LIST OF FIGURES

ANNEX H EXAMINATION OF TECHNICAL SYSTEM ALTERNATIVES FOR MASTER PLAN

This annex presents all detailed information which was prepared for examination technical system alternatives for the master plan and finally for the policy makers to select the optimum alternative. It should be noted that due to this purpose, i.e. a kind of policy making tool, the planning framework set up in this annex is not the same as the ones of the Master and the Feasibility study. Actually, the planning framework of this annex was modified for the Master Plan and the Feasibility study.

H.1 PLANNING FRAMEWORK

H.1.1 Target Year and Population

1) Target Year

The master plan covers a period from the year 1993 to 2010. The targeted years for the master plan as are as shown in Table H.1.1-1.

Table H.1.1-1 Target Year

Plan	Target Year
Master Plan	1993 to 2010
Long Term Improvement Plan	2006 to 2010
Medium Term Improvement Plan	2001 to 2005
Short Term Improvement Plan	1996 to 2000
Immediate Improvement Plan	1993 to 1995

2) Service Coverage

The present service coverage level of Poznan city is approximately 90 %. The city aims to attain and maintain 100% service coverage in and after 2001 as shown in Table H.1.1-1.

Table H.1.1-1 Target of Service Coverage

	1992	2001 - 2010
Service Coverage	90 %	100 %

The general principles of the Basic Town Plan of Poznan City which is being formulated by the Poznan municipality are as follows;

- to compact city by using the present resources and assets in optimally way, and
- cross of green area.

In order to achieve this goal, the service coverage of waste collection services is ought to be improved to 100 %. In terms of the development level and the scale of whole Poznan City, the 100 % collection service is deemed to be obviously reasonable.

H.1.2 Population Forecast

1) Present Population

The basic indices concerning population in Poznan are as follows;

- Population : 590,100
- Total Number of households : 178,573
- Average dwellers per flat : 3.18 person/flat
- Population density : 22.5 person/ha

2) Population Forecast

The Basic Master Plan of Poznan City estimated a population ranging from 610,000 to 620,000 in 2010. Consequently, the 620,000 population estimate in 2010 was adopted for the SWM Master Plan.

The annual population growth rate is, therefore, estimated at 0.275 %. The population forecast and population distribution forecast are shown in Table H.1.2-1 and -2.

Table H.1.3-1 Population Forecast

Year	1992	1995	2001	2005	2010
Population	590,100	595,083	603,388	611,693	620,000

Table H.1.2-2 Population Distribution Forecast

Year	1992	1995	2000	2005	2010
A 1	46,342	46,342	47,043	47,666	48,286
2	38,668	38,989	39,579	40,103	40,627
B 1	59,654	60,149	61,059	61,867	62,676
2	25,101	25,310	25,693	26,033	26,373
3	655	661	671	680	689
4	4,125	4,159	4,222	4,276	4,334
5	39,625	39,955	40,559	41,096	41,633
6	10,690	10,779	10,942	11,087	11,232
7	611	616	626	634	642
8	933	941	955	968	981
9	508	512	520	527	534
10	302	305	309	313	317
C 1	29,431	29,675	30,124	30,523	30,922
2	5,642	5,689	5,775	5,852	5,928
3	17,457	17,602	17,868	18,105	18,341
4	16,563	16,700	16,953	17,177	17,402
5	17,714	17,861	18,131	18,371	18,611
6	42,915	43,272	43,926	44,508	45,090
7	30,321	30,573	31,035	31,446	31,857
8	2,038	2,055	2,086	2,114	2,142
9	30,509	30,762	31,227	31,641	32,055
10	3,866	3,898	3,957	4,009	4,062
11	8,696	8,768	8,901	9,019	9,137
12	2,739	2,762	2,803	2,840	2,878
13	4,984	5,025	5,101	5,169	5,236
D 1	3,535	3,564	3,618	3,666	3,714
2	48,499	48,902	49,642	50,299	50,957
3	29,815	30,063	30,518	30,922	31,326
4	13,103	13,212	13,412	13,589	13,767
5	1,766	1,781	1,808	1,832	1,856
6	4,707	4,746	4,818	4,882	4,945
7	730	736	747	757	767
8	1,928	1,944	1,973	1,999	2,026
9	4,167	4,202	4,265	4,322	4,378
10	1,506	1,519	1,542	1,562	1,583
E 1	5,653	5,700	5,786	5,863	5,940
2	11,033	11,124	11,293	11,442	11,592
3	4,937	4,978	5,053	5,120	5,187
4	694	700	711	720	730
F 1	1,395	4,498	4,627	4,627	4,687
2	4,461	4,498	4,566	4,627	4,687
Z 1	35	35	36	36	37
2	965	973	988	1,001	1,014
3	620	625	635	643	652
4	4,197	4,232	4,296	4,353	4,410
5	2,290	2,309	2,344	2,375	2,406
6	4,357	4,390	4,456	4,517	4,572
Total	590,100	595,000	604,000	612,000	620,000

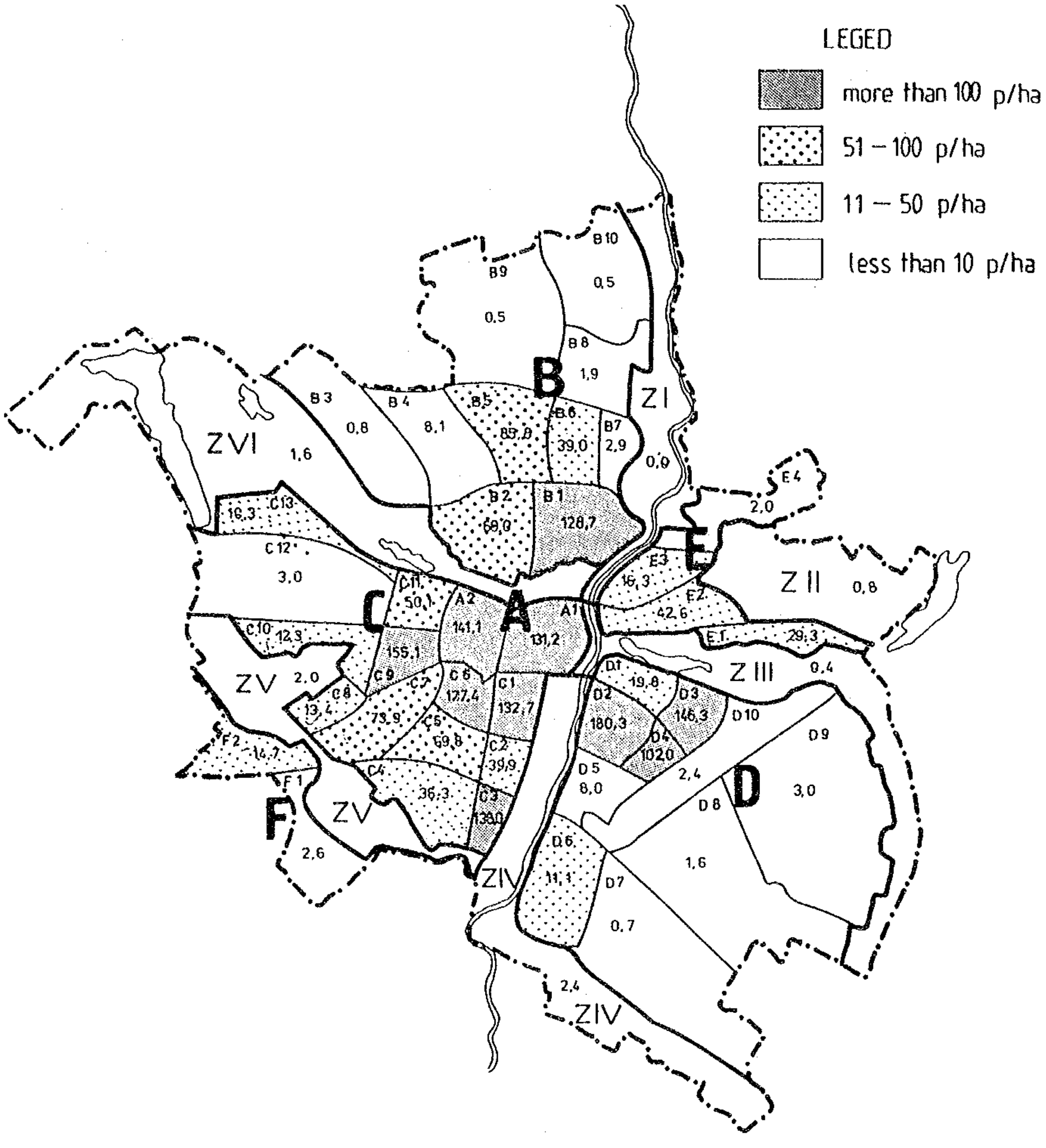


Fig.H.1.2–1 Population Distribution Map

H.1.3 Forecast for Waste Amount and Composition

1) Forecast Model

The Waste Amount and Composition Survey (WACS) carried out by the JICA Study Team was used as a reference in the elaboration of the MSWM estimate of Poznan Municipality.

The forecast model will include interim estimates for the years 1995, 2001 and 2005 of the planning period. The types of waste to be forecast are:

- Domestic waste
- Commercial waste
- Market waste
- Institutional waste
- Road sweeping waste
- Sewage waste
- Other waste

a. Factors in Waste Increase and Composition

The following factors will have an influence on the future generation of waste and its composition:

- The social welfare and the financial capacity of the single consumers/families.

  The welfare determines the general level of consumption and for the "throw away"-mentality.

- Industrial Technology.

  Technology determines the amount and composition of industrial wastes and may influence the products in the market and finally the waste produced by consumers.

- Import of goods.

  The import of goods for consumption will, as stated above, affect the generated waste.

Forecast are difficult to conduct in Poland due to its particular situation. From a financial viewpoint (e.g., the GDP), the wastes of Poland should identify with the developing state of the country. However, with the breakdown of the iron curtain and the opening up to the west, rapid changes in the nature of wastes can be observed due to the inflow of western goods. The Polish industry with its new business environment seems to be buzzing with competition, unlike in the socialist regime where it was protected from it.

Conclusively, it is not reliable to solely base estimates on predictions concerning the general economic development and comparisons with other country's development. The nature of the wastes in Poland compared to its present welfare system will most likely resemble that of Western-European countries faster.

b. Methodology for the Forecast-Model

The forecast-model covers two (2) items. The first item is the forecast of the total amount of waste and its composition. The forecast of the total waste amount will require a study on the relation between GDP and the generation of waste.

The second item is the forecast of the calorific value for the evaluation of the quality of waste to incinerate and consideration of the development of non-compostable waste to forecast those suitable for composting in the future.

For the type of wastes to be forecast, the following assumptions were made:

Domestic Waste

The weighed result for the PEC and non-PEC residential areas will be used. Waste generation will be projected based on the number of inhabitants, with a margin for the effects of a GDP increase.

Commercial Waste

Waste generation will be forecast based on the floor area of shops, with a margin for the effects of a GDP increase.

Market Waste

Waste generation will be forecast based on the number of shops in the market, with a margin for the effects of a GDP increase.

Institutional Waste

Waste generation will be forecast based on the number of employees, with a margin for the effects of a GDP increase.

Other Waste

Waste generation will be forecast based on the population.

2) Increase of Population

The most direct influence on waste generation is the change in population. According to section H.1, the estimated annual population growth in Poznan Municipality for the planning period is 0.275 %.

3) Relation between GDP and Waste Generation

A method to take increased welfare into account in the waste generation forecast is to find a relation between GDP and the waste generation. In advance, a strict relation is not expected to be deduced, but some indications for further analysis may be identified.

An increase in the GDP is expected to have a big impact on the generation of waste per capita of developing countries than of developed countries. Also, at a certain welfare level, increase in GDP will remarkably change the composition of waste.

Japan has fine statistics allowing for the analysis of the relation of GDP and waste generation in a developing economy (1963 - 1970) and a developed economy (1975 - 1988). The year 1970 - 1975 are excluded due to fluctuations in data resulting from a new treatment law, and economic recession and instability caused by the oil crisis.

a. Developing Economy

Based on data of Japan for the period 1963~1970, a developing economy can be characterized as follows:

- Average increase in waste generation per capita: 5.789 %/year
- Average increase in GNP *: 10.438 %/year

* GNP was used due to the unavailability of a GDP.

b. Developed Economy

Based on data of Japan for the period 1975–1988, developed economies are characterized as follows:

- Increase in waste generation per capita: 1.276 %/year
- Increase in GDP: 4.415 %/year

Based on these figures, we assume that the change in GDP will affect the waste generation as follows:

- Elasticity for a developing economy: 0.55 of GDP-change in %
- Elasticity for a developed economy: 0.29 of GDP-change in %

A 4% annual increase in GDP would result to increase in waste generation due to increased welfare, 2.2% and 1.2% for developing economies and developed ones, respectively.

The ratio to be selected will depend on the estimated actual capacity of the economy. Although the increase in the GDP ratio may be high, the actual value could be low, thus effecting a lower impact ratio than the figures from the data of Japan.

The GDP of Poland (expressed as a 1990 constant) is supposed to develop like the average of two scenarios presented in the Progress Report I, page 9-24.

- 1993 - 2000 + 3.5 %

- 2001 - 2010 + 7.0 %

Despite the high increase in percentage, the actual GDP is low for the entire planning period. It is , therefore, assumed that a background that may trigger a Japanese "boom" is unlikely in Poland in spite of the developing state of the economy. The economy of Poland is assumed to develop in the entire planning period, particularly so in the latter half. However, a 0.40 % increase in GDP can be constantly observed in the planning period 1993 - 2010 due to increased welfare on waste generation. The increase in waste generation per capita per year is, therefore, estimated as:

- 1993 - 2000 3.5 x 0.4 = 1.4 %/year

- 2001 - 2010 7.0 x 0.4 = 2.8 %/year

4) Forecast on Waste Amount

The forecast for MSW is presented in table H.2.4-3 based on the WACS results, the assumptions in section H.1 on each type of waste and the impact of GDP growth, and the coefficients from table H.1.3-1 and -2.

Table H.1.3-1 Forecast for Waste Generation Ratio

	Unit	1992	1995	2001	2005	2010
Domestic 1	g/pers/d	430.0	448.7	492.3	565.8	691.7
Domestic 2	g/pers/d	670.0	699.2	767.1	881.6	1,077.8
Shop	g/m²/d	31.0	32.3	35.5	40.8	49.9
Catering	g/m²/d	210.0	219.1	240.4	276.3	337.8
Market	g/nos./d	3,060.0	3,193.2	3,503.6	4,026.6	4,922.6
Institutional	g/empl/d	65.0	67.8	74.4	85.5	104.6
Bulky	g/pers/d	52.5	54.8	60.1	69.1	84.5
Others	g/pers/d	143.3	149.6	164.1	188.6	230.6

Note:Domestic 1 -- Heat Supply; Domestic 2 -- Non-heat Supply

Table H.1.3-2 Forecast for Population and Others

	Unit	1992	1995	2001	2005	2010
Domestic 1	person	354,060	396,718	484,027	543,709	620,000
Domestic 2	person	236,040	198,365	121,022	67,984	0
Total	person	590,100	595,038	605,049	611,693	620,000
Shops	m²	202,966	204,679	208,107	210,392	213,249
Catering	m²	172,725	174,181	177,098	179,043	181,474
Market	nos.	1,970	1,988	2,021	2,043	2,071
Institutional	employee	161,085	162,446	165,166	166,980	169,248

Domestic 1 -- Heat Supply Domestic 2 -- Non-heat Supply

Table H.1.3-3 Forecast for MSW, Poznan Municipality

unit:ton/day; 1 year=365 days

	1992	1995	2001	2005	2010
Domestic 1	152.2	178.0	238.3	307.6	428.9
Domestic 2	158.1	138.7	92.8	59.9	0
Shop	6.3	6.6	7.4	8.6	10.6
Catering	36.3	38.2	42.6	49.5	61.3
Market	6.0	6.3	7.1	8.2	10.2
Institutional	10.5	11.0	12.3	14.3	17.7
Bulky	31.0	32.6	36.4	42.3	52.4
Others	95.0	99.8	111.2	129.0	159.7
Total	495.4	511.2	548.1	619.4	740.8

Note:Domestic 1 -- Heat Supply; Domestic 2 -- Non-heat Supply

5) Forecast on Waste Composition

A change in the composition of waste is expected due to new products and a changed consumption pattern.

In table H.1.3-4 results of the domestic waste from the WACS are compared with the data in Poland provided in the EEC-Study; Municipal Waste - Strategy for Waste Management and Applicable Methods for Collection and Treatment, 1992. Data from a developed country, Denmark were also included. The data from WACS are modified with the moisture content to make them comparable with the data from the EC-Study and Denmark.

Table H.1.3-4 Comparison of Waste Composition Data for Domestic Waste

	WACS 1992 (JICA)	**EC-Study, 1992**	**EC-Study, forecast 2010**	**Denmark 1985**
Garbage	30.2	38	27	35
Paper	19.1	14	28	-
Dry Paper	-	-	-	17
Wet Paper	-	-	-	24
Textile	5.3	2	2	-
Plastic	4.1	2	5	6
Grass and Wood	9.9	-	-	-
Leather and Rubber	1.7	-	-	-
Other Combustibles	-	-	2	3
Metal	5.2	2	14	4
Glass	11.3	7	-	7
Ceramic and Soil	5.7	-	-	-
In-organic	-	35	22	-
Other(Non-Comb.)	7.5	-	-	4
Total	100	100	100	100

Provided that the figure for grass and wood is added to garbage, equilibrium can be achieved among the WACS figures.

It is the impression of the JICA Study Team that the existing data for Poland is not sufficiently updated and that the change in composition occurs very rapidly in these years.

Thus, it is assumed that the WACS for Poznan is the most reliable for bigger cities in Poland. This conclusion is supported by the fact that the calorific value of MSW per tradition is estimated very low by Polish professional. However, WACS calculates a considerable higher calorific value and a value more consistent with the impression gained after visits to the disposal sites in Poland.

The analysis was, therefore, focused on the comparison of the data provided by WACS and Denmark assuming that changes in waste composition would result to wastes characteristic of a developed economy.

Denmark was chosen for its reliable waste data and its geographical and demographic features which is similar to Poland.

The fraction papers necessitate considerations on the carrying out of estimations. Development on the other hand will only be considered as a minor change.

Paper

The difference in the amount of papers is probably smaller than the figures indicates as recycling activities were not yet fully implemented in Denmark in 1985 as opposition to Poznan where recycling is well implemented due to the economic incitement.

A level lower than Denmark, but higher than the present level is expected in the planning period.

Table H.1.3-5 shows the forecast on waste composition.

