	0.50				
1970	0.35				
1975	0.25				
1980		0.21			0.21
1985		0.18			0.18
1986		0.185		0.159	0.172
1987		0.18		0.159	0.170
1988		0.18		0.156	0.168
1989				0.159	0.159
1990			0.178	0.159	0.159
1991			0.176		0.176
1992			0.169		0.169
1993					

Source: FKFV

Note:

Data 1: A KORNYEZET ALLAPOTA ES VEDELME, BUDAPEST 1986 (STATE and PROTECTION of the ENVIRONMENT)

Data 2: Municipality of Budapest, Public Service Division Budapest, Nov., 1989

Data 3: FoVarosi Kozteruletfenntarto vallatat Szemetszallitas mennyisegi adatai

Data 4: Metropolitan data relating to the study dealing with treatment of Solid Waste of settlement

4.3 System Components

The MSW management may be defined as the control of generation, storage, collection, transfer and transport, processing, and disposal of the MSW in a manner that is in accordance with the best principles of public health, economics, engineering, conservation, and aesthetics, and which is also responsive to public attitudes.

Processing and disposal of the MSW can be divided into "resource recovery and recycling," and "intermediate treatment or the MSW volume reduction" including "final disposal of the MSW."

In its scope, the MSW management includes all administrative, financial, legal, planning, and engineering functions involved in the spectrum of solutions to the issues of the MSW thrust upon the community by its inhabitants.

4.3.1 Municipal Solid Waste Discharge and Storage

In order to execute effective and sanitary MSW collection, a well organized MSW discharge and storage system with public cooperation is indispensable.

At the present time, in Budapest a system of the MSW volume reduction and separate discharge/collection has not been in effect, however a MSW collection system, one of the main aims, has largely been achieved.

In view of the expected increase of the MSW in the future, a shortage of the final disposal sites' capacities and worsening of traffic conditions in the city, the present system of the MSW discharge and storage will have to be reconsidered together with the implementation of the MSW volume reduction and a separate collection system.

The MSW increase is expected to be particularly large in the city center and commercial areas.

In the meantime, the negative result of the experiment on resource recovery and separate collection carried out by the Budapest Capital City Government shows that the distance between households and collection containers was one of the main reasons why it was difficult to obtain the residents' cooperation.

An alternative to the present system is the collection in plastic bags used with containers for easy MSW separation. Curbside collection by specially designed trucks is an alternative to the stationed type collection system and is practicable in the city center area.

4.3.2 Municipal Solid Waste Collection

The MSW collection system in Budapest has been well organized in operation, particularly in covering the service area as large as possible by FKFV, almost exclusively. The city has been kept clean so far.

However, considering the expected increase of the MSW generation, economic growth, and social demand for a comfortable and beautiful environment in the city, a multiple system involving separate collection, bulky waste collection and harmful waste collection in addition to the present collection system will be required. Separate collection and harmful waste collection are still under experiment by the Budapest Capital City Government and bulky waste collection is discussed in this Chapter along with a waste crushing system.

By the target year of 2005, two major events, the World Exposition and the construction of HHM2 are planned.

(1) Type of container

The type of container may have to be reviewed for compatibility with containers to be used for a resource recovery and separate collection system in the future.

(2) Number of collection vehicles

In order to deal with the increase of the MSW generation in 2005 by about 25% and the construction of HHM2 in district-XV, two alternatives are discussed in the Section 4.3.3. on transfer and transportation.

(3) High rate of absenteeism of workers in charge of waste collection

In order to reduce this high rate of absenteeism the following countermeasures will be considered.

a) To increase salary or to introduce a system of premiums
b) To improve and/or provide welfare facilities
c) To lighten the work load
d) To motivate
e) To remove the difference of welfare facilities among the three dispatch stations

In contrast to technical matters, such problems are related to human mentalities which must be considered.

4.3.3 Municipal Solid Waste Transfer and Transportation

In view of the expected increase of the MSW volume in the future and the possibility of the HHM2 construction, four alternatives will be considered. It is important to deal with the future increasing of the MSW generation by strengthening the transportation system. Necessary elements to be considered for evaluation of four alternatives are as follows.

a) To increase the number of collection vehicles with drivers and collection workers
b) To examine another dispatch station
c) To examine transportation systems (direct and indirect transport)

Secondly the following facts concerning a system of transportation in Budapest should be considered.

- Locations of dispatch stations (3-motor pool)
- Collection territory of each dispatch station
- MSW collection rate in each collection territory
- Social situation in each area
- Number of collection vehicles
- Number of collection workers

There are three dispatch stations for the MSW collection vehicles, the Ecseri station located in district-IX, southern part of Pest; the Testverhegyi station in district-III, northern part of Buda; and the Ifjugarda station in district-XV, northern part of Pest, as shown on the map, Figure 3-4. Collection territory and percentage of the MSW generation at the districts are presented in the Tables 3-1 and 3-4.

Social factors directly related to the MSW generation of each territory include population, economic activities and life style. The territory which belongs to the Ecseri station is the busiest area in terms of economic activity and has the heaviest populational density. Testverhegyi's territory is a residential area, in the hills, but more economic activity is expected in the flat southern part of this territory. Ifjugarda territory is a residential and agricultural area.

The number of collection vehicles and collecting workers are presented in the Tables 3-3 and 3-6.