Table H.1.3-5 Forecast for Composition of Domestic Waste, Poznan

	1992	1995	2001	2005	2010
Garbage	30.2	30.8	32.1	32.8	34.0
Paper	19.1	20.9	24.6	27.0	30.0
Textile	5.3	5.2	5.1	5.1	5.0
Plastic	4.1	4.5	5.1	5.5	6.0
Grass and Wood	9.9	8.9	7.0	5.6	4.0
Leather and Rubber	1.7	1.6	1.3	1.2	1.0
Others (Combustibles)	-	-	-	-	-
Metal	5.2	5.2	5.1	5.1	5.0
Glass	11.3	11.1	10.6	10.4	10.0
Ceramic and Soil	5.7	5.4	4.9	4.5	4.0
Others (Non-combustible)	7.5	6.4	4.2	2.8	1.0
Total	100.0	100.0	100.0	100.0	100.0

6) Forecast on Calorific Value and Suitability of Waste for Composting

With the change in composition, also changes in the suitability for treatment may change. For suitability for incineration the calorific value is the key-parameter. Composting, on the other hand, shall depend on waste composition.

a. Calorific Value

The lower calorific values obtained through the WACS survey are presented in Table H.1.3-6.

Table H.1.3-6 Result of Lower Calorific Values

Category	Lower Calorific Value (kCal/kg)
Domestic waste	1,544
Market waste	536
Commercial waste	1,126
Institutional waste	2,848

In Denmark, the average calorific values shown in Table H.1.3-7 are registered for the waste received at incineration plants:

Table H.1.3-7 Average Calorific Values for the Incinerator in Denmark

Category	Average Calorific Value (kCal/kg)
Domestic waste	2,000
Bulky waste (selected)	2,500
Commercial waste (selected)	2,500
Industrial waste (non-hazardous)	3,000
Waste from construction activity (selected)	3,000

For non-household wastes the average calorific values varies from plant to plant according to the local structure for trade and industry.

Based on the waste composition forecast, the following calorific value are assumed:

Table H.1.3-8 Forecast for Calorific Value

	unit	1992	1995	2001	2005	2010
Domestic	kCal/kg	1,544	1,650	1,800	1,900	2,000
Market	kCal/kg	536	560	600	600	600
Commercial	kCal/kg	1,126	1,400	1,800	2,150	2,500
Institutional	kCal/kg	2,848	2,700	2,500	2,750	3,000
Sewage Sludge	kCal/kg	389	390	390	390	390
Weight Average	kCal/kg	1,408 ↓ 1,400	1,515 ↓ 1,500	1,677 ↓ 1,700	1,768 ↓ 1,800	1,884 ↓ 1,900

In case that incineration is introduced, market waste should not make any serious influence to incinerators because of too little amount. However, it is advised to reject waste with poor calorific value at the entrance gate. In addition, by allowing for non-hazardous waste from industries it is possible to increase the total average calorific value. Conclusively, it is easier to obtain a higher calorific value than the total stated in the table above.

b. Suitability for Composting

(if C/N-Ratio should be used instead).

In an evaluation of the suitability for composting, the amount of non-suitable matters is used as indicator. Non-compostable items will end as reject, but it will still impose its part of operational and capital costs. Further, the content of harmful matters should be assessed to indicate the quality of the compost.

Experience from Western-Europe indicates that with a development of the society (indicated with an increased GDP), the content of non-compostable and harmful matters will increase resulting in a poor quality of the compost. Thus, it is generally recognized that source segregation of waste is beneficial (necessary) for successful introduction of composting. The source-segregation will serve two purposes; to minimize the amount of reject (and thus minimize the average cost per tonnes produced compost) and to select harmful items to secure the highest possible quality of the compost.

C/N-Ratio

C/N-Ratio is used as a guideline for the suitability of waste for composting. Generally, the ratio used is approximately 35. The chemical analysis of the Poznan waste shows contents of Carbon (C) and Nitrogen (N) as follows:

Table 1.3-9 C/N-Ratio

C/N-Ratio	Residential (PEC)	Residential (non-PEC)	Market	Commercial	Institutional	Weighted Average
Carbon (%)	18.35	17.64	10.90	13.37	27.69	–
Nitrogen (%)	0.88	0.75	0.34	0.37	0.30	–
C/N-Ratio	20.85	23.52	32.06	36.14	92.3	25.72

1.4 Other Pre-conditions

1) Economic and Financial Condition

The economy of Poland is being restructured at present. The economic growth rate for the past several years showed a downward trend due to the collapse of the former economic system although rapid growth can be expected if the social economic condition becomes stable after the socioeconomic structure is successfully reconstructed.

a. Forecast of Economic Growth

The following two projection cases of economic growth rate is assumed.

- case 1:	1992	same as 1990 level
	1993 - 2000	4 % increase/year
	2001 - 2010	8 % increase/year
- case 2	1995	same as 1990 level
	1996 - 2000	3 % increase/year
	2001 - 2010	6 % increase/year

The income level of Poznan is higher than the national average, and its GRDP is expected to increase more than the GDP due to the higher development potentials regional economics have which may be attributed to a border-less and free market system. Nevertheless, the ratio of the GRDP and the financial capability of the municipality is in proportion to the GDP, although population growth rate is lower than the overall population growth rate of the country.

The changes of income level estimated from GDP per capita are shown in Table H.1.4-1.

Table H.1.4-1 Changes of Income level

	1985	1986	1987	1988	1989	1990
GDP (trillion zl)	8.7	10.7	14.0	25.0	105.0	506.3
Exchange rate (Zl/USD)	147.2	175.2	265.2	430.6	1446	9500
Population (million)	37.3	37.6	37.8	37.9	38.0	38.2
GDP per capita (USD)	1,577	1,624	1,398	1,531	1,910	1,395
Reference: (USD) GNP per capita WEIS*	 (6,470)		 (6,883)	 1,860 (7,270)	 1,790 (1,560)	 1,690

Sources : Rocznik Statystyczny 1991
World Development Report
* mark WEIS ARC report (CIA,Economic Statistics 1990)

The calculation results are shown in Table H.1.4-2.

Table H.1.4-2 GDP estimated in 1990 constant price (million USD)

	1990	1992	1995	2000	2005	2010
GDP (bill.USD)						
Case 1	53.3	53.3	59.9	72.9	107.2	157.5
Case 2	53.3	53.3	53.3	61.8	82.7	110.7
Financial affordability of the municipality (bill.zl)						
Case 1		1,362	1,531	1,863	2,739	4,025
Case 2		1,362	1,362	1,579	2,113	2,829

The income level (GRDP per capita) will be between 2,770 USD(case 2) and 3,940 USD(case 1) in 2010.

A shift to a post-industrial society will take place in which trade and services will take the lead. The composition of industries in 2010 will be calculated by extension of the change in the term from 1970 to 1989, as shown in Table H.1.4-3.

Table H.1.4-3 Change of GDP (%)

Business category	1970	1980	1989	2010
Industry	54.6	52.1	47.9	36.5
Agriculture	17.3	15.8	12.7	9.1
Trade	9.9	12.8	18.5	31.2
Other Industry	18.2	19.3	20.9	23.3

The number of employees in each business category will increase in proportion to the share of GDP, although the ratio of total number of employees to the total population keeps present level (about 43%).

2) Conditions for Cost Estimation

All design and cost estimates presented are based on the assumption that new facilities for Poznan will be designed and constructed to meet prevailing EC standards. However, one must bear in mind that the present economy of Poland cannot realistically afford overnight steps to change the level and standard of the facilities. Improvements can only be obtained gradually.

All cost estimates were conducted based on the following:

- The prices were based on the June 1992 prices.

- Labour costs and investments for constructions and equipment available in Poland reflects Polish price level. These prices are presented in Zloty (Zl). Table H.1.4-4 presents information on the June 1992 unit prices in Poznan.

- Prices for equipment not available in Poland reflects price level available in Western Europe. These are presented in CIF prices of USD (1 USD = 13,500 Zl, June 1992).

- Costs for the acquisition of lands as well as for connection fees (electricity, water and sewerage) are not included.

- Costs for preliminary studies and design works of item approved by the authorities concerning the installation of facilities.

- All salaries are net salaries, including 20 % tax and 45 % social security charge.

- The inflation rate is not taken into account.

In order to obtain information on price levels available in Poznan, information on typical unit prices for earthworks, concrete works, buildings, etc. were obtained from AKO-consulting company specializing in the provision of construction services. The information on unit prices is listed below.

Table H.1.4-4 Information on Unit Prices Available in Poznan

DESCRIPTION	UNIT PRICE INCL. ALL MATERIALS AND WORKS POZNAN, JUNE 1992
Salary within construction works including 20 % tax and 45 % social security charge:	
- director	12.3 mill. zl/month
- manager	6.3 mill. zl/month
- engineer and mechanic	5.2 mill. zl/month
- supervisor	4.8 mill. zl/month
- driver and operator	4.8 mill. zl/month
- worker	3.2 mill. Zl/month
- clerk	3.6 mill. Zl/month
Earthworks	
- Excavation of soil and 50 m transport to storage heap	61,000 Zl/m³
- Excavation of soil and 500 m transport to storage heap	68,000 Zl/m³
- Excavation of soil, 50 m transport and compaction in an embankment	85,000 Zl/m³
- Supply of gravel for drainage including laying in a 0.3 m thick layer	62,000 Zl/m²
- D 110 PVC laid in a 1 to 1.5 m deep trench, including all materials and earthworks	550,000 Zl/m.
- Supply and laying of 1 m³ stones for a stone drain	520,000 Zl/m.
Pavements	
Consisting of:	710,000 Zl/m²
- 3 cm asphalt top layer	
- 7 cm asphalt bottom layer	
- 15 cm mechanical stable gravel	
- 30 cm course gravel	
Consisting of 30 cm layer of mechanical stable gravel	160,000 Zl/m²
Concrete works:	
Formwork, reinforcement, concrete and all works for the following:	
- wall	
- slab	1,850,000 Zl/m³
- column	2,100,000 Zl/m³
- continuous footing foundation	2,450,000 Zl/m³
	1,300,000 Zl/m³
Buildings	
- Garage from a steel structure with steel cladding, including foundation and concrete floor	2,950,000 Zl/m²
- Office building of brickwork, including all works	4,250,000 Zl/m²
Fences	
- 2 m high galvanized wire mesh erected on galvanized steel posts each 2.5 m	350,000 Zl/m
- Gate (8 m wide)	8,100,000 Zl
Electrical works	
- 4 x 95 m² (aluminium) including earthwork for trench	220,000 Zl/m
Purchase of Polish equipment	
- Dump truck, 3 axle	370,000,000 Zl
- Dump truck, 2 axle	300,000,000 Zl
- Tractor (type)	100,000,000 Zl
Materials	
- Diesel oil	4,900 Zl/l
- Cement	30,000 Zl/50kg
- Steel beams	15,000 Zl/kg
- Energy	744 Zl/kWh

H.2 Selection Method of an Optimum Alternative

H.2.1 System Components in MSWM

An alternative to the SWM system is a combination of various technical subsystems such as discharge and storage system, collection and haulage system, road sweeping and public area cleansing system, intermediate treatment system and final disposal system. Many alternatives can be made by the combination of possible subsystems.

If all combinations of the above sub-systems were to be studied, the total number of combinations would be equal to hundreds of individual SWM systems. Therefore, it can be deduced that a Master Plan study is the screening work concerning various alternative systems.

In view of the present SWM in the study area, a goal is set up to develop an environmentally sound SWM in Poznan. In addition, the creation of a cost-effective SWM system is a main issue in the generation of alternatives because the implementation of SWM may be quite costly.

Consequently, the following method is applied in the Study for the selection of an optimum alternative for the Master Plan.

H.2.2 Selection Method of an Optimum Technical System

a. Possible intermediate treatment facilities

In order to develop and realize an environmentally sound SWM in Poznan, the introduction of intermediate treatment facilities shall be examined. Possible treatment facilities will be examined and selected.

b. Examination of technical sub-systems

After the selection of possible intermediate treatment facilities, possible sub-system alternatives will be selected for each possible treatment facilities. For example, in case of the introduction of composting plant, segregated collection system (i.e., waste will be separated into compostable and noncompostable) may be selected.

c. Examination of combinations of technical sub-systems

A comparison study on the technical systems will be carried out by combining each technical sub-system.

d. Selection of an Optimum Technical System

Upon consideration of the results of the above-mentioned alternative study, an optimum technical system will be selected by evaluating the following aspects:

i. technical points of view;
ii. economic and financial points of view;
iii. environmental points of view; and
iv. social points of view.

e. Selection of the Optimum Institutional System

After the selection of the optimum technical system, a study will also be made to generate alternatives for the organizational, institutional and financial aspects which will be suitable to the selected technical system. After the comparative study on the above-mentioned alternatives, an optimum SWM system will be finally selected.

H.3 Examination of System Component

H.3.1 Discharge and Storage

The above said components of SWM system are closely related each other, and also they are closely related to the people's way of living. It is very difficult to replace an existing system with a new system, because there are too many factors to be taken into account for the formulation of the new system.

The system, which has been established already, has been generally met with almost all requirements of that area. As for Poznan city, the system, which originally established in 1930s, and it has been continuing until today, accumulating many minor adjustments. It looks to be still quite functioning. Consequently the examination is made for only applicability of various technologies.

1) Discharge

The waste discharge method is divided into two categories; combined discharge and separate discharge.

In Poznan, only combined discharge is executed and some bottles and glass are voluntarily discharged separately to the containers installed by the recycler in the town. According to our public opinion survey, almost 100% of citizen agree to cooperate with separated discharge for resource recovery. The result of the public onion survey also presents that the most people are much interested in environmental protection activities. Therefore the separate discharge is recommended to be adopted in future because the people's will of participation are admitted to be strong.

2) Storage

There is a wide range of issues to be considered in order to select the most appropriate storage equipment for a certain area. The examples are as follows;

- the quantity and composition of the waste generated;
- the number and composition of the waste components which the waste should be separated into;
- the collection frequency, most often determined by the climate in combination with the waste composition;

- the space available near the source and the accessability of the collection vehicles;
- environmental and occupational health aspects;
- the adaptability in the actual environment, i.e., is the function consistent with the actual user;
- the ability to stand misuse, rough climate and animals (rodents etc.);
- the total investment and operational costs over given period;
- the habits and traditions of the users and the collection crews.

b. Type of Storage Equipment

The storage equipment which are possible to be used in Poznan are listed in Table H.3.1-1. At present 110 l dustbins, 1.1 m^2 containers and 6 to 10 m^3 containers are being used mainly, and all those structure are steel.

Table H.3.1-1 Storage Equipment for Solid Waste

Type	Material	Size	Wheels	Lid	Applicable for	Truck
Bag	Paper Plastic	50-110 l	no no	Yes;No Yes;No	Detached house Detached house	All All
Bin						
Container Small Middle Large Very Large	 Plastic Steel Steel Steel Steel	 1.1 m^3 1.1 m^3 2-3 m^3 6-10 m^3 15-30 m^3	 Yes Yes No No No	 Yes Yes Yes Yes Yes	 Apartment Apartment Apartment New Apartment Bulky Waste Recyclable waste	 Compaction truck Compaction truck Truck with crane Hoist truck Arm-roll truck

c. Capacity

- waste generation rate: 229 kg/person/year
- average person: 3.18 person/household

229 x 3.18 : 365 = 1,995 kg/household/day
1.995 kg x 7 day : 0.2 = 70 l /houschold/week.

A domestic waste discharge, 70 l per a week, was obtained by the 1st phase study. The present 100 l dustbin is thereby considered to be suitable for a household under the once a week collection frequency.

d. Sanitary aspect

The following properties are required for the waste storage equipment in terms sanitary aspect.

- cover is required
- study containment
- little noise
- safe structure
- be easy to keep clean

3) Recommendation

All types of containers which are used in Poznan are recognized to be generally suitable. The issues to be improved are as follows;

- 110 l dustbin
  . no wheel
  . too weak on structure
  . too weak on cover hinge

- 1.1 m^3 container
  . too heavy to carry
  . cover structure is easy to be damaged

- 6 to 10 m^3 container
  . no improvements

110 l dustbin and 1.1 m^3 containers should be changed to a plastic structure. The large containers is not need to be improved.

H.3.2. Collection and Haulage

The collection and haulage system is mainly composed of the following items:

- collection frequency
- mixed or separate collection
- collection system
- collection time
- collection vehicle
- haulage method
- transfer system

1) Collection Frequency

The collection frequency must be restricted by the sanitary aspects. Twice a week collection is desirable in summer in order to maintain sanitary conditions but once a week collection may be possible in winter season.

Organic waste should be collected rather frequently than inorganic waste. The collection should be determined by the waste composition in case of separate collection because the required collection frequency depend on the waste composition.

2) Combined or Separate Collection

Separate collection require people to give more cooperation of source segregation and combined collection does not give people any more endeavour. However, separate collection can contribute to make more effictive recycling and this system is more sound for environment. Moreover, separate collection can give make higher efficiency of heat supply by the incinerator and prolong the life period of the incinerator. Therefore the separate collection system is recommended. However, it must be reminded that the success of implementation of separate collection extremely depend on public cooperation.

3) Collection Service

a. Type of collection service

The most common types of residential services used for low-rise detached dwellings are common in the study area include;

- curb collection;
- alley collection;
- setout-setback collection;
- setout collection;
- backyard collection; and
- bell collection.

The characteristics of these collection services are compared in Table H.3.2-1.

i. **curb collection**

The householder is responsible for placing the containers at the curb on collection day and for returning the empty containers to their storage location until the next collection.

ii. **alley collection**

Where alleys are part of the basic layout of a city or a given residential area, alley storage of containers used for solid wastes is common.

iii. **setout-setback collection**

Containers are set out from the premises and set back after being emptied by additional crews that work in conjunction with the collection crew responsible for loading the collection vehicle.

iv. **setout collection**

Setout collection is essentially the same as setout-setback collection, except that the householder is responsible for returning the containers to their storage location.

v. **backyard collection**

The collection crew enters the premises and collects the wastes form their storage location.

vi. **bell collection**

The collector calls out to the residents for discharge of their waste when a collection vehicle arrives at a certain collection point.

b. **Selection of collection services**

Setout-setback collection is being carried out officially in Poznan city, however, setout collection is also carried out in quite many areas with the householders' voluntary cooperation. In order to improve working efficiency of waste collection introduction of curb collection is required, however it may be difficult because carrying waste container is quite dangerous for old people. In view of increase of old people, this is expected to lead increase of accidents. Therefore, the present setout-setback collection is recommended to be continued and minor improvement such as shifting container yard to near the road should be taken.

4) Collection Time

Traffic congestion is seen every weekday in the downtown area, and it is disturbing efficiency of waste collection work. A few sub-contractors of Sanitech thereby carry out the night collection with a compaction truck. The night work should be limited within the commercial and business area.

5) Collection Vehicles

a. Type of waste collection vehicles

The 3 types of vehicles for waste collection services are as described below.

- compaction truck type;
- detachable container truck type; and
- standard truck type.

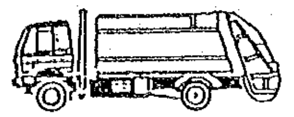
b. Comparison of waste collection vehicles by type

The three types of waste collection vehicles are compared in Table H.3.2-1 in terms of their advantages and disadvantages and also shown in Fig.H.3.2-1.

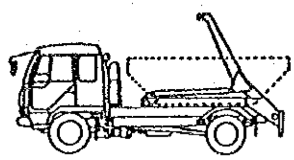
c. Selection of suitable refuse vehicles

In Poznan all three types of refuse truck are working at present and their assignment is rightly made. The compaction truck covers the detached and semi-detached house area and the old building area, and the detachable container truck covers the new building area. The ratio of this combination is determined by the population ratio of each building category. Therefore this ratio should be varied in conformity with the change of the town structure.