(1) Alternatives for the future transportation system

Alternative-1. The number of collection vehicles

To determine the number of collection vehicles to be added in accordance with the increased MSW generation, there are six factors to be considered: the MSW generation volume in each district, location of the final disposal site, average capacity of collection vehicle, the allowable number of collection trips and a transportation system.

In this Section, two cases are examined for the Alternative-1. In the first case, all the generated MSW will be disposed of by HHM1 and dumped at the present final disposal sites. In this case, as a matter of course, the capacity of the final disposal sites to be required should be obtained in accordance with the increased MSW.

In the second case, all the combustible MSW will be incinerated by HHM1 and HHM2, and the incombustibles will be disposed of at the final disposal sites. In this case HHM2 will be operated from 1999, and a Transfer Station (T/S) will be put in operation from 1999 to transport the combustibles generated in the southern areas by using container trucks effectively.

The previous five factors are specified as follows.

- MSW volume to be hauled by FKFV is 92% and the combustible MSW of the total generated is 69%.

The MSW generation volume in each district can be obtained based on the data presented in the Table 3-1.

- Locations of the new final disposal sites:
  The new Akna site will be operated from 1993.
  The Bajna site will be operated from 1994.
  Selected 14 potential sites will be obtained and operated one after another by 2005.

- Capacity of collection vehicles is assumed to be 4.8 tons on average.

- Allowable number of trips for collection and transportation will be calculated.

- Another transfer station will be operated from 1994, which will only be used for the Bajna site.

The purchasing schedule of collection vehicles for two cases were planned in the Table 4-3.

Table 4-3 Purchasing Plan of Collection Vehicles

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Case 1													
Truck*1	15	7	4	2	2	2	-	-	-	-	2	2	10
Container Truck*2		2											
Case 2													
Truck*1	15	7	4	2	2	2	-	-	-	-	-	-	2
Container Truck*2							2						

Note: *1 For 12 m^3 (min.), *2 For 24 m^3 (18 ton) container

Between 1991 and 1994, the decisive factors such as locations of the final disposal sites and a transportation system are quite the same for two cases. Therefore, purchasing plans will eventually be the same, differences are observed in the period from 1999 to 2005 which are chiefly related to whether HHM2 and T/S for HHM2 will be constructed or not.

15 collection vehicles in 1993 were planned to urgently replace very aged vehicles.

Seven collection vehicles in 1994 were planned in connection with the establishment of T/S for the Bajna final disposal site situated about 40 km from Budapest.

Next, from 1995 to 1998, the planned numbers of collection vehicles were aimed to deal with increase of the MSW generation. The large difference between two cases from 1999 to 2005 is influenced by the construction of T/S for transportation of the combustible MSW to HHM2 and the final disposal site in district-XVIII, assumed to be only one site in 2005. For case 1, all the MSW except 2,100,000 m^3 to be incinerated by HHM1 should be hauled to this one site in district-XVIII. With these conditions, the expenses, such as vehicle purchase cost, maintenance cost, operational cost and personnel cost, for case 1 will be more than those of case 2.

Alternative-2. Another dispatch station

To deal with the increase of the MSW volume in the future, a new dispatch station may be established as one alternative, to share the MSW collection areas and amount of the MSW more evenly in four blocks.

In case of a large collection area with heavy traffic density, a dispatch station will not have more effect than T/S in terms of economic and environmental aspects.

Evaluation

Judging from the present and conceivable future MSW generation volume in each district, obtainability of the land, geographical conditions and the possibility of the HHM2 construction in district-XV, the most suitable place for a new dispatch station will be in the southern part of Budapest, from functional and economical viewpoints.

However, there is already the Ecseri dispatch station in the southern part of Budapest, so an additional dispatch station would not be a realistic solution.

A better solution might be the T/S system in place of the dispatch station system.

Alternative-3. Types of collection vehicles

The present collection vehicles in use have been selected in accordance with the MSW management system in Budapest.

Not only the type of collection vehicle, but also the functions provided with vehicles and their capacity are important. This will be true particularly if a resource recovery and recycling system is introduced in the future.

Instead of collection vehicles of 12 m^3 capacity, for instance larger collection vehicles with a capacity more than 12 m^3, on which a mechanized compaction device is provided, will be proposed.

Collection vehicles of 12 m^3 and 5 m^3 will be kept to a minimum.

Organization

A new organization for managing the T/S system will be essential for effective operation and maintaining good relationships with residents.

Alternative-4 Direct or indirect transport

1) Indirect transport

In the field of waste management, the functional elements of a transfer station include the means, facilities, and equipment used to transfer wastes from relatively small collection vehicles to larger vehicles and to transport them over extended distances to either a processing center (intermediate treatment) or disposal site.

Since HHM2 will be located in district-XV, the same site with HHM1, according to the decision of the last Budapest City Assembly Meeting in 1992, all the combustible MSW generated in southern areas consisting of districts-IX, X, XI, XVII, XVIII, XIX, XX, XXI and XXII should be collected and hauled to HHM1+2, in the northernmost part of district XV, for which the Ecseri dispatch station is in charge of collection and transport. The distance between HHM1+2 and each district averages about 20 km.

In consideration of Ecseri's collection territory with the biggest MSW generation, about 39% of the total amount in the Budapest city, and the location of HHM2 at the same site with HHM1 far from Ecseri's territory, T/S should be located in district-X midway between north and south. There it will be able to cover half of the city area and transport the MSW to HHM1+2 and some final disposal sites if required. district-X is situated on the way to the site of HHM1+2 from southern districts.

In the meantime, in determining the necessity of T/S, several critical factors are considered as follows.

- Distance between T/S and destinations
- Traffic conditions between the MSW collection points and destinations
- Environmental situation in the city

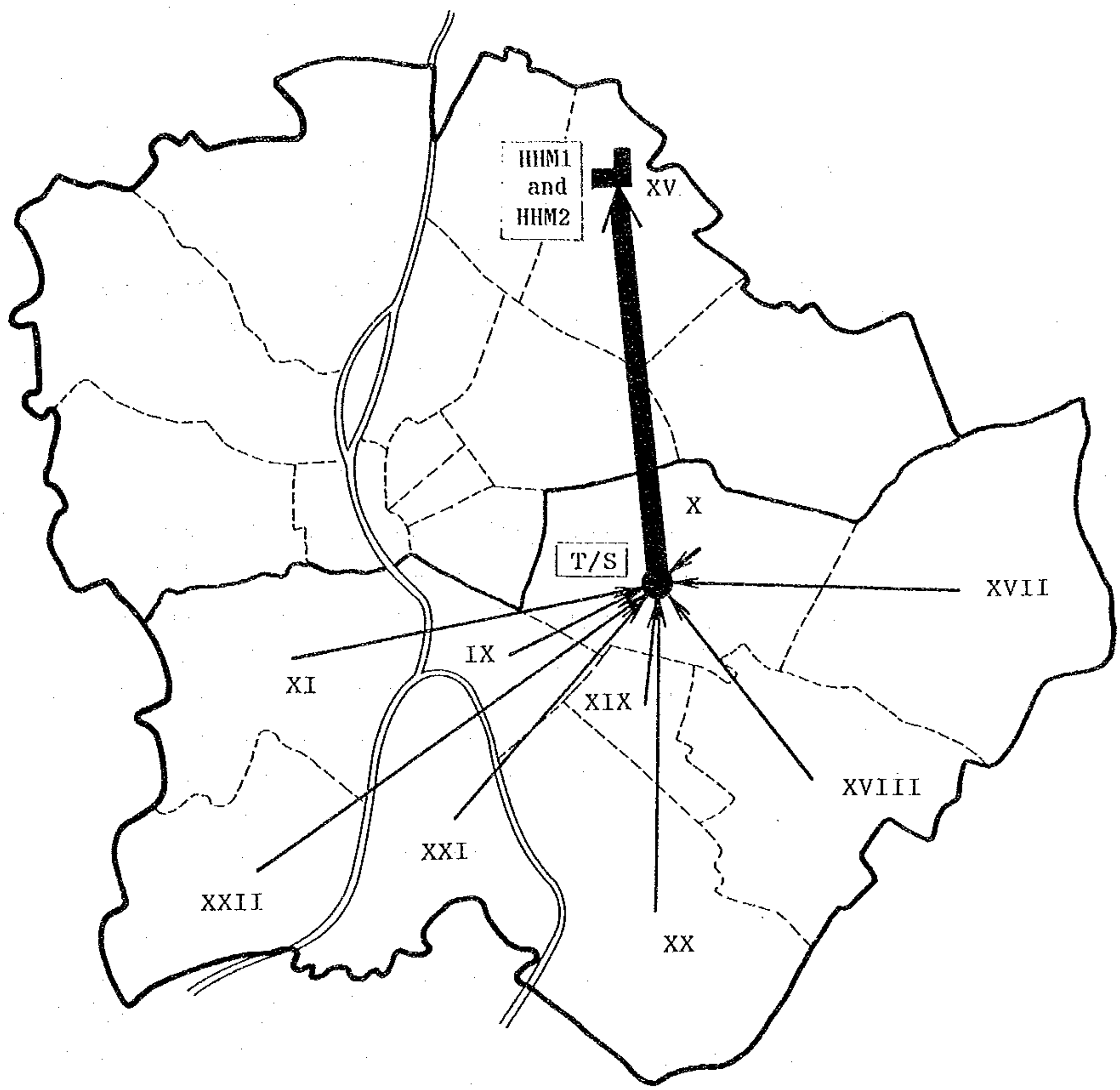
In terms of traffic condition, the heaviest traffic on north-south routes is in districts-V, VI, VII, XIV and partly X, which form the city center and surrounding areas.

If T/S is located in district-X (Akna site) the combustible MSW in all the collected MSW from districts-IX to XXII will be hauled by large container-trucks between T/S and HHM1+2, about 10 km away (Figure 4-8). The distances between the center of each district and the site of T/S average about 10 km with exceptions for districts-XI, XXI and XXII.

At the present time the air pollution situation in the Budapest city center is becoming worse; therefore, legal countermeasures have already been taken.

In consequence of the above situation, from not only economic but also environmental viewpoints, T/S will eventually be needed in the southern part, in district-X.

Figure 4-8 MSW Flow of Indirect Transport



The T/S system will bring enormous improvements to the environment, such as air pollution, noise, and the MSW collection and transportation efficiency, as well as economy.

2) Direct transport

At present most MSW generated in southern areas is dealt with by the Ecseri dispatch station, and disposed of at the Akna and Peteri major final disposal sites. Therefore, the combustible MSW to be generated in the same areas should be directly hauled to HHM1+2 by the ordinary in use collection vehicles.