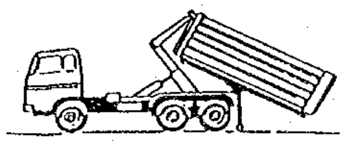
Compaction truck



Detachable container truck
Hoist truck



Roll-on Roll-off



Standard truck

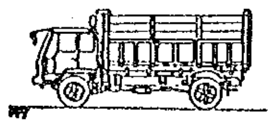


Fig.H.3.2-1 Type of Waste Collection Vehicles

Table H.3.2-1 Comparison of Waste Collection Vehicles

Advantage	Disadvantage
Compaction Type - Highest waste loading factor - No waste scattering during transportation - Ease in discharge	- Complicated maintenance procedure - Most expensive - Incapable of loading bulky waste
Detachable Container Truck - Relatively easy maintenance - Ease in discharge - Container can be used as collection box - Highest collection and haulage efficiency	- Highest purchase cost due to large number of containers required - Wastes scattering possibility during transportation, if the open loading type is used - Difficult to load bulky wastes
Standard Truck - Ease in maintenance - Ease in operation - Ease in discharge - Capable of collecting bulky waste - Cheapest - Compatible with present collection system, and relatively simple in operation - Multi-purpose	- Low waste loading factor - High possibility of waste scattering during transportation, if the open tipper is employed - Possibility of being used for other purposes

6) Haulage Method

There are four kinds of haulage methods in principle as shown below;

- motor vehicle haulage,
- railway haulage,
- water haulage, and
- pneumatic and hydraulic methods.

In order to combine the above-mentioned methods, a transfer station is sometimes installed.

a. Motor vehicle haulage

The motor vehicle is the most common means of transportation for solid wastes all over the world.

The refuse trucks are classified into three categories as follows:

- Compaction truck
- Detachable container truck
- Standard Truck

The present motor vehicle haulage system in Poznan started in 1930s and it is functioning nicely at present. This is the most suitable method to Poznan which include old and new building areas, because it has a very wide range of applicability. This applicability can be widened by combining various kinds of refuse trucks properly.

b. Railway Haulage

Although railways were commonly used for the transport of solid wastes in the past, they are now used by only a few communities. However, renewed interest is again developing in the use of railways for hauling solid wastes, especially to remote areas where highway travel is difficult an railway lines now exist, and where railways own property or adjacent land for filling is available. As for Poznan city, it is possible to transport wastes to the cavities of old coal mining by using return trains which transport coal to Poznan.

Advantages;

- large haulage capacity

- haulage cost per km is cheap

Disadvantages;

- two transfer stations are necessary at loading and unloading points.
- inter-cooperation is essential.
- less flexibility.

The feasibility of this plan might be studied in future when the inter-cooperation of SWM is established. However, this is not a practical method at this moment, because there are still some proper candidate site remained within Poznan city.

c. Water Haulage

Barges, scows, and special boats are being used to transport solid wastes. Wastes are gathered at a transfer station with refuse trucks and loaded on the boats for water haulage.

Advantage;

- large haulage capacity

Disadvantage;

- two transfer stations are necessary at loading and unloading points
- difficulty under the bad weather
- less flexibility

This method is ordinarily used for sea transportation and for sea reclamation disposal site. Poznan city has a large river of Warta, however, the river is not so suitable for waste transportation because the transfer station at river requires a expensive loading equipment.

d. Pneumatic and hydraulic system of haulage

Both low-pressure air and vacuum conduit transport systems have been used to transport solid wastes. The most commonly used system is the transport of wastes from high density apartment or for loading into transport vehicles.

From a design and operational standpoint, pneumatic system are more complex than hydraulic systems because of the complex control valves and ancillary mechanisms that are required. The necessity to use blowers or highspeed turbines further complicates the installation form a maintenance standpoint. Because installation costs for such systems are quite high, they are most cost-effective when used in new facilities.

The concept of using water to transport wastes is not new. Hydraulic transport is now commonly used for the transport of a portion of food wastes (where home grinders are used). One of the major problems with this method is that ultimately the water used for transporting the wastes must be treated. As a result of solubilization, the organic strength of this waste water is considerably greater than that of other domestic wastewater.

These methods have never been operated in the wide scale. The initial investment is very large and O & M cost is also high. This method should be limited to areas with high waste generation density.

7) Transfer Station

a. Introduction

Transfer and transport operations become a necessity when haul distances to available disposal sites or intermediate treatment plant increase to the point that direct hauling is no longer economically feasible. Transfer operations and the introduction of transfer stations are necessary in the case that the following is observed;

- The location of disposal sites is relatively far from collection routes (generally more than 15 km).
- The use of small-capacity collection trucks (generally under $15m^3$).
- The widespread use of medium-sized containers for the collection of wastes from commercial sources.
- The use of hydraulic of pneumatic collection systems.

b. Necessity of Transfer system

The average distance from the collection area to the proposed disposal site in Franowo-Michalowo is about 7.5 km. Therefore, it is dispensable to adopt large scale transfer system.

H.3.3 Road Sweeping, Public Area Cleansing

1) Introduction

Street cleaning is one of the most visible of all governmental activities. Consciously or unconsciously, residents allow their opinions of the effectiveness of street cleaning programs to influence their feelings toward their municipalities and local officials. Visitors may instinctively rate municipalities on this cleanliness before they learn anything else about them. Such opinions can help to shape a community's future. Street cleaning has been associated primarily with aesthetics.

The major goal of street cleaning programs has been to remove litter and dirt so that streets appear presentable and traffic will not create dust. In some areas particularly, regular street cleaning is necessary to prevent sewers from becoming clogged. Knowledgeable officials now recognize the pollution potential of particulate matter when washed into sewers.

Municipalities must balance the costs of adequate street cleaning and effective litter control programs, improved sewer operations, safety of pedestrians and vehicle occupants, reduction of air and water pollution, and economic development. Public education, however, will not eliminate all street litter. Debris also accumulates from air pollution fallout, animals, oil drippings, parts dropped from vehicles, spillage from solid waste collection, mud tracked onto pavements of this dirt and debris.

2) System of Road Sweeping

Street Cleaning Methods

As practised today, street cleaning methods may be grouped conveniently under these general headings:

- manual cleaning,
- mechanical cleaning,
- vacuum cleaning,

- flushing,

a. Manual Street Cleaning

Manual street cleaning is by far the oldest method. And although it has been widely replaced by mechanical methods, it still retains certain advantages, as follows:

Advantages;

- low capital cost,
- great flexibility of operation,
- applicable to the work where the debris, accumulates most frequency
  - to clean beneath parked vehicles,
- to clean under subfreezing weather,
- to clean on rough cobble stone pavement,
- low operation noise,

Disadvantages;

- high labour cost,
- difficulty of supervision,
- danger under heavy traffic condition,

The equipment required for manual sweeping is simple and inexpensive. Sweepers use stiff bristled push brooms and wheeled carts carrying barrel-like containers, shovels, and possibly a few other tools for special tasks. Motor scooters have sometimes replaced push carts for certain manual cleaning assignments.

b. Mechanical Cleaning

Mechanical cleaning is a cleaning method to utilize various sorts of machines as much as possible.
A three as four-wheel sweepers are mainly used for wide main road, and a self-propelled sweeper and a water sprinkle truck are used supplementally.

Advantages;

- great productivity,
- low manpower,
- safety on work.

Disadvantages;

- high capital cost,

- low flexibility of operation,
- difficulty of work in narrow areas,
- big operation noise,
- difficulty of work under heavy traffics.

Mechanical Cleaning is generally the cheapest cleaning method for wide roads. For more than 6m road in width, this method should be used generally.

c. Vacuum Cleaning

Vacuum street sweeping appears to be increasingly attractive because it minimizes water pollution by removing more of the fine dust on the street as well as the larger debris. The flicking action of the broom is not as effective on fine materials as is the vacuum. Mechanical sweepers were designed to remove the larger debris; they do so in commendable fashion when the operator is capable and conscientious.

Vacuum units can also pick up larger debris, raining from cigarette butts to beer bottles at operating speeds of 15 miles per hour. Vacuum units also use gutter brooms to loosen and deflect debris so it can be picked up. They also have an additional broom to windrow the dirt which may or may not be used in picking up debris. This second broom loosens the street dirt and pushes it toward the vacuum nozzles where it is drawn into the storage compartment. A filter system traps the dust and confines it to the sweeper hopper.

Advantages;

- high cleaning capability,
- no harm to sewage pipes by dust,
- less dust.

Disadvantages;

- high capital cost,
- low flexibility of operation,
- difficulty of work in narrow areas,
- big operation noise,
- difficulty of work under heavy traffic.

d. Flushing

Street flushers hydraulically move debris from the street surface to the gutter. Since disposing of street dirt in sewers and catch basins is regarded with increasing disfavour because of its pollution effects, several municipalities now flush only to aid sweeping and not as the sole method of cleaning. Flushing before sweeping washes street dirt to the curb for collection by motorized sweepers. This type of flushing ordinarily employs smaller quantities of water and lower nozzle pressures, which also minimizes splashing pedestrians and vehicles, to keep the dirt from flowing into the inlets. The benefits of flushing after sweeping are that the entire pavement is made cleaner and that only small quantities of dirt are washed into inlets and catch basins.

Advantage;

- no dust.

Disadvantages;

- necessity of a large amount of water,
- to lead clog of sewage pipes,
- danger in winter,
- low flexibility of operation,
- difficulty of work in narrow areas,
- difficulty of work under heavy traffic.

3) Applicability to Poznan

Mechanical cleaning seems to be sufficiently working in Poznan, because the road is still maintained nicely. Mechanical cleaning can be thereby continued in future.

Vacuum cleaning is able to be adopted in future, because it is the most suitable and the modern type method. This method is recommended to be introduced if the financial situation allow it. However, it is advised that the present road sweepers will be utilized while they are feasible, because there are surplus road sweepers in Poznan city at present.

H.3.4 Intermediate Treatment (Processing and Recycling)

1) Intermediate Treatment System

A technical system of SWM consists of 3 main sub-system, i.e., collection and haulage system, intermediate treatment system requires not only the highest technology but also considerable amount of construction cost and O & M cost. In addition, the intermediate treatment system is not indispensable in SWM, while the other two sub-systems are so. The construction of an intermediate treatment facility is often the biggest investment project in a local government. It is, therefore, very important to carefully examine the introduction of an intermediate treatment facility to a local government.

As for the intermediate treatment technology, there are various processing and resource recovery (including recycling) facilities as shown in Fig.H.3.4-1. In this section, the following intermediate technologies are examined and primarily screened for the comparison of the technical system alternative;

- incineration;
- composting;
- RDF;
- pyrolysis;
- ash solidification;
- biogas;
- size reduction (crushing and shredding); and
- sorting.

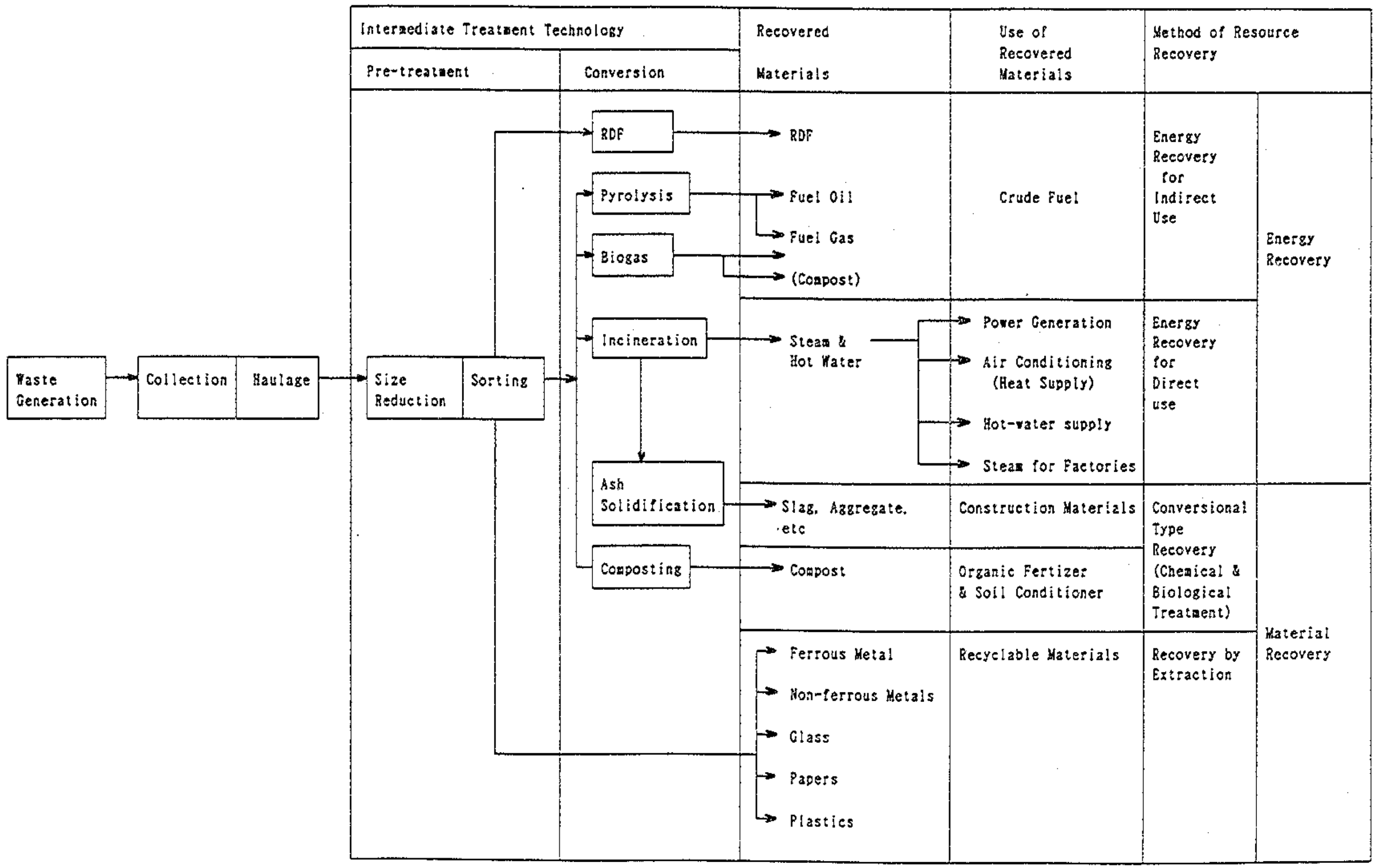


Fig.H.3.4-1 Intermediate Treatment Technologies and Resource Recovery Methods

2) Characteristics of Each Technology

(1) Incineration

a. Introduction

Incineration of municipal solid wastes is one of the most popular method for processing wastes in developed countries recently. The Waste is converted into mainly stable oxidized gases and partly stable inorganic matters by high temperature of combustion. Generally, the incineration makes the biggest volume reduction of wastes among various intermediate treatment technologies and it also achieves stabilization of putrescible organic wastes.

A general observation would indicate that incinerators may be feasible where land available for landfilling is scarce, expensive or very remote from the actual solid waste generation centre.

Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment and makes it possible to locate plants even in densely populated areas.

b. Components of an Incinerator

A modern incinerator consists of a number of basic components. Typical of these will include an unloading are, refuse feeding device, burning grate area, combustion chamber, air supply system, residue quench and disposal system, flue-gas scrubber and water treatment system and stack. Selection and design of these basic components will be the deciding factor in differentiating one incinerator from another.

Major differences in typical modern incinerators are noted in both refuse feed systems and grate designs. Feeding of refuse may be accomplished by either batch or continuous mode. Batch feed of refuse has experienced a declining use rate in recent years in favour of continuous feed methods.

c. Movable grate (stocker) incinerator

A movable grate (stocker type) incinerator is the most widely used modern incinerator and the best tested technology for the thermal treatment of waste.

Various grate designs are in use for refuse burning. Each of these design functions to perform a number of tasks. A grate is designed to satisfy the following objectives:

- to provide support for the refuse;
- to distribute underfire air through grate openings;
- to transport the refuse from feed chute to ash quench;
- to agitate the bed to break up clumps; and
- to redistribute the burning mass.

d. Fluidized bed incinerator

A major new development in refuse burning involves the application of fluidized-bed technology. Fluidized-bed incineration has been employed to some extent. High heat transfer and reaction rates achieved in such a unit have demonstrated favourable characteristics for the incineration of refuse with good burnout of residue.
Construction cost and power consumption of this type incinerator are generally higher than other conventional types.

e. Residue disposal

After combustion, there still will remain some residue, consisting of small fractions of both little combustible and non-combustible items.

Residue disposal is most generally accomplished by landfilling. When deposited at the landfill, cares should be taken in the same manner as raw wastes.

f. Heat utilization

The heat utilization of municipal refuse incineration plants is very common and a significant element of waste incineration. The heat is used for power generation, district heating and cooling, hot water supply, followed by welfare facility for dwellings and direct steam supply to industries.

g. Construction, maintenance and operating costs

A major factor contributing to the disfavour of incineration as an economical disposal solution is the high capital requirement. Total capital requirement per ton will generally decrease with increasing capacity, however, unit values are typically higher than other disposal alternatives, especially sanitary landfilling.

Therefore, detailed cost evaluation have to be made on the construction cost, annual running and maintenance cost, versus expected income which could be obtained from the supply of electricity or heat.

h. Advantages and disadvantages

Basic advantages are;

i. The system has wide range of availability. Almost all kind of waste except bulky inert materials can be treated.
ii. High reduction in bulk volume and weight in lower transportation costs due to possible location near cities and landfill requirements.
iii. Hygienic way of treating waste.
iv. Revenue will be expected from the sale of surplus electricity by means of power generation in the plant (in case of high calorific value of waste).

Disadvantages of incineration include:

i. Considerable investment costs and high operation and maintenance costs.

ii. Residues may have a higher concentration of heavy metals and other hazardous items.

(2) Composting

a. Introduction

Waste composting is a method which achieves microbial degradation of organic matter, to produce a recycled organic product for use in gardens, parks, horticulture and so on.

Waste composting can be applied to household and vegetable wastes, garden wastes including branches and litter.

Composting technology is divided into two main categories, i.e., on-site composting and composting plants. There are the following composting plants.

- windrow type;
- high-rate composting type;
- modified landfill employing im-place composting; and
- biogas and compost production.

b. Composting technologies

i. on-site composting

On-site composting is the simplest possible composting technique and is carried out at each generation source (mainly each household) and it requires;

- the sorting of organic wastes in the kitchen; and
- the provision of a standard model compost container for each house hold.

Containers can be made of recycled plastics and constructed so as to allow air to enter in the bottom through simple holes, and with simple air outlets in the top.

ii. windrow type

Numerous windrow type plants were constructed throughout the world during this century, in which several types of turners have been designed to turn windrows or compost stacked over a wide area. In the last two decades, windrow composting has gained acceptance in Europe, especially for making compost from garden wastes.

Windrow composting is the conventional process of composting, used for unsorted or sorted and sieved organic wastes.