3) Evaluation

Transfer and transport operations become a necessity when hauling distances to available disposal sites or intermediate treating centers increase to the critical point that direct transportation is no longer economically feasible. In addition, environmental and technical factors also have to be considered.

a) Economic comparison of transportation alternatives

It is important to determine the break-even time between the indirect and direct transportation systems for the MSW transportation from southern Budapest to HHM1+2. Preconditions and assumptions are as follows.

- MSW quantity to be dealt with by T/S: 770 t/day
- Location of T/S: Akna site (District-X)

- Districts to be covered by T/S: IX, X, XI, XVII, XVIII, XIX, XX, XXI and XXII
- Location of HHM1+2: XV
- Total mileage: 784 km by 7 container-trucks
- Total haulage time: 567 hours
- Investment and operating costs are summarized in the Table 4-4

Table 4-4 Investment Cost (Fixed cost) and Operating Cost (Variable cost)

Investment Cost (Fixed cost)

Unit: Ft

	Indirect transport	Direct transport
Construction cost/year	3,599,400	0
Personal cost/year	2,880,000	0
Maintenance cost/year	601,280	0
Total	7,000,680	0
Unit cost Ft/ton	97.5	0

Operating Cost (Variable cost)

Unit: Ft

	Indirect transport	Direct transport
Personal cost/year	8,100,000	12,600,000
Fuel cost/year	59,340,960	66,915,180
Maintenance cost/year	10,756,500	12,460,000
Total	78,197,460	91,975,180
Unit cost Ft/ton	1.38	1.79

For the indirect transport system, necessary facilities including two compacting machines, one truck scale, one dolly system and an administrative office building should be provided; seven workers will be involved in station operation. For transportation, 15 containers and seven container trucks will be available for daily operation.

For the direct transport system in addition to the present number of collection vehicles 14 new collection vehicles should be purchased.

To determine the break-even time between the direct and indirect transport systems, first the transportation cost per metric ton of the MSW will be calculated taking into account investment and operating costs, then the round-trip driving time for each transport system will be calculated.

$$\text{Transport cost} = \frac{\text{Investment and operations costs (fixed cost)}}{\text{The MSW quantity per day (in ton)}}$$

in case of the indirect transport = 31.8 Ft/ton

in case of the direct transport = 0 Ft/ton

$$\text{Transport cost per round-trip time} = \frac{\text{Transport costs (variable cost)}}{\text{Total required time (in hour)} \times 60}$$

In case of the indirect transport = 1.38 Ft/min.ton

In case of the direct transport = 1.79 Ft/min.ton

Break-even time(T): 1.79T = 31.8 + 1.38T

T = 78 min. = 1.3 hours

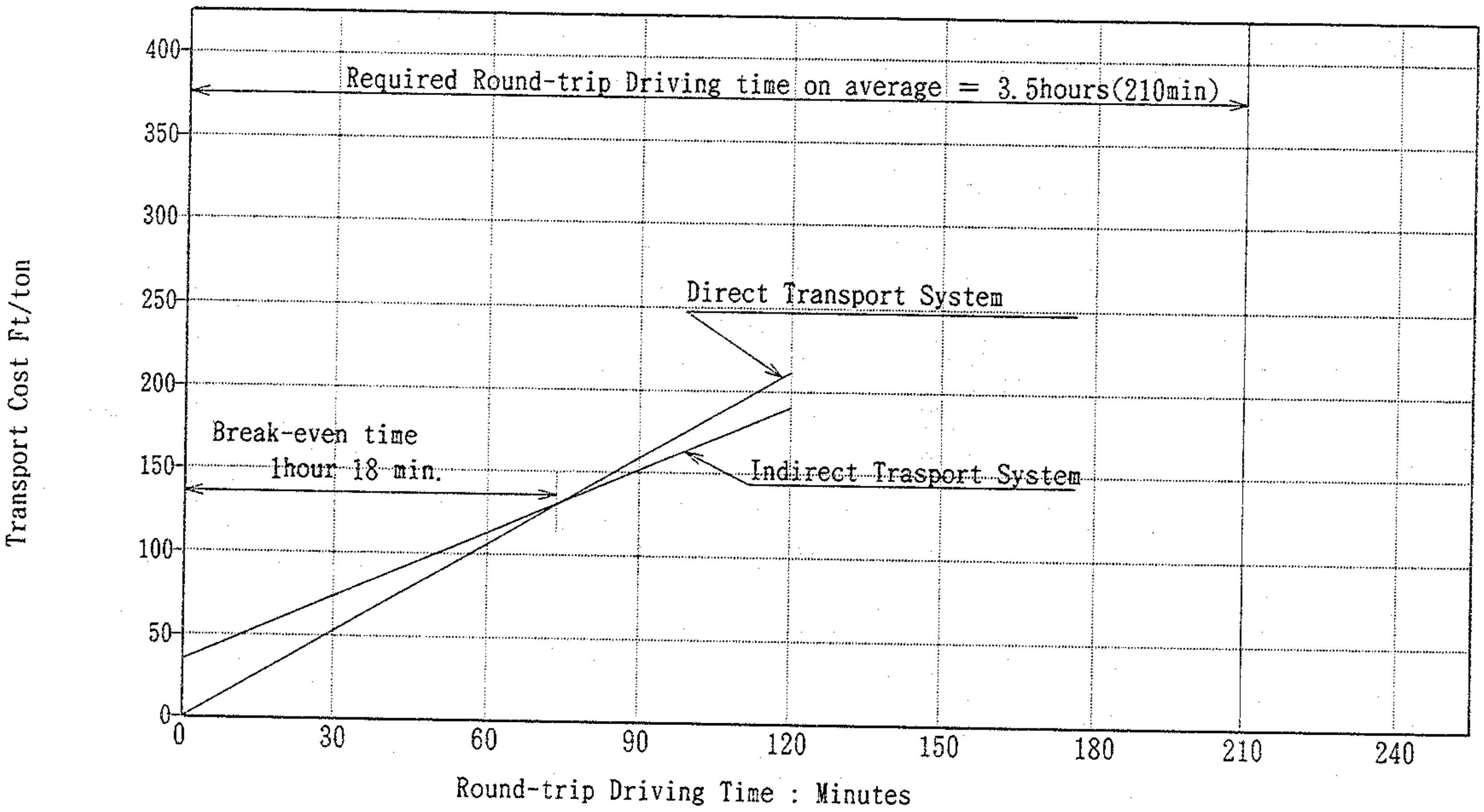
Conclusion 1.3 < 3.50 (required round-trip driving time on average)

The relation between transport cost (Ft/min. ton) and round-trip driving time is shown in the Figure 4-9. An intersection point which gives the break-even time is shown in the same Figure 4-9.

In this case the break-even time is 78 minutes (1.3 hours) that is less than the calculated time (3.5 hours on average) to be required for one round-trip.

This indicates the necessity of T/S for an indirect transport system and its necessities to be verified from an economic view point are shown in the Figure 4-9.

Figure 4-9 Break-even Time Determination



The T/S systems have been widely applied, particularly in the United States of America, on a large scale, and in other countries with relatively small capacity. Therefore, it can be said that T/S technologies are reliable.

Environmentally, a remarkable reduction in the number of collection vehicles by using large container trucks in place of ordinary 12 m^3 trucks would improve the environment in Budapest city center particularly, in terms of air and noise pollution.

4.3.4 Municipal Solid Waste Intermediate Treatment

The most important principle in the MSW management is, first of all, to minimize waste volume to be generated at each generating point and the total amount of the MSW generated through the whole process from generation to disposal, in accordance with the system in the Figure 4-10.

After execution of the first step, the MSW volume reduction at each generating point with further remaining recoverable materials processed by intermediate treatment systems to reduce volume to a minimum is needed in order to extend the life of final disposal sites.

Prior to discussion of intermediate treatment, the following present issues will be identified.

- There is a lack of final disposal sites and the extreme difficulty of expanding the existing final disposal sites' capacity and obtaining new final disposal sites.
- There are few existing intermediate facilities, one incineration plant (HHM1) with less than 60% actual capacity to the 1,200 tons/day of nominal combustion capacity, and one resource recovery/recycling plant

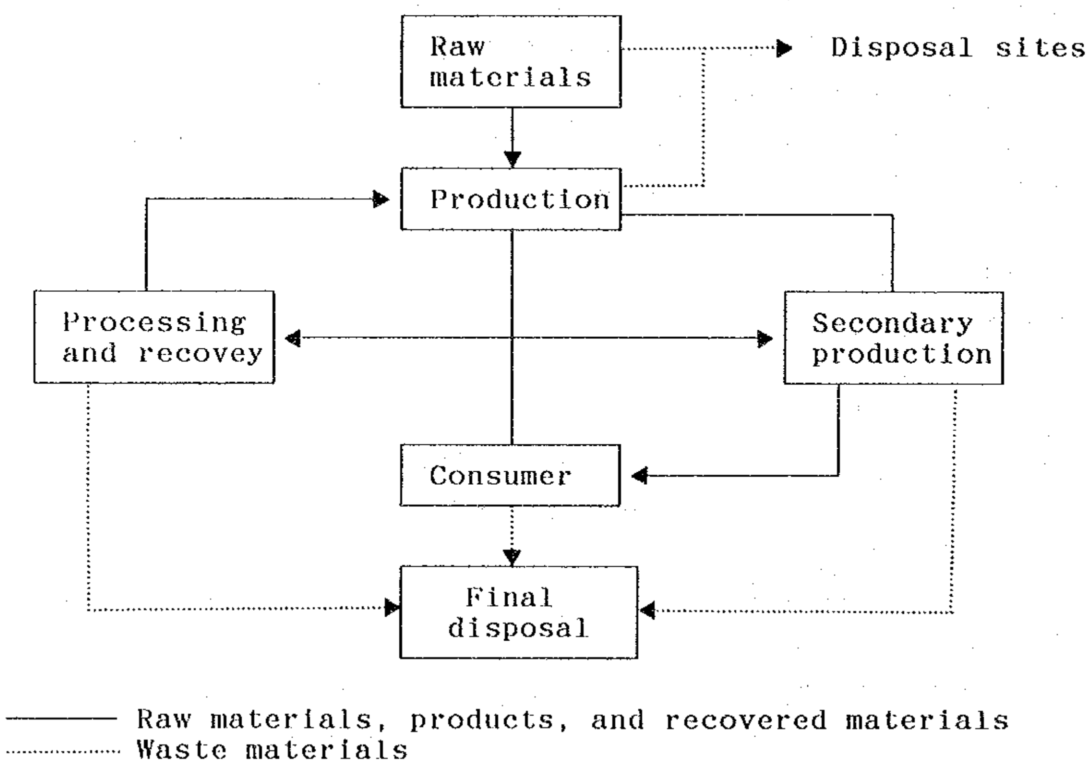
by MEH in Budapest, which is mainly for industrial wastes.