The process may be equipped with different pre-and post-treatment machinery devices to:

- prevent the input of undesirable metals, etc.;
- break large components into smaller fragments as to make it compostable;
- sort incoming materials depending on density;
- give a biological pre-treatment as mentioned above;
- aerate the windrows;
- sort the compost product, to recirculate larger fragments, or to send them for incineration; and
- fill up bags and sacks for sale.

iii. high-rate composting type

High rate composting system consists of various equipment, devices, etc., (with a unit operation) in order to perform the function of composting treatment, regardless of its method or size. This system has functions of feeding principally sorted and collected solid wastes, shredding, sorting and adjusting wastes in the equipment, fermentation, maturing and post-treatment then taking out refined compost and residue continuously and smoothly.

Composting operation must be kept at a constant condition so that oxygen amount, temperature, moisture, and C/N ratio, etc. can be easily controlled and secondary pollution especially offensive odour can be prevented securely. High-rate composting plants can be located at the urban areas with the environmental protection facilities such as a deodorant facility.

iv. modified landfill employing in-place composting

This process has been recommended as the lowest cost composting method yet available today. Essentially the process calls for pre-shredding of refuse and placing it in a sanitary landfill without cover. Composting may be conducted by the use of forced air blown through pre-laid, low-cost, four inch corrugated polyethylene pipes. Pre-shredding can be accomplished either centrally or with a rotor shredder on site. The cost of the stabilized refuse is approximately the same as or slightly more than a sanitary landfill, but there are the advantages of; (1) no cover, (2) less water pollution, and (3) approximately one-third of the landfill area required due to digestion and greater compaction. The end product can be dug out and sold if a market exists thus making room for more material. The filled area can be reused, making the pile deeper with a second and a third layer possible.

c. Value of organic matter, utilization and marketing.

Organic composts used as low-grade fertilizer or soil conditioner have a real benefit to most soils but particularly heavy clays or loose sand where its usage can increase crops.

The need for organic matter in the soil can be summarized as follows;

- improvement of physical character of soil;
- increase of moisture holding capacity;
- reduction of chemical fertilizer leaching especially nitrogen and phosphorous; and

- stimulation of healthy acting for root growth.

d. Advantages and disadvantages

Composting system has several advantages and disadvantages. Advantages are as follows:

i. Compost product by waste are used as organic fertilizer and soil conditioner, i.e. recycling of nutrients.
ii. A certain quantity of reusable material can be recovered at the pretreatment stage.
iii. A certain quantity of reduced waste volume at landfill is expected.

Disadvantages are as follows:

i. If composting is not preceded by any sorting, the compost produced will contain potentially polluted materials, making it less usable or even unusable for land and garden use.
ii. The recovery rate of compost product is not high (normally 35% of total waste weight). Rejected materials have to be hauled to the landfill site again.
iii. Reduction of waste volume can not be considerable expected compare with incineration system.
iv. Quality of waste suitable for composting is very limited. Therefore in order to collect the above material for compost, modifications of existing systems for collecting and hauling may be required.
v. Efficiency of compost system is not enough, therefore:
   . It takes a long time for fermentation.
   . Wide stock yard for fermentation and storing the compost product will be required.
vi. Compared with chemical fertilizer, compost have the following inconveniences due to the amount of volume for the use of fertilizer.
   . high transportation cost.
   . difficulty for spreading in plantation.
vii. Generation of offensive odour has to be avoided.

(3) RDF (Refuse Derived Fuel)

a. Introduction

RDF (Refuse Derived Fuel) is based on replacing e.g. coal in a conventional power or district heating plant by pellets made of waste.

The production of refuse derived fuel can be done in several ways. In some of the earlier systems raw refuse was first shredded to a nominal particle size of about 4 inches. More recent systems employ a rotary trommel before shredding. This trommel allows for prior separation of heavy, larger materials. After shredding, ferrous metals are separated magnetically for recycling. The remainder is then separated into a lighter, mostly combustible fraction and a heavier, mostly noncombustible fraction using an air classifier. The lighter fraction is then further processed to produce the RDF through secondary shredding and screening. The RDF that is produced can be burned as a coal or can be burned as a primary fuel in a specially designed boiler.

Today, RDF systems are mainly adopted in the United States and Canada. But the extensive use of this technology elsewhere in the world may not be recommendable due to the following problems observed;

- Occupational health problems at the plants specially at manual sorting lines.
- The pre-treatment plant is capital intensive leading to high waste disposal prices in order to make the pellets competitive with coal.
- The pellets still have a high content of pollutants (heavy metals and chloride) which conventional coal fired plants are not equipped for filtering.
- The need to alter the combustion conditions of conventional boilers and burners if a significant amount of RDF is to be burnt.

There are following kinds of RDF:

- fluff-RDF
- densified-RDF
- dust-RDF
- wet-RDF

b. Advantages and disadvantages

- Advantage is:
  i. Combustibles in municipal waste can be converted to substitute fuel which can be stored and is easy to handle.

- Disadvantages are:
  i. Waste which can be converted to RDF is very limited, and their availability can be found only in waste with much paper content.
  ii. The market for RDF product will be limited due to the necessity of a special burner which can burn hard solid fuel such as coal.
  iii. Some technical difficulties such as causing explosions in crusher, clogging in storing silo, etc., have to be solved.

(4) Pyrolysis

a. Introduction

Recently, considerable attention has been given to pyrolysis in providing means of recycling municipal solid wastes. Pyrolysis is a process for breaking down organic substances by applying heat, in the range of 700–1,200 °C, in the absence of oxygen or at oxygen levels insufficient for total combustion. Under these temperature and pressure conditions, organic materials break down to shorter chain organic compounds and in some cases are reduced to charcoal, a carbon residue. A variety of potentially useful products may be produced, depending on refuse composition and operating conditions. Master products are charcoal, tar and pitch, light oil, organic acids, ammonium sulphate and combustible gases.

Theoretically, pyrolytic operations lend themselves well to a total recycling approach. Prior to the actual pyrolysis step, waste materials must go through a number of preparatory operations. Generally solid wastes are first shredded, glass and metals are separated and these materials are sold where an available market exists. Unusable residue, reduced to a small percentage of the original total, is left for ultimate disposal at a sanitary landfill.

In USA, the technology aims at recovery of storable energy while in Japan it is being developed for non-pollution intermediate system for wastes.

b. **Advantages and disadvantages**

Pyrolytic processing operations are certain advantages and disadvantages. Among the advantages are:

i. reduced land requirements for final disposal;
ii. reduction of solid wastes to a minimum volume;
iii. little air or water pollution (since little or no oxygen is involved, combustion products may not be a factor of pollution.);
iv. recycling of solid wastes into potentially useful products. Considering the effective energy saving, production of such items as fuel oils, gas and steam are desirable and needed.

Basic disadvantages are;

i. Large capital investment and high operation cost.
ii. The nature of oil or gas obtained form the facility is still in insufficient for commercial use, therefore the market is limited to in-plant use only. For purifying the oil or gas, high cost have to be consumed, therefore it is not effective regarding their cost.

c. **Notes**

i. In Japan, first commercial pyrolysis gasification plant which has 450 tons/day capacity had commenced in operation in 1983. However, due to several accidents caused during its operation, many revisions or improvement work were made to this plant. Although the plant is still in operation, it is said that large scale basic improvement plan is now under way by the unfavourable reasons, such as the lack of energy recovery benefit, complexity, high waste treatment cost, etc..

ii. The present situation on the pyrolysis technology in the United States indicates:

"Pyrolysis of municipal waste to produce a marketable oil or gas product has not been proven feasible. The pilot plants that were being developed for that purpose have been closed."

(5) Ash Solidification

a. Introduction

Besides increase in the quantity, refuse of the present day is diversified quality-wise. Even after complete incineration, there still remains a large quantity of substances which can not be treated such as incineration ash and sludge from discharged waste water treatment. For heavy metals, in particular, fundamental solution is desired because of the environmental problem at the places of disposal and difficulty to acquire a land for disposal.

Ash solidification technology is developed so as to dissolve and solidify such substances by high temperature or to change into solid concrete by using cements and other bonding agents.

b. Advantages and disadvantages

As for the melting treatment system, there are following advantages:

i. If the system is combined with an incineration, waste volume reduction in this system is 95 to 97%. Then, it is considered to have the best reduction effect compared with any other treatment systems.

ii. The fritted, glassy aggregate obtained from this plant is completely sterile, therefore, the problems of leachate from the landfill site for the residue of the plant is not to be considered.

Further efforts to develop a useful end-use are being followed as to concrete aggregate, building blocks, road way base and filter base.

iii. As heavy metals are sealed into slag under stable condition, there is no flow-out yet. Turing into a resource is also possible.

Disadvantages are;

i. Large capital investment cost.

ii. The technology is in developing stage.

iii. High operation cost. Inert materials contained in wastes have to be melted into molten slag, therefore, a large amount of additional fuel is required leading to high operation costs.

iv. Difficulty of operation. It is rather difficult to keep stabilized and continuous operation. In this system, skilful operators are required.

(6) Biogas

a. Introduction

Biogas is produced when organic material decomposes under anaerobic circumstances. The energy will be bound in the hydrocarbon combination methane, which is the main element of natural gas. Anaerobic degradation of organic matter, resulting in biogas production, is an efficient means of degrading organic wastes, and making it hygienic. Anaerobic waste treatment is a well know process relating to treatment of farmyard manure, sewage sludge and industrial waste water and other sludge.

A biogas plant consists of a reception and pre-treatment part, a process part, and post-treatment part including stock facilities. In the process part the organic material is transformed into carbohydrate, proteins, and fat by means of micro organisms. First the material is decomposed by certain bacteria to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids including hydrogen to methane.

Bio gas can be utilized both for heat and power production. The residues are compost and can be utilized as soil improving agent.

From a practical point of view, it is an advantage to place the biogas producing plant near a waste water treatment plant, in order to supply the biogas plant with water to dilute incoming wastes, and to supply power to the waste water treatment plant and achieve useful synergy.

It is possible to add the following wastes to biogas producing waste treatment plants:

- organic wastes from households, including meat and vegetables
- flowers, including herb wastes from gardens
- coffee grounds - tea leaves including paper filters
- fruit wastes
- paper kitchen towels and tissues
- organic sludge and waste water from industry, including the food industry
- sewage sludge

However, one should exclude waste water and wastes containing heavy metals, and wastes from some branches of the chemical industry.

It has to be started, that this type of waste processing technology is rather new, which means, that it has not been possible to find experience from plants, which have been working for more than a few year. On the other hand, plants for agricultural and industrial purposes are well documented and reliable.

b. Advantages and disadvantages

Advantages are;

i. resource recovery of wastes into potentially useful products, i.e., methane gas and compost;
ii. minimal potential soil, water and ground water pollution; and
iii. possible location near urban areas.

Disadvantages are;

i. high investment cost;
ii. only few years operational experience of municipal wastes;
iii. transportation costs; and
iv. requirement of pre-sorting of organic wastes.

(7) Size Reduction (Crushing and Shredding)

a. Introduction

A size reduction facility, which normally has crushing and shredding functions, is generally used as a pre-treatment facility for an incineration plant, composting plant and other intermediate treatment facilities, and also used in order to improve sanitary landfill operation.

As for shredding for sanitary landfill, shredding make volume reduction of waste carried into the final disposal site. The shredded waste, as compared with the non-shredded one, will be settled more quickly when used for a sanitary landfill. The land users near the sanitary landfill make little complaint about the landfill, because the landfill work progresses sanitarily. In addition, fewer fires will break out during the landfill work. Fewer rodents and insect hatches will require less insecticides and raticides are needed.

The shredded wastes causes less damage to the landfill equipment and trucks for the sanitary landfill work than the non-shredded waste. The shredded waste has a less settlement than non-shredded one because of its high compaction ratio.

The term "crush" has various meanings, i.e., shredding, milling, pulverizing, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed, respectively. For example, an ordinary hammer mill where a swing hammer attached to the horizontal or vertical shaft rotates very fast. Waste is dumped from above, and discharged from the opening at the bottom after it is pulverized by shear force of the cutting board.

The grindability depends upon the substances to be crushed, and the size required for the purpose of each treatment system. The pulverizing process will be accompanied with sieving, if necessary.

b. Advantages and disadvantages

Several advantages can be described and they are as follows;

i. Shredding and crushing (size reduction) contributes to the work efficiency of the other intermediate treatment facilities;

ii. Shredding and crushing is well adapted to the local conditions and intended plans because (1) shredding reduces volume by about 50 percent thus making transportation by truck easier and more efficient, and (2) shredded waste spreads more easily. Shredded waste is compacted better in the sanitary landfill and thus takes up less space making the landfill area last longer.

iii. Shredding and crushing makes for more compact and ultimately more stable sanitary landfill and hence, the ultimate value of land after filling would be great.

iv. Since shredding and crushing facilitates more compaction of the waste, there have been less fire on such operations particularly if solid waste disposed receives a final cover. In addition, problems of flies and rodents would be greatly minimized.

v. Shredding and crushing definitely increases compaction thus making landfills denser and reduces the percentage of settlement.

Shredding and crushing have the following disadvantages:

i. The use of the rotary type hammer crusher consumes large quantity of electricity as it usually requires a high power electric motor.

ii. Damages due to explosion caused by inflammable matter contained in waste might occur frequently. Therefore, strict checking and sorting out of dangerous matter have to be done.

iii. According to tremendous wear of mechanical parts such as hammer beaters, shear blades, etc., frequent maintenance work, repairing or replacement of damaged parts shall be necessary.

(8) Sorting

a. Introduction

An important point to be considered in both the treatment and disposal id that a system for recovery of the resource such as paper, glass, metal, plastics, etc., must be provided in the early stage of planning. The most desirable method is a system which allows as many kinds of waste as possible at the lowest cost, and not causing any secondary environmental pollution.

The lay-out of sorting plants and the specific operational requirements vary between plants, but the plants in general serve one of two purposes;

- To salvage recyclable materials from the waste stream in order to increase the amount of recycling. (Positive sorting). The reject is disposed of at a landfill or incinerated.

- To separate unwanted materials from the waste stream before further processing (recycling, incineration, composting etc.). (Negative sorting).

Furthermore, as the incoming waste usually has to be separated at source before coming to the plant, the plant will act as a control unit for the quality of the collection system and source separation.

Based on the above the following types of sorting plants are most relevant:

- Sorting of source separated wastes;
- Sorting of waste before incineration;
- Sorting of waste before composting;
- Sorting of building and demolition waste;
- Sorting of bottom ash from incineration.

However, it shall be stressed that the market price for the output material in combination with the quality of the input material are the determining factors for the economic viability of the plant.

b. Type of salvage process

The major purposes of the salvage are to recover the valuables. For metal, nonferrous metal, paper, cardboard, glass, plastics, rag, leather, etc., to be recovered as valuables, a dry classifier which uses wind power, magnetic separator vibration, and human power are mainly used in accordance with each characteristic of the valuables. Dry classifying is usually performed in air. In addition to this method, available are the wet classification by means of liquid and the semi-wet classification by means of less liquid. Both the dry classifier and the wet classification have a wide range of application in accordance with their characteristics. Various sorting methods are described as follows:

- i. Mechanical Sorting
  - Dry Classification
    - Mechanical Type
      - Vibrating sieving
      - Trommel
      - Brush
    - Wind Power Type
    - Magnetic Type
    - Electric Type
      - Electrostatic Method (for non-ferrous metals)
    - Optical Sorting (for glass)
  - Wet Classification
    - Mechanical Type (Semi-wet)
    - Water Power Type
    - Heavy Liquid Type

ii. Manual Sorting

c. Advantages and disadvantages

Advantages of sorting systems are:

i. With the adoption of sorting devices such as pneumatic, mechan–ical, magnetic, etc., sorting out operation is executed effectively under hygienic environmental condition.

ii. Many sorting systems are relatively simple and easy to operate. Further–more, technically those devices are stable.

iii. Investment cost, utility cost and maintenance cost are usually cheaper than other systems.

Disadvantages are:

i. The suitable wastes to sort in this system are generally limited to such waste that are relatively dry and with rich inert material content. Therefore not so much contribution will be expected for waste volume reduction.

ii. Objects rejected after usable materials are sorted have to be hauled to landfill site again.

iii. Generally, quality or purity of materials which are obtained by mechanical separation device is insufficient, compared with manual sorting. For example, light fraction such as plastic films and papers are recovered as a mixture by pneumatic device. Each fraction can not be completely separated though because the specific gravity of both materials is almost equal to the specific weight, thus the market price will be reduced.

iv. As for manual sorting, a waste contaminated with other kinds of waste often will result in unacceptable working conditions for the personnel on a sorting plant.

3) Examination of System Components

Generally, the possibility of introducing appropriate intermediate treatment facilities must be examined because the acquisition of new disposal sites is becoming increasingly difficult and that better environmental conservation measures should be introduced.

a. Selection criteria for intermediate treatment

The following criteria are considered in the selection of possible intermediate treatment

i. volume reduction of solid waste

The facility should be capable of reducing the solid waste volume for final disposal, thereby contributing to extend the life of disposal sites.

ii. resource recovery

The facility should assist the recycling of resources.

There are two ways of resource recovery from solid waste. One is the extraction of economically usable materials from solid waste, and the other is the extraction of energy from waste.

iii. protection of environmental pollution

The facility should contribute to the improvement of environmental conditions.

b. Possible intermediate treatment

In response to the above-mentioned criteria, the following intermediate treatment systems are discussed in this report:

- incineration;
- composting;
- RDF;
- pyrolysis;
- ash solidification;
- biogas;
- size reduction (crushing and shredding); and
- sorting.

Each system can be employed independently or jointly, and has advantages and disadvantages. It is, therefore, important to select an optimum system or an optimum combination of systems, taking the following points into account:

- construction, operation, maintenance and repair cost
- acceptability of various kinds of wastes

- volume reduction effects for final disposal
- marketability and price stability in markets of recovered materials
- ease in operation
- reliability and stability of treatment plants (degree of technical development and operation results, etc.)
- impact on surroundings and its intensity
- simplicity in design of plants (pre-treatment, back-end treatment, etc.)

Table H.3.4-1 shows characteristics of possible processing systems.

c. Relationship between intermediate treatment systems and solid waste quality

The processing systems should be selected according to qualities of waste. Table H.3.4-2 shows the general characteristics of various kinds of solid wastes (percentage of organic materials, water content, inorganic materials and calorific value), and types of wastes most effectively treated by the respective processing plants.

Each intermediate treatment technology and its characteristics are described below;

i. incineration

Suited for a wide variety of waste except for incombustible bulky waste. Waste from hospital and carcass are low in calorific values. However, they should be incinerated in a special furnace for sanitary purposes.

ii. composting

Generally, suited for domestic waste, other similar types of waste and some kinds of commercial waste.

iii. RDF

Commercial waste especially rich in paper content might be proccessable.