- There is potential environmental impacts from the MSW management.
- The proportion of the MSW to be recovered to the MSW collected by collectors other than FKFV is about 0.5%.
- The volume reduction by HHM1 to total MSW is about 50%.

The up-to-date available technologies for intermediate treatment which will be able to cope with the present issues including potential environmental impacts will be discussed in this Section.

General relationships among the functions shown in the Figure 4-10 represent a flow of materials and the waste in business and waste disposing, and a suggestion where solid waste volume reduction has to be considered.

Figure 4-10 Solid Waste: Definitions, Characteristics and Perspectives



(1) Resource recovery and recycling

The MSW or recovered materials from the MSW, depending on local conditions, may be of value as a resource of raw materials for industrial production, for power generation, and materials that can be used for the backfilling of mined holes. There has been considerable relevant experience in the industrialized countries.

The principal issues with respect to processing and recovery are as follows.

(a) To establish priorities of recoverable materials
(b) To select the most adequate method
(c) To identify markets for sale of recovered materials
(d) To determine materials specification
(e) To assess the impact of market stability on the MSW management system

In this Section, since an MSW selective collecting experiment at the generating points of consumers (household), was carried out by FKFV under the control of the Budapest Mayor's office from April 2, 1992 - September 31, 1992, a discussion of the results of the experiment will be given from various viewpoints.

1) Completion of the experiment

In the framework of the preparatory planning in the collection areas, all applicable techniques and collection methods were considered. Both the preliminary and the ongoing publicity campaigns have been elaborated, and the details of collected materials to be received were determined with MEH.

Two main sampling areas were assigned for the experiment (in Districts-II and XIX) as well as other eleven busy intersections of the city - with the approval of the district government.

These areas were occupied by different type settlements (high blocks, apartment buildings, family houses, etc.) including shopping centers. Five different fractions were chosen to be collected from the two main sampling areas (light and colored glass, paper, plastic, metal, and dry battery), while at the intersections light and colored glass were collected. The experiment affected 100,000 residents.

316 properly reshaped and labeled plastic/metal containers with a capacity of $1.1m^3$/each were prepared to use for the collection.

Special high loading capacity vehicles were assigned to empty the containers according to a fixed schedule.

Before the experiment a wide-ranging publicity campaign was carried out involving several media channels (press, press conferences, info-sheets, radio, cable TV) and was continued throughout the experiment to obtain residents' cooperation.

As a new feature, thirty-one primary/secondary schools were directly involved in the experiment through some informative publications widely spread among the students.

Most of the collected materials (glass, paper, metal) were received by MEH, and by the Aszod Hazardous final disposal site for dry batteries. Despite those efforts, no company was found to receive and reuse the collected plastic fractions.

Throughout the experiment cautious date-registration, control and inspection works were performed and all interim results were made public.

The FKFV's inspection committee, with the Budapest Capital City Government's support, followed the experiment with the help of FKFV's management.

2) Collected amounts:

The amounts collected through the experiment (April 2, 1992 - September 31, 1992) are summarized as follows.

Kind of waste	Tons
- Glass	103.6
- Paper	116.0
- Metals	21.3
- Plastics	32.4
- Dry batteries	1.8

3) Summary of results

- Glass: Despite efforts to collect light and colored glass separately using both kinds of designated containers, they were found mixed, which resulted in a very low receipt price (50 Ft/t). The clean bottles were acceptable. Bigger amounts were registered near shopping areas.

- Paper: Paper gave the biggest portion of the collected fractions. Its cleanness was also acceptable. Mostly newspaper and scrap paper were found in the containers. These containers were used effectively.

- Metals: The amount of collected metal was relatively small; the material was mixed with others and dirty, thus its recycling value was very low.

- Plastics: Extremely contaminated and mixed (even the material itself). Most of the containers showed that a high amount of plastics was being generated in households. Such mixed plastics cannot be sold, thus recycling value is very low.

- Dry batteries: The collected amount was not too large, however any hazardous waste which would contaminate the final disposal sites is still considerable from an environmental viewpoint.

The next scheduled experiment for dry battery collection, which will be started from schools and expanded to the whole area of Budapest, will probably succeed.

4) Evaluation of equipment

- Containers used in normal every-day MSW collection practice - even in their modified states - did not function well. A high level of contamination in the collected waste made these containers unsightly. The use of specially designed shaped containers with gay colors may positively affect the residents' approach.

- Collection and transportation vehicles performed well.

5) Evaluation of residents' cooperation

At the beginning residents cooperated rather willingly, which proved the demand for such selective waste collection. It is obvious however that for a real effective cooperation in the long run personal motivation will be needed.

City dwellers feel a bit "distant" from their self-generated waste. A lack of personal interest will gradually lead to an increasing passivity, carelessness and even vandalizing or theft of equipment.

6) Evaluation of receipt and economic effect

Most of the collected materials were prearranged to be received by companies, but in consideration of the extremely low interest in the industry for dealing with such materials, no guarantee to receive such materials can be expected in the future. This is however the key-issue of selective waste collection, so the establishment of a proper recycling system must be the starting point of the whole issues.
The following balance shows that selective collection of waste is not profitable.

cost:	22,391 thousand Ft
revenues:	115 thousand Ft

Selective waste collection, despite the red ink, must be promoted because of its environmental importance.

7) Summary

This experimental selective waste collection, in spite of financial concerns, was successful from a technical view point.

The following conclusions can be drawn.

a) Kinds of material to be collected

A positive outcome may be expected in the reuse of glass and paper as well as metals and drink cans.

b) Carefully thought-out separate collection of harmful wastes (dry batteries, waste medicines, other chemicals) also appears to give good results and be essential in the future.

c) The development of a suitable container system is essential and helps to maintain an attractive environment.

d) The system will be expanded to more geographical areas to make it effective on a larger scale.

e) Necessity of a resident motivation system

f) Necessity of financial resources

g) A guaranteed receipt system for all collected materials by both industry and commercial sides

h) Necessity of proper legal control system

i) A financing model to answer questions such as:

"What should be recovered by whom and with which financial sources?"

The source of finances may partly be from the state budget, and mainly be certain revenues produced by the system or waste handling fees.

8) Conclusion

It is obviously premature to plan a resource recovery and recycling system in the framework of the Master Plan (M/P).

However, experiments will be continued on a "trial and error" basis for a few years and an adequate system through the experiments will be chosen in accordance with the selected MSW management system for the target year of 2005.

In parallel with the experiments along with the examination of social elements such as new laws and taxation, a system to facilitate the purpose and the study of examples in EC countries will be necessary.

This conclusion was agreed to by C/P and the JICA Study Team.

(2) Composting

The main objectives of the MSW treatment are:
- Reduction of the volume and weight of the MSW to be disposed of,
- Reduction of potential impacts on the environment,
- Recovery of resources, and recycling, with minimum disposal cost.

Composting is one of systems which may achieve these objectives. It is an aerobic biological decomposition process in which some of the organic material is decomposed to carbon dioxide and water, while stabilized products, principally humic substances, are synthesized.

In case of composting, if the mass of the material is enough to be self-insulating, the heat of biological

oxidation raises the temperature to the point where only thermophilic microorganisms can survive and pathogenic organisms as well as weed seeds are destroyed, provided that thermophilic temperature levels are maintained for a sufficient time.
Subsequent microbial activity converts the organic residues to a humus that is useful as a soil conditioner and fertilizer.

Present situation

At present, in the Budapest city there is a composting facility of windrow method, which is operated by "FOKERT" who is also responsible for maintenance of the most of green areas in Budapest.

1) Material to be treated

Green waste from gardens, play grounds, and other green areas are collected and transported to the yard by "FOKERT".

2) Advantages and disadvantages

a) Advantages

- To reduce waste volume
- To produce reusable fertilizer for public green areas
- To increase the heating value of remaining waste to be incinerated
- To extend the life of the final disposal sites

b) Critical points

- Investment cost
- Quality of products
- Training of operators

3) Evaluation

For evaluation the following matters should be examined.

a) Recovered material (products)

Necessity to produce high quality compost for soil conditioner and/or fertilizer.

b) Maturity of system

Composting is well proved technology in use for many years, particularly in Japan and Europe with satisfying results.

c) Recycling effect, marketability

Essentially only high quality products can be used for parks, plantation gardens, street green areas and recultivation of the final disposal sites. Marketability cannot be expected.

d) Volume reduction

In case of green waste composting it is about 70%.

e) Environmental impact

In case of appropriate composting technology, no environmental impact takes place.

f) Acceptability by the public

According to the results of a public opinion survey, 90% acceptance was observed; however, environmental countermeasures should be taken into account.

g) Profitability

Profitability will not be expected.

4) Conclusion

C/P and the JICA Study Team agreed not to plan composting as a component in the framework of the M/P until an appropriate process depending on local situations is established through further experimental operation.

(3) Shredding

Mechanized shredding will be very useful for size reduction of bulky wastes.

At present time 150,000 - 200,000 m^3/year of bulky wastes are generated and shortening the life of the final disposal sites.

1) Advantages

a) Advantages

- To reduce the size of bulky wastes
- To raise the heating value of waste with shredded combustibles
- To extend the life of the final disposal sites

b) Disadvantages

- Causes noise.
- Requires investment for facilities.
- Requires special operators.

c) Critical points

- Location of facilities
- Number of facilities
- Environmental protection (noise)

2) Evaluation

From economic and environmental viewpoints facilities will be located in the incineration plant. By treating the bulky wastes in the plant instead of installating shredding machines at all final disposal sites, the investment and operation costs, and noise and vibration impacts, can be reduced effectively.

a) Recovered materials after shredding

Chiefly, the recovered materials will be classified into the combustible and incombustible MSW.

b) Main system

Basically all bulky wastes collected from households have to be hauled to the incineration plant (HHM2) by FKFV; after shredding the combustible materials will be incinerated in the furnace, and the metal will be recovered at the final disposal sites in the future after establishment of a feasible recycling system. Therefore, the shredding facilities will consist of receiving and feeding equipment, and a shredding unit. Environmental protection facilities have to be provided.

c) Maturity of technology

The technology and all necessary machines are fully mature.

d) Recycling effect

Almost 70 - 80% will be achieved.

e) Quality

The shredded combustibles can be a complete fuel, and metal will be a second raw material.

f) Marketability

It is no necessity to sell the combustibles, but metal can be sold to MEH.

g) Volume reduction

Almost 70 - 80% will be possible

h) Environmental impact

Necessity of environmental protection for noise and vibration

i) Acceptability

With environmental protection measures, this will be accepted.

3) Conclusion

The JICA Study Team and C/P agreed to install a shredding facility in HHM2.