Table H.3.4-1 Examination of Intermediate Treatment Technologies

ITT	Recovered Material	Main Target of system	Contribution to Landfill			Special Cautions								Remarks
			Volume reduction	Harmless	Stabilization	Stability of Technology	Pre-treatment	Post treatment	Rejected Substances	Acceptability of Refuse Quality	Construction Cost (us$/ton)	Marketability of recovered Material	Environmental Impact	
Incineration	Heat/or Electric Power	Volume Reduction & Energy Conversion	B	B	B	A	Not Necessary	Not Necessary	None	A	84,000*1	(Electricity or Heat) C	B	- Initial/Running Cost - Possibility to find User of Heat
Composting	Compost	Conversation to Fertilizer	C	C	C	A	Necessary	Necessary	Glass, Stone, Plastic, etc.	C	46,000*2	C	C (Odour)	- Stability of Market for Products
RDF	Solid Fuel	Conversation to Fuel	C	C	C	C	ditto	ditto	Noncombustibles	C	N.A.	?	C (Noise & Dust)*	- Marketability of Products
Pyrolysis	Gas or Oil		B	B	B	C	ditto	ditto	Incombustible Carbon	C	N.A.	X	B	- Incompletion of Technology - Initial/Running Cost
Ash Solidification	Slag	Volume Reduction & Prevention of Water Pollution	A	A	B	C	Occasionally Necessary	Not Necessary	None	B	N.A.	?	B	- Large Consumption of Supplemental Fuel _ Difficulty of Operation
Biogas	Gas & Compost	Conversation to Fuel & Fertilizer	C	C	C	C	Necessary	Necessary	Glass,Stone ,Plastic etc.	C	97,500*3	C	B	- Stability of Market for Products
Crushing & Shredding	Ferrous etc.	Volume Reduction of Bulky Waste	C	C	B	B	Extraction of Explosive Object	ditto	Discarded Material	C		C	C (Noise & Dust)	- Large Consumption of Electricity - Much Expense for Maintenance - Possibility of Explosion
Sorting (Mechanical or Manual Sorting)	Ferrous, Glass, Paper, Plastic etc.	Recycling	C	C	C	A	Occasionally Necessary	Necessary	Discarded Material	C	N.A. 46,000*4 to 82,000	B	B	- Stability of Market Salvaged Material

Note: A: Excellent B: Good
C: Fair or ( ) to be considered D: Poor and ( ) shows reason

ITT: Intermediate Treatment Technology
*2 : The cost for 19,000 tonnes of garden waste per year from the EC PHARE Report
*4 : The cost from the EC PHARE Report for 20,000 tonne/year

*1 : The cost for 120,000 ton/year plant was estimated in the EC PHARE Report (Municipal Waste-Strategy) for Waste Management and Applicable Methods for collection and Treatment)
*3 : The cost for 36,000 tonnes per year from the EC PHARE Report

Table H.3.4-2 Kinds of Waste and Availability to International Treatment System

	3-Elements of Waste				Incineration	Composting	RDF	Pyrolysis	Ash Solidification*2	Biogas	Crushing & Shredding	Sorting
	Organic Substances B	Moisture Contents W	Inorganic Substances A	Calorific Value of Waste								
Municipal Waste												
. Domestic Waste	Much	Fair	Less	Middle	A	A	B	A	A	A	B	A
. Commercial Waste (mainly from offices and shops)	Fair	Less	Fair	High	A	-	A	A	A	-	B	A
. Commercial Waste (mainly from markets)	Much	Much	Less	Low	A	A	-	-	A	A	B	-
. Carcasses	Much	Much	Less	Low	A	-	-	-	A	-	-	-
. Other Waste (Road Sweeping and public area clearing wastes)	Much	Much	Less	Middle	A	B*1	-	-	A	-	-	-
Industrial Waste (Non-Toxic)	Fair	Less	Fair	High	A	-	A	B	A	-	B	B
Bulky Waste												
Combustible Bulky Waste	Much	Less	Less	High	A	-	B	B	A	-	A	B
Incombustible Bulky Waste	Less	Less	Much	-	-	-	-	-	B	-	A	A
Hospital Waste	Much	Much	Less	Low	A	-	-	-	A	-	-	-

Remarks

	Ranking System for 3-Elements of Waste:	Ranking System for Calorific Values of Waste:
A Suitable	. Much	. High
B Processable	. Fair	. Middle
- Normally not for processing	. Less	. Low
	. Low	

Note : *1 : Only for garden wastes.
*2 : All evaluation is for the plant combined with an incineration.

iv. pyrolysis

Limited only to waste with low moisture content and high calorific value.

v. ash solidification

Suited for ash including inert materials.

vi. biogas

Limited only to organic wastes including paper and organic and sewage sludge.

vii. size reduction (crushing & shredding)

An independent plant is only for bulky waste. However, crushing and shredding devices are necessary for the other intermediate treatment systems.

viii. sorting

Suited for inert waste.

4) Conclusion

Upon consideration of the examination of intermediate treatment systems and the present SWM in the city of Poznan, the following systems are redundant and omitted:

- RDF;
- pyrolysis;
- ash solidification;
- biogas; and
- size reduction.

While the followings are retained for further study;

- incineration;
- composting;
- sorting;

As for the size reduction (crushing and shredding), it will be examined as a pre and/or post-treatment facilities for incineration, composting and sorting plant.

The reasons are described as follows;

a. RDF

i. Waste which can be converted to RDF is very limited.
ii. The technology is in a developing stage.
iii. The market for RDF product is limited.

b. Pyrolysis

i. The waste quality is limited.
ii. The technology is under development.
iii. The operation of plant is very difficult.
iv. Large capital investment and high operational cost are required.

c. Ash solidification

i. Large capital investment and high operational cost are required.
ii. The technology is in developing stage.
iii. Land for final disposal is still available in the study area.
iv. Difficulty of operation

d. Biogas

i. High investment cost.
ii. The technology is in developing stage only a few years operational experience in MSW.

e. Size reduction

i. Waste is limited to the bulky waste and the production of it is not so much.
ii. The bulky waste will be collected at the recycling centres and may be recycled by the manual.

H.3.5 Final Disposal

1) Possible System Alternatives

Upon consideration of the possible system alternatives of final disposal, the following aspects are to be considered:

- location and number of final disposal sites;
- final disposal methods;
- landfill structure;
- recovery of methane gas; and
- level of sanitary landfill development and operation.

2) Location and Number of Final Disposal Sites

As for the location and number of final disposal sites for the Master Plan alternatives study, it was confirmed as follows;

i. The possibility of utilizing the existing Suchy Las disposal site after the year 1993 should not be taken into account for the formulation of the Master Plan.

ii. The tree candidate sites for primary facilities, Janikowo, Starolenka and Franowo–Michalowo were proposed by the Poznan Municipality at the end of May 1992. These sites were investigated during the 1st study period in Poland in response to the request from the Poznan Municipality. It was reported to the Polish side in the Progress Report (1) that the Franowo–Michalowo site was judged to be the most suitable disposal sit for Poznan City according to the site survey and collected data.
In response to the Progress Report (1), the Polish side requested to the JICA Study Team that only Franowo–Michalowo site should be considered as the modern facility site including processing and final disposal site for the Master Plan.

3) Final Disposal Methods

There are several final disposal methods as listed below:

- open dumping;
- controlled tipping; and

- sanitary landfill.

Although the controlled tipping method is generally employed in the Study area, the use of the method should not be tolerated in the future in view of their adverse effects on the landscape, public health and environment.

A sanitary landfill should be used for final disposal. A sanitary landfill is proven to be the most economical and acceptable method for the disposal of solid wastes.

The advantages of sanitary landfills are shown below.

- Where land is available, a sanitary landfill is usually the most economical method of solid waste disposal.

- The initial investment is low compared with other disposal methods, such as composting and incineration.

- A sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.,

- A sanitary landfill can receive all types of solid wastes, eliminating the necessity of separate collections.

- A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.

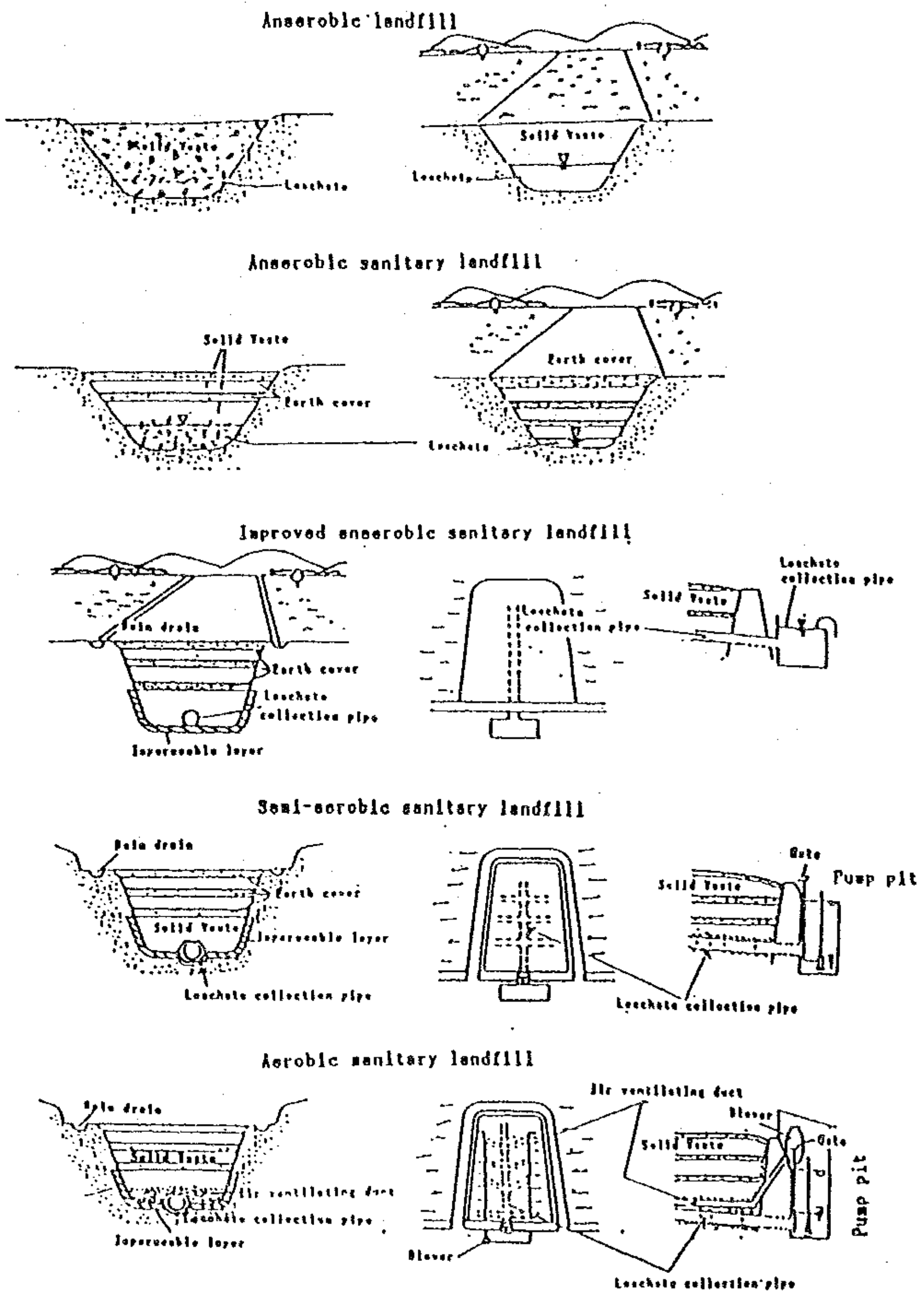
- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical garden, etc..

4) Landfill Structure

There are five types of landfill structure, as follows:

- anaerobic landfill;
- anaerobic sanitary landfill;
- improved anaerobic sanitary landfill;
- semi-aerobic sanitary landfill;
- aerobic sanitary landfill;

Fig.H.3.5-1 Landfill Structures



Source; Japan-United States Governmental
Conference on Solid Waste Management,
Oct.1976 by Dr.Masataka Hanashima

The contribution to the mitigation of environmental pollution is improved in accordance with the above list. Fig.H.3.5-1 shows the structure of each landfill type.

a. Anaerobic landfill

As the leachate generated in the landfill layers is hardly drained, the landfill layers constantly maintain anaerobic condition. The quality of the leachate is very poor, causing bad odour and the propagation of vector and vermin.

b. Anaerobic sanitary landfill

Covering soil is applied on each layer of waste. This covering soil restrains the bad odour, incidental fires and the propagation of harmful insects to a certain extent. However the problems of leachate and gas generation remain. As in the case of anaerobic landfill, the disposed solid waste maintains anaerobic conditions.

c. Improved anaerobic sanitary landfill

In addition to covering soil, a drainage facility for the leachate is introduced a the bottom of the disposal site. The quality of the leachate is accordingly improved, although the anaerobic conditions are still maintained.

d. Semi-Aerobic sanitary landfill

As the leachate is constantly drained by drainages pipes, the quality of the leachate is fairly improved. These drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers. As a result, the decomposition of the solid waste is accelerated.

e. Aerobic sanitary landfill

In addition to the drainage pipes used in semi-aerobic landfill, air supply pipes are introduced for forced air injection to achieve aerobic conditions in the layers, accelerating the decomposition and stabilization of the solid waste and improving the leachate quality.

The Landfill site in the Study area currently employs the improved anaerobic sanitary landfill structure.

In view of the above advantages and disadvantages of the landfill structure types, it is planned that final disposal sites in the Master Plan will employ the semi-aerobic sanitary landfill structure with leachate drain pipes.

5) Recovery of Methane Gas

The recovery of methane gas will not be considered in the alternative study due to the following reasons;

i. The proposed disposal site is flat and it is rather difficult to recover the methane gas at the flat and shallow disposal site.

ii. It will take many years for the recovery or methane gas and also require a mounting-up disposal operation.

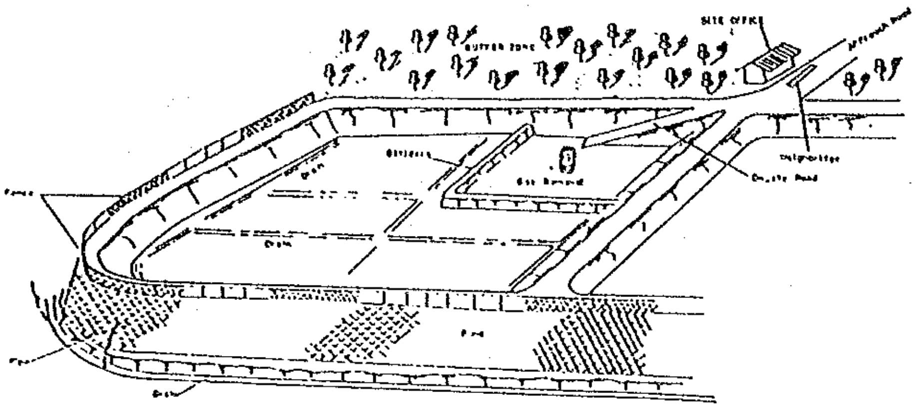
6) Level of Sanitary Landfill Development and Operation

The level of sanitary landfill development and operation can be classified into the following four levels.

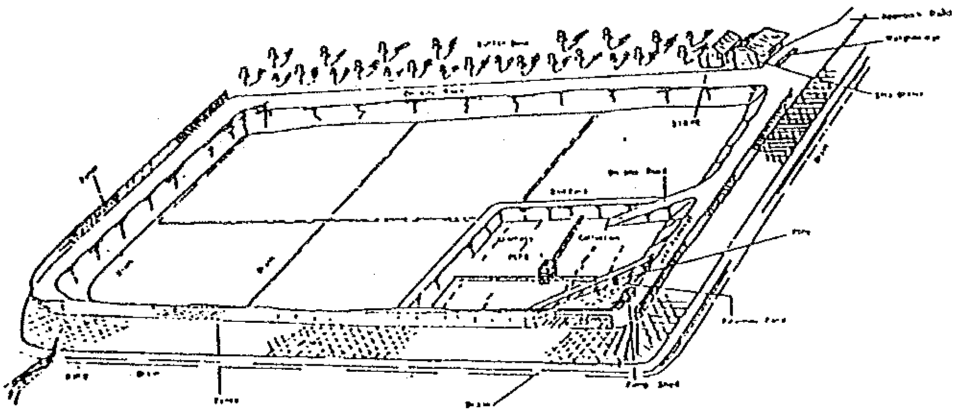
a. Level 1 Controlled tipping
b. Level 2 Sanitary landfill with a band and daily soil covering
c. Level 3 Sanitary landfill with leachate circulation
d. Level 4 Sanitary landfill with leachate treatment

The details of above mentioned level of sanitary landfill development and operation are described below. The prospective levels of sanitary landfill development and operation are illustrated in Fig. H.3.5-2.

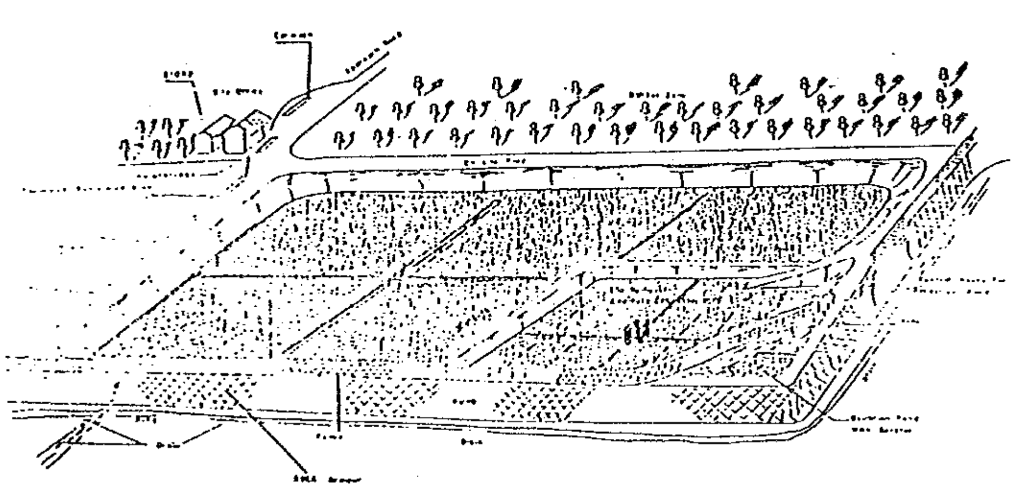
In order to accord the EEC standard, the level of sanitary landfill is determined as level 4. The leachate treatment, however, shall be done at the municipal sewage treatment plant.



Level 2



Level 3



Level 4

Fig.H.3.5-2 Prospective Illustration of Sanitary Landfill Development and Operation in Level 2, 3 and 4

H.4 Technical System Alternatives

H.4.1 Concept of Each Alternative

Upon consideration of the proposed goal and the present SWM in Poznan, the introduction of the following intermediate treatment will be examined:

- recycling centres;
- a sorting plant;
- an incineration plant; and
- a composting plant.

Seven studied alternatives consisting of the above-said system components are shown in Table H.4.1-1.

Table H.4.1-1 List of Alternatives

Alternative Plan		1	2	3	4	5	6	7
Collection	Mix Collection	x	x		x		x	
	Separate Collection			x		x		x
Recycling	Recycling Centre		x		x	x	x	x
	Sorting Plant			x				
Treatment and Dis-posal	Incineration Plant				x	x		
	Composting Plant						x	x
	Sanitary Landfill	x	x	x	x	x	x	x

Note: Alternative Plan 1 is a reference plan to be used for comparison purpose.

1) Recycling Centres

a. Objectives

- to offer private householders and small traders the opportunity to hand in all sorts of waste except kitchen refuse.
- to let users sort the waste into appropriate containers at the centres
- to increase the utilization of recycling materials

- to ensure that the intermediate treatment plant only receives waste that is suitable for the production, whereas other categories of waste are separated to be recycled, composted, or dumped.
- to reduce illegal dumping

b. Method

Recycling centres are supervised container sites, which are in principle open a certain number of hours every day throughout the year. Admission is free for all householders. However, the registered total weight of vehicles must not exceed a certain amount, for example 3,500 kg, in order to avoid industrial waste disposal. The householders sort their own waste into appropriate containers, which are distinctly labelled.

c. Waste Disposal

Materials for recycling such as paper, cardboard, glass and bottles, metal and perhaps clothes and plastic are sent to recycling enterprises. The rest is sent to the incineration plant, the composting plant or the disposal site in accordance with the sorts of waste and the existing treatment facilities.

2) Sorting Plant

a. Objectives

The objectives of the sorting plant is to make it possible to sort out recyclable materials and non-combustible objects.

b. Method

The waste is unloaded into a pit and carried to the picking band by means of an apron conveyor. A crane is installed at the band to remove large and heavy items. Through side hoppers the separated materials are thrown into containers or conveyor bands leading to containers. Cardboard is collected in compression containers.

c. Waste Disposal

Recyclable materials are sold to recycling industries, whereas the rest goes to landfills.

3) Incineration Plant

a. Objectives

The main objectives of the incineration plant is to treat solid combustible waste, with proper consideration for the environment. The purpose is also to make the waste hygienic and to reduce its volume, in order to minimize the amount of waste to be landfilled.
Another main purpose is to utilize waste heat for heat supply to the district heating systems and/or electricity supply.

b. Method

The process of incineration reduces the waste to about 5 % of the original volume, the residue consisting of raw clinker and fly ash. Most of the clinker are to be disposed of at a landfill.

c. Waste Disposal

Recyclable materials such as metal are sorted after burning and sold to recycling industries. The rest is sent to the disposal site.

4) Compost Plant

a. Objectives

- to utilize organic waste for compost
- to reduce disposal volume

b. Method

If organic materials are separated from municipal solid wastes and subjected to bacterial decomposition, the end product remaining after dissimilatory and bacterial activity is called humus. The entire process involving both the separation and microbial conversation of the organic solid waste is composting.

c. Waste Disposal

Recyclable materials such as metal are sorted and sold to recycling industries. The rest is sent to the disposal site.

H.4.2 Basic Conditions for the Examination of Each Alternative

1) General Conditions

a. The proposed SWM facilities sites is assumed to be Franowo–Michalowo area, in accordance with the decision stated in the minutes of meeting dated July 22, 1992.

b. The comparison and evaluation on each alternative are executed based on the technical system in the year 2010.

2) Conditions for Waste Flow Forecast

a. The waste generation ratio used for forecasting does not include the amount of materials which is being recycled by the recyclers in 1992. This amount shall not be taken into account for forecast, because the present municipal recycling amount can not be identified. Therefore it is assumed that this amount will be maintained in future.

b. The rate of the waste amount, sent to all recycling centres by householders to the total waste amount is assumed to be 15%. 10% of the waste gathered at the recycling centres is re–used.

c. The treatment capacities of the sorting plant, incineration plant and composting plant are determined to meet the required treatment capacities in 2010.

d. The ratios of usable materials which can be salvaged at the intermediate treatment facilities are assumed to be as follows;

- Alternative 3
  82.5% of recyclable waste can be salvaged at the sorting plant. (According to the data in Japan, 75 to 90% or an average of 82.5% is salvaged.)

- Alternative 4
  Metal is salvaged from the bottom ashes and its recovery rate is 50% (It was assumed that the rate of iron to metal is 60% and the recovery capacity is 85%. Recovery rate of metal, 50%, was calculated based on this assumption.)

- Alternative 5

Metal and glass are sorted from non-combustible wastes and recovery rates are 50% respectively. (This was determined based on the data of Germany in 1987.)

- Alternative 6

  Metal and glass are sorted from the mixed refuse at the pre and post-treatment and those recovery rates are 60%. (This rate was determined based on the data of trommel sorting machines in Japan.)

- Alternative 7

  Metal and glass are sorted form the non-compostable waste and those recovery rates are 80% respectively.
  (same as alternative 5)

e. The reduced ratio of waste by the incineration is assumed to be as follows in weight,

Combustible waste (100%)	=>	ashes	(30%)
		+ additive chemicals for gas treatment	(4%)
		Total residue	(34%)

f. The waste is changed as follows through the composting plant in weight

Waste (100%)	=>	residue (20%)
	=>	compost (30%)
	=>	volatilization (50%)

3) Conditions for Economic and Financial Evaluation

a. All heat produced by the incineration plant proposed in the alternative 4 and 5 is sold.

b. All compost produced by the composting plant proposed in the alternative 6 can not be sold because its quality is not qualified for sale due to combined collection.

c. All compost produced by the composting plant proposed in the alternative 7 is sold.

H.4.3 Alternative 1

1) Proposed System

Mix Collection (present system); and
Sanitary Landfill

2) Purpose

– to improve sanitary level of the disposal site

3) Method

This system is same as the present system and only sanitary level of the disposal site operation is improved. All municipal wastes generated are carried and disposed of at the proposed disposal site without any special measures of resource recovery and recycling. This system is obviously the cheapest one in the area where the wide area is available for the disposal site. However, the sanitary landfilling, especially an embankment type on a flat land like common landfills in Poland, tends to decrease in the most developed countries due to the citizens' opposition.

4) Advantages and Disadvantages

Advantages;

- Cheapest investment.
- Cheapest **O & M** cost
- Simple and common technology.

Disadvantages;

- Wide area is necessary.
- No recycling.
- No resource recovery.
- Future land use of disposal site is limited.
- A large amount of soil is required of soil coverage for operation.
- A large scale topographical change is lead.
- Possibility of soil deterioration by leachate.

5) Waste Flow

Alternative 1

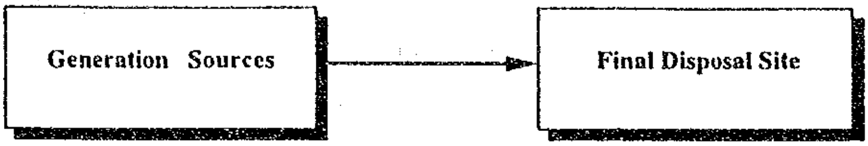


Fig.H.4.3-1 Projected Waste Flow for Alternative 1

H.4.4 Alternative 2

1) Proposed System

Mix Collection;
Recycling Centres (2-large and 6-small); and
Sanitary Landfill

2) Purposes

- to collect bulky waste through the citizen's participation
- to prevent illegal dumping
- to collect hazardous wastes through the citizen's participation
- to promote recycling
- to improve sanitary level of the disposal site

3) Method

This system is what the recycling system is added to the Alternative 1.

The citizens are requested to separate wastes into recyclable and non-recyclable wastes. Citizens carry recyclable wastes to the convenient recycling centres by themselves and discharge them into the classified containers for free. Non-recyclable wastes are discharged for the normal collection services in the same way as today and it is disposed at the sanitary landfill site.

4) Advantages and Disadvantages

Advantages;

- Cheap investment and cost of **O & M.**
- Simple and common technology.
- Recyclable wastes are salvaged.
- Decrease of illegal dumping.

Disadvantages;

- Quite wide area is necessary for a disposal site.
- Less resource recovery.
- Future land use of disposal sites are limited.
- A large amount of soil is required of soil coverage for operation.
- A large scale topographical change is lead.
- Effort to carry recyclable waste to recycling centres are requested to people.

5) Waste Flow

Alternative 2

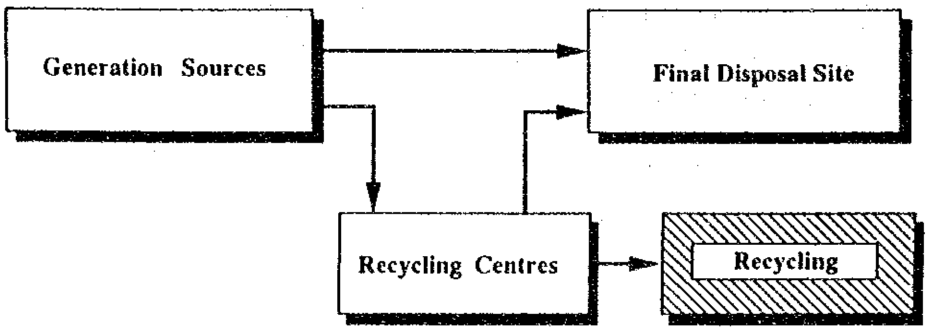


Fig.H.4.4-1 Projected Waste Flow for Alternative 2

H.4.5 Alternative 3

1) Proposed System

Separate Collection;
Recycling Plant; and
Sanitary Landfill

2) Purposes

- to salvage reusable material
- to improve sanitary level of the disposal site

3) Method

In this system, householders obligatorily separate wastes into recyclable wastes and non-recyclable wastes and then discharge them separately. Those segregated wastes are separately collected and recyclable wastes are carried to the sorting plant which is proposed in Franowo-Michalowo site. Recyclable wastes are sorted to paper, glass, plastic, metal, etc. by manual and a magnet sorter, and then they are carried to the manufacturers for reuse as resource. Residues discharged from the sorting plant are carried and disposed of at the disposal site. Non-recyclable wastes are directly carried from discharge points to the disposal site.

4) Advantages and Disadvantages

Advantages;

- Less expensive investment.
- Less expensive operation cost under the condition of the cheap labour cost.
- Simple and common technology.
- Recyclable wastes are recovered.
- Less disposal area.

Disadvantages;

- Manual sorting is very intensive work.
- Manual sorting is dangerous and bad for health of workers.
- The fluctuation ranges of selling price are big.

- Less resource recovery.
- Effort of waste segregation is imposed to all citizens.
- More waste containers are necessary for separate collection.
- Waste collection and haulage cost is more expensive than combined collection.

5) Waste Flow

Alternative 3

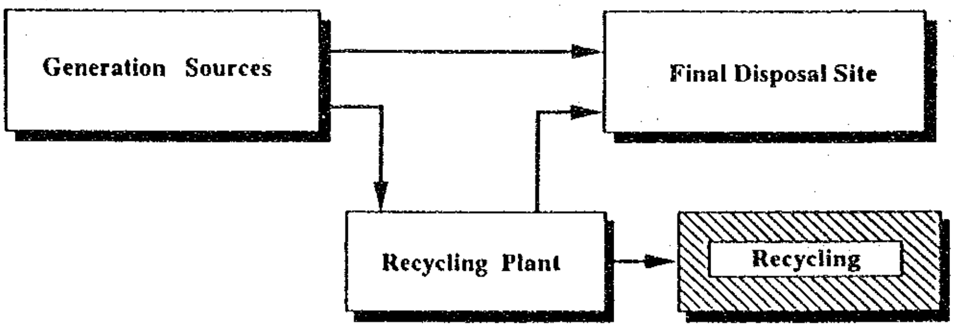


Fig.H.4.5-1 Projected Waste Flow for Alternative 3

H.4.6 Alternative 4

1) Proposed System

Mix Collection;
Recycling Centres (2-large and 6-small);
Incineration Plant; and
Sanitary Landfill

2) Purposes

- to collect bulky waste through the citizen's participation
- to collect hazardous wastes through the citizen's participation
- to prevent illegal dumping
- to promote recycling
- to recover heat energy from waste
- to improve sanitary level of the disposal site

3) Method

This system consists of the following sub-system;

- recycling centres to salvage reusable wastes
- incineration plant to recover resource and to reduce waste volume for disposal
- sanitary landfill

The citizens are requested to separates waste into recyclable and non-recyclable wastes. Citizens carry recyclable wastes to the convenient recycling centres by themselves and discharge them into classified containers for free. Recyclable waste gathered at the recycling centres are received by the users of the recyclable. Residue from recycling centres is carried to the disposal site. Non-recyclable wastes are discharged to the containers in the same manner as the present and then they are carried to the incineration plant by the collection contractor. Wastes are burned at the plant and heat generated by burning is utilized for heat supply. Ashes are to be disposed of the disposal site.

4) Advantages and Disadvantages

Advantages;

- Most of recyclable wastes are reused through recycling centres.
- Most non-recyclable wastes are utilized as energy source for heat.
- Fluctuation range of selling prices of heat is little.
- Delivery costs of heat is cheap.
- The life span of the disposal site can be prolonged by reduction of disposal waste volume.
- Required area for SWM site is the least.

Additional advantages;

- Infectious wastes can be burned safely.
- Sewage sludge can be treated.
- By using hot water, an amenity facility for the surrounding residents such as swimming pools, public bathes, etc., can be provided.

Disadvantages;

- Initial investment is big.
- **O & M** cost is expensive.
- High technology must be introduced from the foreign countries.
- Any local enterprise can not construct an incineration plant, by only itself
- Emission is discharged from the incineration plant, however, this can be maintained with environmental protection equipment in the level not to harm fauna and flora.

5) Waste Flow

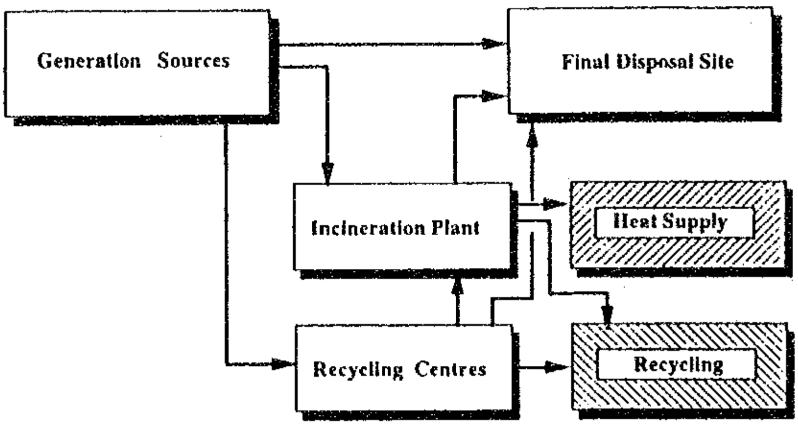


Fig.H.4.6-1 Projected Waste Flow for Alternative 4

H.4.7 Alternative 5

1) Proposed System

Separate Collection;
Recycling Centres (2–large and 6–small);
Incineration Plant; and
Sanitary Landfill

2) Purposes

- to collect bulky waste through the citizen's participation
- to collect hazardous wastes through the citizen's participation
- to prevent illegal dumping
- to promote recycling
- to recover heat energy from waste
- to improve sanitary level of the disposal site

3) Method

The different point of Alternative 5 from 4 is that the obligatory waste segregation, combustible and non–combustible, at discharge source is added. This system is effective to protect an incinerator from damaging by metal, ceramic, plastic, etc., and also higher efficiency of heat supply.

4) Advantages and Disadvantages

Advantages;

- most recyclable wastes are reused through recycling centres
- most non–recyclable wastes are utilized as energy source for heat
- fluctuation ranges of selling prices of heat is little
- delivery costs of heat is cheap
- the life span of the disposal site can be prolonged by reduction of disposal waste volume
- required area for SWM site is the least
- the life span of the incinerator can be prolonged

Additional advantages;

- Infectious wastes can be burned safely.
- Sewage sludge can be treated safely.
- By using hot water, and amenity facility for the surrounding residents such as swimming pools, public bathes, etc., can be provided.

Disadvantages;

- Initial investment is big.
- **O & M** cost is expensive.
- Waste collection and haulage cost is more expensive than combined collection.
- More waste containers are necessary for separate collection.
- High technology must be introduced from the foreign countries.
- Any local enterprise can not construct an incineration plant by only itself.
- Emission is discharged from the incineration plant, however, this can be maintained with environmental protection equipment in the level not to harm fauna and flora.
- Effort of waste segregation is imposed to all citizens.
- Effort to carry waste to recycling centres are requested to people.

5) **Waste Flow**

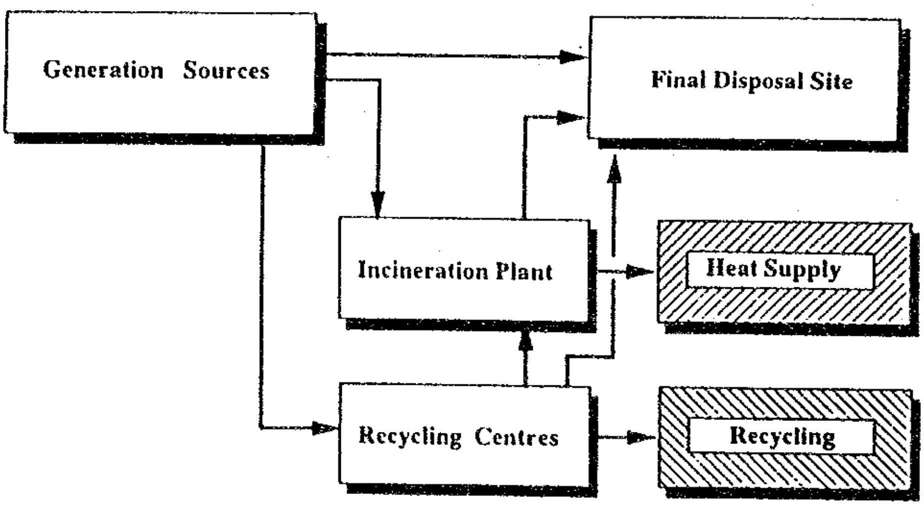


Fig.H.4.7-1 Projected Waste Flow for Alternative 5

H.4.8 Alternative 6

1) Proposed System

Mix Collection;
Recycling Centre (2-large and 6-small);
Composting Plant; and
Sanitary Landfill

2) Purposes

- to collect bulky waste through the citizen's participation
- to collect hazardous wastes through the citizen's participation
- to prevent illegal dumping
- to promote recycling
- to neutralize organic waste
- to improve sanitary level of the disposal site

3) Method

This system consists of the following sub-systems;

- recycling centres to salvage reusable wastes
- composting plant to utilize organic waste
- sanitary landfill

The citizens are requested to separates waste into recyclable and non-recyclable wastes. Citizens carry recyclable wastes to the convenient recycling centres by themselves and discharge them into classified containers for free. Recyclable wastes gathered at the recycling centres are received by the users of the recyclable. Residue from recycling centres is carried to the disposal site to the containers in the same manner as the present and then are carried to the composting plant by the collection contractor. Only organic wastes are sorted from the wastes and utilized for compost production. The residue from the composting plant is carried to the disposal site.

4) Advantages and disadvantages

Advantages;

- Most recyclable wastes are reused through recycling centres.
- Organic waste is utilized for compost.
- The life span of the disposal site can be prolonged by reduction of final disposal waste volume.
- Simple technology.
- No emission.

Disadvantages;

- Wide stock yard of compost is necessary.
- Transport cost of compost is high.
- Quality of compost is not good.
- Possibility of secondary environmental pollution by compost utilization such as heavy metal contamination by compost.
- High investment.
- High **O & M** cost.
- Pre-sorting plants is necessary.