(4) Mechanical waste compaction

Compaction is aimed at increasing waste transport efficiency by reduction of waste volume after compaction by mechanical means.

1) Advantages and disadvantages

a) Advantages

- To increase transport efficiency over long distances
- To increase loading efficiency of collection vehicles

b) Disadvantages

- Requires several places for installation of compaction facilities.
- Requires high operational cost.
- Requires an engineer and a few operators.
- Requires noise protection.

2) Evaluation

When most of the collection vehicles in use now are equiped with a compaction mechanism, it is not necessary to use compaction.

For evaluation the following matter has to be examined.

a) Recovered material

This method does not recover any raw material, this is only for compaction of waste.

b) Main system

Basically the system will be unified with machines for receiving, feeding, and compression, a hydraulic unit and conveyors.

c) Maturity of system

The system and all necessary machines are fully mature.

d) Recycling effects

Refer to item a).

e) Quality of recovered material

Quality is not improved by compaction. The compaction ratio will be about 30 - 40%.

f) Marketability

Mechanical waste compaction does not need a market.

g) Volume reduction

About 30 - 40% in the transportation stage. This does not contribute to the expected waste volume reduction.

h) Environmental impact

Noise and vibration should be considered.

i) Acceptability by the public

Refer to item h).

3) Conclusion

C/P and the JICA Study Team agreed not to plan a mechanical compaction machine as a component in the framework of the M/P.

(5) Incineration

An incineration system acts as a thermal energy recovering plant reducing waste volume remarkably.
By this system all kinds of the MSW can be treated together at the same time. This system has been employed in various ways in many countries.

This system has been adopted mostly by developed countries. Its technical reliability and effectiveness have widely been verified. In the countries having limited area for waste disposal, incineration is highly valued.

1) Advantages and disadvantages

a) Advantages

- Reduces the MSW volume over 90%.
- Treats a huge amount of waste.
- Produces clean energy, thus recycling with a profit.
- Improves the environmental quality.
- Treats waste efficiently.
- Treats many kinds of waste at the same time.
- Increases the life of the final disposal sites.
- Incineration residues can be reused.

b) Disadvantages

- Requires a great investment cost.
- Requires a well selected large area for installation.
- Has relatively high operational cost.
- Requires many engineers and operators.

c) Critical points

- Design of optimum process and facilities of the incineration plant depends substantially on design basis such as characteristics of waste and environmental requirements.
- Accordingly the investment and operational costs of the plant significantly depends on the type of combustion system and down stream process of the plant.
- Waste volume reduction effect depends chiefly on the capacity of the plant and combustion efficiency.
- Environmental impacts depend mainly on the process design parameters and operational conditions.

2) Evaluation

For evaluation the following matter should be examined.

a) Recovered materials

In the course of waste incineration, waste energy can be recovered in the form of steam and/or hot water and/or electricity, and the ferrous metal from residues will be separated magnetically. Furthermore, the technologies for recovery treatment and use of residues and ash have been developed in several European countries, Japan and the U.S.A (solidification, vitrification).

b) Main system

This system, in general, will chiefly consist of the following facilities.

- Waste scaling facility
- Waste receiving and feeding facilities
- Waste combustion facilities
- Waste heat recovery facilities
- Flue gas treating facilities
- Residue and ash handling facilities
- Effluent water treating facilities
- Electric and control facilities
- Maintenance facilities
- Power generating facilities

All these facilities will be integrated in a functional plant to ensure the maximum waste volume reduction recovering clean energy at the same time in an environmentally sound way.

c) Maturity of system

Technologies for each component composing a system are fully mature and verified.

d) Recycling effect

By recovering the waste heat energy, pure heat energy and electricity can be generated for the plant's own use and sale.

e) Quality of recovered materials

- Recovered energy is in the form of steam, hot water, electricity.
- Ferrous metal from the residues is of low quality.
- Residue and ash from the combustion process will be reused as road or building construction materials.

f) Marketability

In Hungary, the market for district heating depends on the location of plant, while the electric power market is more stable.

g) Volume reduction

It is over 90%, the most effective system for increasing the life of the final disposal sites.

h) Environmental impact

In the course of the operation process, typically NOx, HCl, SOx, HF, dust and dioxins will be emitted in the flue gases, and BOD, COD and some heavy metals in the effluent water in general.

In the process, noise and vibration will be generated. However, all these environmentally impactable elements can be controlled by means of sophisticated technologies associated with a plant processing system.

i) Acceptability by the public

By completing the control of the environmental impacts to meet the Hungarian standards and regulations, which are much more severe than the EC's standards, and similar to the German standards which are the most stringent in the world, the incineration system may be accepted by the public.

3) C/P and the JICA Study Team agreed to consider an incineration system as the first priority project in the M/P, in which the system is one of the main components of the M/P.

(6) Smelting treatment

A smelting system treats the MSW by putting it into a smelting furnace at almost 1400 - 1500°C. The high temperature is created with a chemical reaction of coke and pure oxygen. This slag after melting in the furnace will be produced in a quenching basin.

The completely harmless slag's specific weight will be 2.0-3.5 tons/m^3, of which the volume is about a 1/98 of the original MSW volume. Therefore this system will also be able to contribute to extend the life of the final disposal sites.

1) Advantages and disadvantages

a) Advantages

- All the waste under a certain size can be treated at the same time.
- Waste volume is reduced.
- Completely harmless slag, which can be utilized for road construction for example, is produced.
- Clean heat energy is recovered from the smelting process.