5) Waste Flow

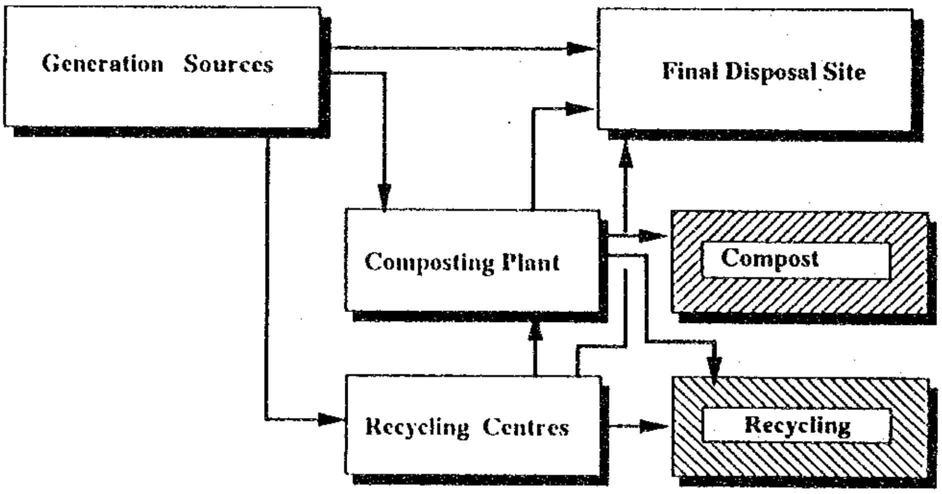


Fig.H.4.8-1 Projected Waste Flow for Alternative 6

H.4.9 Alternative 7

1) Proposed System

Separate Collection
Recycling Centres (2-large and 6-small);
Composting Plant; and
Sanitary Landfill

2) Purposes

- to collect bulky waste through the citizen's participation
- to collect hazardous wastes through the citizen's participation
- to prevent illegal dumping
- to promote recycling
- to produce compost by utilizing organic wastes
- to improve sanitary level of the disposal site

3) Method

The different point of Alternative 7 from 5 is that the obligatory waste segregation, organic and non-organic waste, at discharge sources is added. This system make it possible to produce fine compost.

4) Advantages and disadvantages

Advantages;

- Most recyclable wastes are reused through recycling centres.
- Organic waste is utilized for compost.
- The life span of the disposal site can be prolonged by reduction of final disposal waste volume.
- Simple technology.
- No emission.

Disadvantages;

- Effort of waste segregation is imposed to all citizens.
- The quality of compost product depends upon the law materials. As such the other mode of waste such as livestock waste shall be co-utilized with MSW.

- Wide stock yard of compost is necessary.
- Transport cost of compost is high.
- To improve the quality of compost requires a certain effort.
- High investment.
- High **O & M** cost.
- More waste containers are necessary for separate collection.
- Waste collection and haulage cost is more expensive than combined collection.
- People are required efforts to do waste segregation.
- People are required efforts to carry some waste for the recycling centres.

5) **Waste Flow**

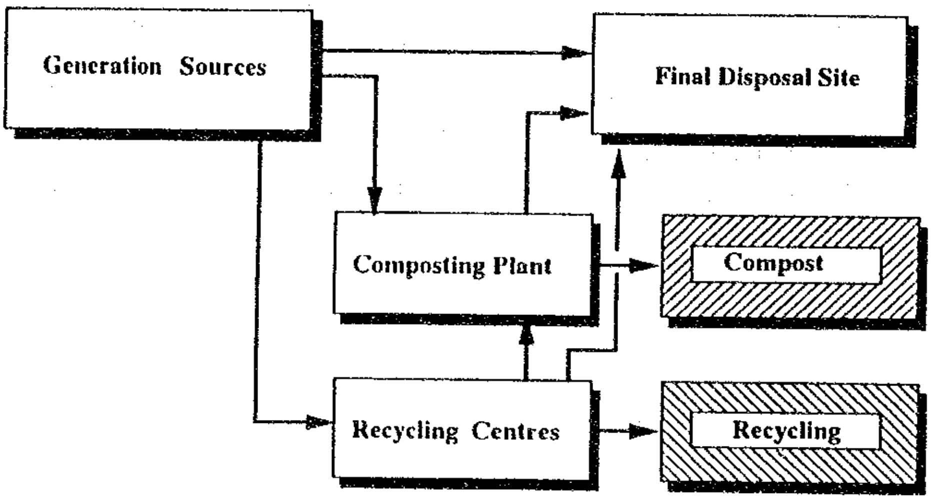


Fig.H.4.9-1 Projected Waste Flow for Alternative 7

H.5 Conceptual Design and Cost Estimate

This Section presents conceptual design and cost estimates for the following facilities for solid waste handling:

- Storage, collection and haulage system.
- System for road sweeping and public area cleansing.
- Incineration plant.
- Composting plant.
- Sorting plant.
- Recycling centre.
- Sanitary landfill.

Provisionally, it is evaluated that the above mentioned facilities might be feasible for the future solid waste management system of Poznan.

H.5.1 Storage, Collection and Haulage

1) Introduction

Present storage, collection and haulage system have been established based on the properties of the building structures, as shown in Table H.5.1-1.

Table H.5.1-1 Present Situation of Storage, Collection and Haulage

<table>
<tr><th>Building</th><th>Container</th><th>Refuse Truck</th></tr>
<tr><td>Detached and semi-detached houses</td><td rowspan="2">Dustbin (0.11 m^3)</td><td>Compaction truck A</td></tr>
<tr><td rowspan="3">Old buildings</td><td rowspan="2">Compaction truck B</td></tr>
<tr><td>Small container (1.1 m^3)</td></tr>
<tr><td rowspan="2">Large container (6-10 m^3)</td><td rowspan="2">Hoist truck</td></tr>
<tr><td>New building</td></tr>
</table>

This system is efficient and feasible for Poznan city, therefor, the variation of the present system is not necessary. However, sub-systems should be in accordance with the proposed intermediate treatment system. The examination on these minor points will be conducted in the Phase II study. The conceptual design is executed in this section according to the following principles.

- The present system shall be maintained.
- The number of containers and refuse trucks shall be varied based on the requirement by the proposed treatment system.

2) Design Data

a. Objective wastes by the plan

a1 The objective wastes dealt by the storage, collection and haulage plan are as follows;

- Domestic waste;
- Market waste;
- Commercial waste;
- Institutional waste;
- Bulky waste, and
- Other waste

a2 The forecast of these waste generation is shown in Table 3.4.1-2.

Table H.5.1-2 Forecast of Waste Generation

Type of Waste	1992	2001	2010
- Domestic waste	310.4	331	429
- Market waste	6.0	7	10
- Commercial waste	42.6	50	72
- Institutional waste	10.5	12	18
- Bulky waste	31.0	36.4	52.4
Total	400.5	436.4	581.4

a3 The annual working days are determined as follows;

- total days per year : 365
- Sunday : 53
- Public holiday : 8

total working days : **304 days/year**

b. Design Data of Containers

b1 The number of existing containers in Poznan in June 1992 are indicated in Table H.5.1-3.

Table H.5.1-3 Number of Existing Containers in June 1992

Items	Existing numbers
- 110 l dustbin	34,678
- 1.1 m^3 container "Bobr"	5,515
- 7 to 10 m^3 container	850

b2 The existing number of containers is deemed to be sufficient. The waste overloaded number of containers which is frequently seen at many places is due to shortage of haulage capacity and not due to lack of containers.

b3 The required number of container for source separate collection is more than that for the combined collection by following ratios:

- 110 l and 1.1 cu.m : 1.5 times
- 7 to 10 cu.m. : 2 times

b4 The present service coverage is 90% in 1992. Most households who do not have waste collection services live in detached and semi-detached houses or in isolated areas. Therefore, the increase in the number of the containers caused by the improvement in service coverage 90% to 100%, is calculated as follows:

Non-collection service population : 60,000 persons
Increase in the number of containers :
dustbin - 60,000 person x 1 no./3 person = **20,000 nos.**

b5 The required number of containers varies in accordance with the amount of collected waste.

c. Design Data of Refuse Trucks

c1 The number of existing refuse trucks, which are utilized to collect the above-said wastes, are shown in Table H.5.1-4.

Table H.5.1-4 Number of Existing Refuse Trucks in June 1992

Items	Existing numbers
- Compaction truck	47
- Hoist truck	22
- 2 to 4 ton truck	8

c2 The present haulage capacity of the compaction trucks is estimated to be insufficient by 10% in view of the present difficult condition to maintain the periodical and regular waste collection. The optimum unit of the compaction trucks is deemed to be **1.111 times** of the present units.

c3 The present haulage capacities of the hoist trucks and 2 - 4 ton trucks are diagnosed to be adequate.

c4 Shifting of the waste reception sites from Suchy Las to Franowo-Michalowo will make decrease of the haulage distance. It will lead surplus of haulage capacity, and, this surplus is included in the unit cost of haulage work.

c5 The present operation rate of refuse trucks is approximately 70%. It is planned to be improved to 80% in 2001.

c6 The required number of refuse trucks is varied in accordance with the rate of the change in the amount of collected waste.

c7 The required number of refuse truck for source separate collection is 10% more than for combined collection, considering work efficiency.

d. Design Data of Container Truck

d1 It is assumed that the container truck makes 4 trips per day between recycling centre and Franowo-Michalowo.

3) Estimation of Required Number for Each Alternative

Computation of the required numbers of storage and haulage equipment for each alternative are shown in Table H.5.1-5 to -9.

Table H.5.1-5 Collection and Haulage Equipment for Alternative 1

	unit	1992	2001			2010
Design Data						
- Waste generation per day	t/d	411.0	448.3			598.1
- Daily collected waste (365d=1y)	t/d	369.9	448.3			598.1
- Daily collected waste (304d=1y)	t/d	444.1	538.3			718.1
Number of Containers			b4	b5 x1.212		b5 x1.334
- 110 l dustbin	nos	34,678	54,678	**66,278**		**88,413**
- 1.1 m^3 container "bobr"	nos	5,515	5,515	**6,685**		**8,918**
- 7-10 m^3 container	nos	850	850	**1,031**		**1,375**
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x1.212	c6 x1.334
- Compaction truck	unit	47	52.2	45.7	**55**	**74**
- Hoist truck	unit	22	24.4	21.4	**26**	**35**
- Truck	unit	8	8.8	7.8	**10**	**13**

Note:
The above table is calculated as follows and the other tables such as above are calculated in the same manner for referential purpose.

b4 = 34,678 + 20,000 = 54,678 (for 110 l dustbin)
b5 & c6 = 538.3/444.1 = 1.212
b5 & c6 = 718.1/538.3 = 1.334
c5 = 70% / 80% = 0.875

Table H.5.1–6 Collection and Haulage Equipment for Alternative 2

	unit	1992	2001			2010
Design Data						
– Waste generation per day	t/d	411.0	448.3			598.1
– Daily collected waste (365d=1y)	t/d	369.9	448.3			598.1
. at discharge source	t/d	0	367.3			485.5
. at recycling centre	t/d	0	81.0			112.6
– Daily collected waste (304d=1y)	t/d	444.1	538.3			718.1
. at discharge source	t/d	0	441.0			582.9
. at recycling centre	t/d	0	97.3			135.2
– Residue from recycling centre	t/d					
. 365 days/year	t/d	0	73.4			101.5
. 304 days/year	t/d	0	88.1			121.9
Number of Containers			b4	b5 x0.993		b5 x1.322
– 110 l dustbin	nos	34,678	54,678	**54,296**		**71,767**
– 1.1 m^3 container "bobr"	nos	5,515	5,515	**5,477**		**7,239**
– 7–10 m^3 container	nos	850	850	**844**		**1,116**
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c6 x1.322
– Compaction truck	unit	47	52.2	45.7	**46**	**60**
– Hoist truck	unit	22	24.4	21.4	**22**	**29**
– Truck	unit	8	8.8	7.8	**8**	**11**
Roll–on roll–off truck from Recycling Centres	unit	0	5			7

Table H.5.1–7 Collection and Haulage Equipment for Alternative 3

	unit	1992	2001				2010
Design Data							
– Waste generation per day	t/d	411.0	448.3				598.1
– Daily collected waste (365d=1y)	t/d	369.9	448.3				598.1
– Daily collected waste (304d=1y)	t/d	444.1	538.3				718.1
Number of Containers			b4	b5 x1.212	b3 x1.5,2		b5 x1.334
– 110 l dustbin	nos	34,678	54,678	66,278	**99,419**		**132,626**
– 1.1 m^3 container "bobr"	nos	5,515	5,515	6,685	**10,028**		**13,377**
– 7–10 m^3 container	nos	850	850	1,030	**2,060**		**2,748**
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c7 x1.1	c6 x1.322
– Compaction truck	unit	47	52.2	45.7	46	**61**	**82**
– Hoist truck	unit	22	24.4	21.4	22	**29**	**39**
– Truck	unit	8	8.8	7.8	8	**11**	**14**

Table H.5.1-8 Collection and Haulage Equipment for Alternative 4

	unit	1992	2001			2010
Design Data						
- Waste generation per day	t/d	411.0	448.3			598.1
- Daily collected waste (365d=1y)	t/d	369.9	448.3			598.1
. at discharge source	t/d	0	367.3			485.5
. at recycling centre	t/d	0	81.0			112.6
- Daily collected waste (304d=1y)	t/d	444.1	538.3			718.1
. at discharge source	t/d	0	441.0			582.9
. at recycling centre	t/d	0	97.3			135.2
- Residue from recycling centre						
. 365 days/year	t/d	0	27.0			37.6
. 304 days/year	t/d	0	32.4			45.1
- Transport from recycling centres to incineration						
. 365 days/year	t/d	0	46.0			63.9
. 304 days/year	t/d	0	55.2			76.7
Number of Containers			b4	b5 x0.993		b5 x1.322
- 110 l dustbin	nos	34.678	54.678	54.296		71.767
- 1.1 m^3 container "bobr"	nos	5.515	5.515	5.477		7.239
- 7-10 m^3 container	nos	850	850	844		1.116
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c6 x1.322
- Compaction truck	unit	47	52.2	45.7	46	60
- Hoist truck	unit	22	24.4	21.4	22	29
- Truck	unit	8	8.8	7.8	8	11
Roll-on roll-off truck from Recycling Centres	unit	0	5			7

Table H.5.1-9 Collection and Haulage Equipment for Alternative 5

	unit	1992	2001				2010
Design Data							
- Waste generation per day	t/d	411.0	448.3				598.1
- Daily collected waste (365d=ly)	t/d	369.9	448.3				598.1
. at discharge source	t/d	0	367.3				485.5
. at recycling centre	t/d	0	81.0				112.6
- Daily collected waste (304d=ly)	t/d	444.1	538.3				718.1
. at discharge source	t/d	0	441.0				582.9
. at recycling centre	t/d	0	97.3				135.2
- Residue from recycling centre							
. 365 days/year	t/d	0	28.5				37.6
. 304 days/year	t/d	0	34.2				45.1
- Transport from recycling centres to incineration							
. 365 days/year	t/d	0	46.0				63.9
. 304 days/year	t/d	0	55.2				76.7
Number of Containers			b4	b5 x0.993	b3 x1.2.2		b5 x1.322
- 110 l dustbin	nos	34.678	54,678	54,296	81,444		107,650
- 1.1 m^3 container "bobr"	nos	5.515	5.515	5.477	8,216		10,860
- 7-10 m^3 container	nos	850	850	844	1,688		2,231
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c7 x1.1	c6 x1.322
- Compaction truck	unit	47	52.2	45.7	45.4	50	66
- Hoist truck	unit	22	24.4	21.4	21.3	24	31
- Truck	unit	8	8.8	7.8	7.6	9	12
Roll-on roll-off truck from Recycling Centres	unit	0	5				7

Table H.5.1-10 Collection and Haulage Equipment for Alternative 6

	unit	1992	2001			2010
Design Data						
- Waste generation per day	t/d	411.0	448.3			598.1
- Daily collected waste (365d=1y)	t/d	369.9	448.3			598.1
. at discharge source	t/d	0	367.3			485.5
. at recycling centre	t/d	0	81.0			112.6
- Daily collected waste (304d=1y)	t/d	444.1	538.3			718.1
. at discharge source	t/d	0	441.0			582.9
. at recycling centre	t/d	0	97.3			135.2
- Residue from recycling centre						
. 365 days/year	t/d	0	53.4			74.2
. 304 days/year	t/d	0	64.1			89.1
- Transport from recycling centres to incineration						
. 365 days/year	t/d	0	19.6			27.3
. 304 days/year	t/d	0	23.5			32.8
Number of Containers			b4	b5 x0.993		b5 x1.322
- 110 l dustbin	nos	34,678	54,678	**54,296**		**71,767**
- 1.1 m^3 container "bobr"	nos	5,515	5,515	**5,477**		**7,239**
- 7-10 m^3 container	nos	850	850	**844**		**1,116**
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c6 x1.322
- Compaction truck	unit	47	52.2	45.7	**46**	**60**
- Hoist truck	unit	22	24.4	21.4	**22**	**29**
- Truck	unit	8	8.8	7.8	**8**	**11**
Roll-on roll-off truck from Recycling Centres	unit	0	5			7

Table H.5.1-11 Collection and Haulage Equipment for Alternative 7

	unit	1992	2001			2010
Design Data						
- Waste generation per day	t/d	411.0	448.3			598.1
- Daily collected waste (365d=1y)	t/d	369.9	448.3			598.1
. at discharge source	t/d	0	367.3			485.5
. at recycling centre	t/d	0	81.0			112.6
- Daily collected waste (304d=1y)	t/d	444.1	538.3			718.1
. at discharge source	t/d	0	441.0			582.9
. at recycling centre	t/d	0	97.3			135.2
- Residue from recycling centre						
. 365 days/year	t/d	0	53.4			74.2
. 304 days/year	t/d	0	64.1			89.1
- Transport from recycling centres to incineration						
. 365 days/year	t/d	0	19.6			27.3
. 304 days/year	t/d	0	23.5			32.8
Number of Containers			b4	b5 x0.993	b3 x1.22	b5 x1.322
- 110 l dustbin	nos	34,678	54,678	54,296	**81,444**	**107,650**
- 1.1 m³ container "bobr"	nos	5,515	5,515	5,477	**8,216**	**10,860**
- 7-10 m³ container	nos	850	850	844	**1,688**	**2,231**
Number of Refuse Truck			c2 x1.111	c5 x0.875	c6 x0.993	c7 x1.1
- Compaction truck	unit	47	52.2	45.7	**45.4**	**66**
- Hoist truck	unit	22	24.4	21.4	**21.3**	**31**
- Truck	unit	8	8.8	7.8	**7.6**	**12**
Roll-on roll-off truck from Recycling Centres	unit	0	5			7

Table H.5.1-12 Summary of Container Forecast

unit: numbers

	Year	110 l dustbin	1.1 m³ container	6-10 m³ container
in June, 1992	1992	34,678	5,515	850
Alternative 1	2001 2010	66,267 88,413	6,685 8,918	1,031 1,375
Alternative 2	2001 2010	54,296 71,767	5,477 7,239	844 1,116
Alternative 3	2001 2010	99,419 132,626	10,028 13,377	2,060 2,748
Alternative 4	2001 2010	54,296 71,767	5,477 7,239	844 1,116
Alternative 5	2001 2010	81,444 107,650	8,216 10,860	1,688 2,231
Alternative 6	2001 2010	54,296 71,767	5,477 7,239	844 1,116
Alternative 7	2001 2010	81,444 107,650	8,216 10,860	1,688 2,231

Table H.5.1-13 Summary of Refuse Truck Forecast

unit: numbers

	Year	Compaction Truck	Hoist Truck	Standard Truck	Roll-on Roll-off Truck
in June, 1992	1992	47	22	8	0
Alternative 1	2001 2010	56 74	26 35	10 13	0 0
Alternative 2	2001 2010	46 60	22 29	8 11	5 7
Alternative 3	2001 2010	61 82	29 39	11 14	0 0
Alternative 4	2001 2010	46 60	22 29	8 11	5 7
Alternative 5	2001 2010	50 66	24 31	9 12	5 7
Alternative 6	2001 2010	46 60	22 29	8 11	5 7
Alternative 7	2001 2010	50 66	24 31	9 12	5 7

4) Cost Estimate

a. Price level of containers

The Price level of containers in Poland, June of 1992, are shown in Table H.5.1-14.

Table H.5.1-14 Price List of Containers

Container	Price level in Poland (mill.zl)
- 110 l dustbin	0.19
- 1.1 m^3 steel container "Bobr"	2.10
- 6 to 10 m^3 communal container	12.00

b. Price level of refuse trucks

The price level of refuse trucks in Poland, June of 1992, are shown in Table H.5.1-15 to -18.

Table H.5.1-15 Cost Estimates for Compaction Truck

Refuse truck Type: Compaction type	Price level in Poland June 1992 (mill.zl)
Investment:	
- Equipment	510.0
Total, investment	510.0
Annual Operation Costs:	
- Salary, Driver	57.6
- Salary, 2 - Waste collect worker	76.8
- Repair and maintenance of equipment (5%)	25.5
- Diesel and lubricants	178.8
Total, annual operation costs	**338.7**

Table H.5.1-16 Cost Estimates for Hoist Truck

Refuse truck Type: Hoist truck type	Price level in Poland June 1992 (mill.zl)
Investment:	
- Equipment	325.0
Total, investment	325.0
Annual Operation Costs:	
- Salary, Driver	57.6
- Repair and maintenance of equipment (5%)	16.3
- Diesel and lubricants	74.8
Total, annual operation costs	**148.4**

Table H.5.1-17 Cost Estimates for Truck

Refuse truck Type: Truck type	Price level in Poland June 1992 (mill.zl)
Investment:	
- Equipment	190.0
Total, investment	190.0
Annual Operation Costs:	
- Salary, Driver	57.6
- Salary, Waste collection worker	38.4
- Repair and maintenance of equipment (5%)	9.5
- Diesel and lubricants	98.0
Total, annual operation costs	**203.5**

Table H.5.1-18 Cost Estimate of Roll-on Roll-off Truck (for Recycling centre)

Container truck from Recycling Centre to waste reception	Price level in Poland June 1992 (mill.zl)
Investment:	
- Equipment	470.0
Total, investment	470.0
Annual Operation Costs:	
- Salary, Driver	57.6
- Repair and maintenance of equipment (5%)	23.5
- Diesel and lubricants	49.7
Total, annual operation costs	**130.8**

H.5.2 Road Sweeping, Public Area Cleansing

The present road sweeping system and the public area cleansing system which are performed in Poznan city are sufficiently functioning, because the results of performance are observed to be satisfactory.

1) Road Sweeping

The system of the road sweeping work in Poznan city has been established and the enough number of equipment have been ready for works. There are twelve units of road sweeping equipment in Poznan city, however, only four units are being employed in 1992 due to the financial difficulty.
Consequently the existing problems concerning the orad sweeping work in Poznan city are not caused by the technology and equipment, but caused mainly by finance.

Therefore the target of road sweeping work is set for that the performance level of the year 1991 should be maintained until 2010, because its level of 1992 is not sufficient already.

2) Public Area Cleansing

The system of the public area cleansing work has been also established and functioning nicely in Poznan city.

Therefore the target of road sweeping work is set for that the performance level the year 1991 will be maintained until 2010.

H.5.3 Incineration Plant

1) Introduction

Incineration is a very hygienic and efficient method for waste treatment. The main reasons are as follows:

- Disinfection of the waste. The method reduces the risk of polluting the ground water. Polluting of the ground water has caused serious epidemics for other cities.
- Great reduction of the weight and volume of combustible waste. The method reduces the pressure on finding areas for new landfills and is prolonging the life of existing landfills.
- Production of heat. Energy from waste incineration can be utilized for the production of district heating and/or electricity, and the income from sale of energy contributes considerably to the economics of the plant.

Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment and makes it possible to locate plants even in urban areas. leading to reduced transportation costs for waste. Due to the characteristics of Polish municipal waste (low calorific value caused by high moisture content and contents of soil and ash from heating) incineration is up to date considered not suitable for Polish conditions. Poznan had an incineration plant in operation from 1928 to 1954.
As Poznan City operates a network for district heat distribution, heat production is very likely a most feasible solution, considering an increased general welfare of the country leading to higher calorific value of municipal waste.

2) Design Data

Though incineration is a versatile treatment method the waste has to fulfil some basic requirements. The main requirement is the lower calorific value. Approx 7,000 kJ/kg (1700 kcal/kg) is recommended as the lowest value for obtaining reasonable combustion without additional fuel. Another requirement is that bulky combustible waste needs to be reduced in size by shredding prior to combustion.

Calorific Value

In relation to this study a survey on waste composition and quantity has been carried out in June 1992 and a new survey is planned for November. The results appear in Section H.1.2. The calorific value has been measured as follows:

Table H.5.3-1 Calorific Value of Waste

Waste Type	Lower Calorific value, kCal/kg	
	June 1992	November 1992
Domestic Waste	1,544	
Market Waste	536	to be
Commercial Waste	1,126	completed
Institutional Waste	2,848	
Total	1,516	

From Table H.5.3-1 the lower calorific value of domestic waste (approx. 1550 kCal/kg in June 1992) appears to be below the recommended lowest value (1700 kCal/kg). It is expected that the value which will be measured in November will be even lower due to an expected higher content of ash during the winter months. There are a number of methods to increase the calorific value of waste which is brought to an incineration plant. Some of these methods are mentioned below:

- Separate collection system for the higher calorific municipal wastes could be introduced. This system should remove ash and soil from waste taken to an incineration plant.
  Also, separate collection of vegetable matter should be considered. This option has the possibility of combining well with proposals for composting the vegetable fraction. However, the cost of separate collection systems is high and the total financial viability of such a scheme would require careful study.

- Municipal waste could be supplemented with selected high calorific value wastes from industry and commerce, such as paper, cardboard, plastics, etc. Alternatively, the problem with the low calorific value of the waste could be solved either by using supplementary fuels or residuals from a possible composting plant.

- A feedstock preparation plant could be installed to process the municipal waste prior to incineration. Such a plant would have to be adapted to the conditions in Poznan, but would likely include a screening plant to separate out material less than about 50mm in size, which would comprise mainly ash, soil and glass.

Forecasts for the waste composition has been prepared in Section 2.2. The forecasts are based on developments in Western Europe and linked with the anticipated changes of lifestyle, economic and social conditions in Poland.
The following technical description and cost estimates for the incineration plant is based on an assumed lower calorific value of 1700 kCal/kg by year 2000.

Working Hours

It is assumed that the incineration plant will be operated in 3 shifts i.e. 24 hour/day, 7 days a week. Thus the annual operational availability of the plant is assumed at 8,000 hours. The thermal plant efficiency is assumed at 0.6.

Waste Quantity

The quantity of combustible waste which is expected to arrive at the incineration plant has been estimated in Section H.1.2. The main figures appear below.

Table H.5.3-2 Quantity of Combustible Waste from Poznan

Year	Model 1 All combustible waste is incinerated (tonnes/year)	Model 2 Half of the combustible waste is incinerated (tonnes/year)
2001	168,000	84,000
2005	189,500	94,800
2010	226,000	113,000

Complying with Table H.5.3-2 the following models for the distribution of waste between incineration and landfilling have been defined:

Model 1. All waste suitable for incineration is treated at the incineration plant.

Model 2. Only half of the combustible waste is treated at the incineration plant.

3) Required Capacity

Assuming 20% variation from month to month of the generated waste quantity and year 2010 to be the target year the overall capacity of the incineration plant is calculated as follows:

$$Model1: \frac{226{,}000x1.1}{8{,}000} = 31 tonnes/hour$$

or 3 incineration lines each 10.3 tonnes/hour.

Model 2: 2 incineration lines each 9 tonnes/hour.

4) Technical Description

Several incineration technologies have been developed, but today the most appropriate is considered to be the movable grate incineration system based on mass burning of waste without pretreatment, (except for bulky combustible waste). Other incineration technologies employing fluidized bed technology or RDF have been developed, but technical problems, high costs and limited data and experience leave the mass burning principle as the most reliable solution.

Conventional mass burn incineration of waste without prior sorting or shredding and with a movable grate incineration is undoubtedly the most widely used and the best tested technology for the thermal treatment of waste. In combination with an advanced flue gas cleaning system this technology is developed and tested, and can meet the demands of technical performance and environmental standards which are now required in the EC. Furthermore, the moving grate incinerator is a very versatile and tolerant plant which is able to accommodate large variations in waste composition.

An example of a typical mass-burn incinerator is shown in Fig. H.5.3-1. The essential plant parts are described below:

1. Waste reception
2. Waste pit
3. Waste cranes
4. Hopper
5. Incinerator
6. Primary air inlet
7. Secondary air inlet
8. Grates
9. Bottom ash discharger
10. Boiler
11. 1. radiation pass/secondary combustion chamber
12. 2. radiation pass
14. Economizer section
15. Bottom ash vibration conveyor
16. Reactor
17. Cyclone
18. Bag filter
19. Scrubber
20. Reheater
21. Recirculation system
22. Water spray
23. Mist eliminator
24. Fan
25. Stack

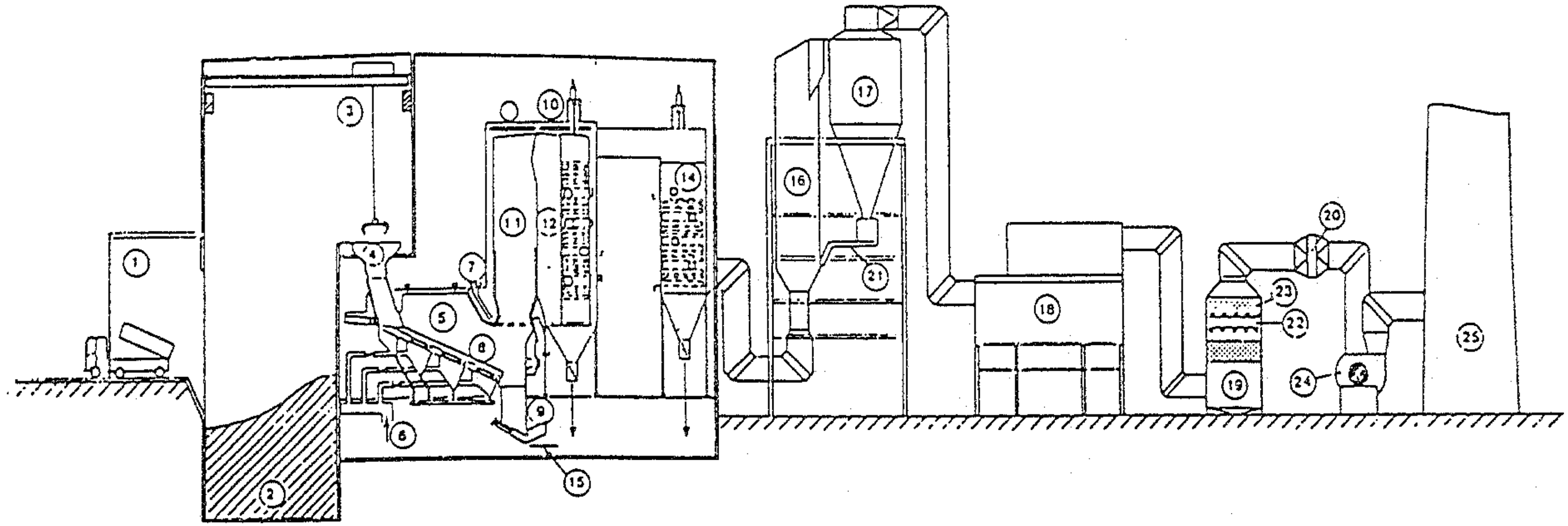


Fig.H.5.3-1 Conceptual Layout of the Incineration Plant

Reception Area

The reception facilities comprise:

- Access road
- Weigh bridge and weigh house
- Installations for waste control
- Building for waste reception including paved area in front of the building facilitating easy access and unloading of the trucks

Waste pit and cranes

The waste pit should be designed for storing waste which is collected during weekdays but incinerated during the weekend. The capacity of the waste pit is calculated as follows:

$$Model1: \frac{226{,}000x1.1x3}{0.25x52x7} = 8{,}000cu.m$$

Model 2: **4,000** *cu.m*

Overhead cranes including drivers cabin are recommended for feeding the incinerator lines. The cranes must as a minimum have a capacity corresponding to the design capacity of the incineration plant. The cranes will also be used for mixing the waste before feeding and for removing of waste from the unloading area. These functions will require additional capacity. Estimated capacities of the cranes are as follows:

Model 1: 2 cranes, capacity 20 tonnes/hour or 40–50 cu.m/hour each crane
Model 2: 1 crane, capacity 20 tonnes/hour or 40–50 cu.m/hour.

Combustion Plant

The capacity of the combustion plant should be divided into at least 2 lines. As estimated earlier the required capacity is as follows:

Model 1: 3 treatment lines each 10.3 tonnes/hour
Model 2: 2 treatment lines each 9 tonnes/hour

The combustion plant, which is installed in new building facilities, comprise the following installations:

- Waste hopper and feed chute.
- Grates. In order to obtain an adequate drying and total combustion of the waste from Poznan, a relative long grate, with a long drying/heating section is required. Further, the combustion plant might be furnished with a rotary kiln if the waste includes material of varying composition and material difficult to burn such as vegetables, compact paper, coarse pieces of wood, etc.
- Furnace room. The geometry of the furnace room must be selected according to the character of the waste. The basic requirements for the furnace are among others adequate temperatures (950–1,050°C) good mixing of the flue gasses in the furnace and correct heat load (GJ/m^2).
- Combustion air blowers (primary, secondary, and cooling air). Installation for pre-heating of the combustion air is assumed due to the relative high water content of the waste.
- Bottom ash discharger and sluice.

Boiler Plant and District Heating System

The boiler plant comprises:
- Radiation part
- Convection parts
- Flue gas damper
- Primary pipe system and pumps
- Water treatment plant

The district heating system comprises:
- Exchanger plant
- Secondary pipe system with pumps
- Heat disposal system
- Cooling plant

Flue gas Cleaning System

Today, different flue gas cleaning systems are available. The basic systems are:
- The dry system
- The semi-dry system
- The wet system

The above systems have advantages as well as disadvantages. All systems are adequate in relation to the current EC standard. Generally, a semi-dry scrubber will yield better results than a dry scrubber, and it is usually possible to obtain an acid gas reduction of 95% with a reasonalble lime consumption.

Equipment for handling of Slag and Ash Products.

The equipment for handling of slag and ash comprise vibrating conveyors, screw conveyors and slag hoists.

Auxiliary Equipment

This equipment includes the following:
- Instrumentation
- Monitoring and control system
- Hydraulic installations
- Compressor installations
- Low and high voltage installations
- Fire fighting installations and equipment
- Drainage systems
- Heating and air conditioning
- Lighting
- Cleaning facilities
- Supply systems (air, water, electricity, etc.)

Buildings and Site

For the incineration plants the required building areas are as follows:
Model 1: Approx 6000 sq.m.
Model 2: Approx 5000 sq.m.
Furthermore, internal roads and open areas are required.

Waste Flow

Input to and output from an incineration plant is indicated in Fig.H.5.3-2.

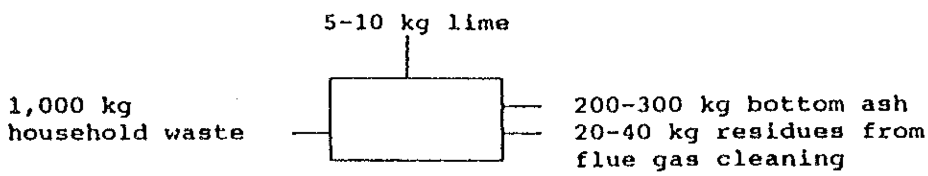


Fig.H.5.3-2 Input and Output in Weight Fractions from an Incineration Plant assuming a Semi Dry Flue Gas Cleaning System

Output

Because of the well-established network for district heating in Poznan, and the present situation of surplus electricity supply the in-incineration plant is assumed to produce district heating only.
In planning, the following figures for saleable energy per tonne waste as input is used (the lower calorific value of waste is assumed at 7,000 kJ/kg):

Heat production:
4,200 MJ heat/tonne.

Based on the forecasts for waste quantity and composition (refer Section H.1.2), the estimated output from the incineration plant appears from Table H.5.3-3.

Table H.5.3-3 Estimated Output from the Incineration Plant Model 1

Year	Mixed (combustible and noncombustible) waste incinerated		
	Waste received (ton/year)		Heat for sale
	Combustible	Total	GJ/year
2001	136,000	168,000	571,000
2005	157,000	189,500	659,000
2010	192,000	226,000	806,000

5) Cost Estimates

Based on the described conceptional lay-out, this Section presents cost estimates for the construction and operation of the incineration plant in Poznan.
All estimates are elaborated assuming price level as described in Table H.1.3-4.

Table H.5.3-4 Initial Investments for Incineration Plant, 31 tonnes/hour capacity

MODEL 1: Capacity: 31 tonnes/hour	PRICE LEVEL IN	
Mechanical and electrical equipment and civil works	WESTERN EUROPE MILL USD	POLAND MILL. ZL
- Furnaces, boilers, semidry flue gas cleaning systems incl. bag filters and blowers. Computerized operation/monitoring system:	31.0	
- Various machinery cranes, shredder, weigh bridge, compressors etc.:	3.2	
- Construction works incl. waste silo, buildings (approx 6000m$_2$), chimney, earth works, roads etc:(a)		70.000
- Design, supervision and training:	3.1	10.000
- Miscellaneous 10%:	3.7	10.000
TOTAL: Investments	41.0	90.000

Note: Investment for purchase of land and connection fees (sewerage, electricity, water etc.) are not included.

Table H.5.3-5 Operation Costs for Incineration Plant, 31 tonnes/hour capacity

MODEL 1: Capacity 31 tonnes/hour	Price level in Poland mill. ZL/year
Operation costs, average for period 2000 to 2010	
- Labour Costs (50 persons):	2.400
- Lime, electricity etc.:	11.800
- Disposal costs of residues: (b)	2.100
- Maintenance:	8.900
- Administration (15%)	3.800
TOTAL: Annual operation costs	29.000

Note: Disposal costs assumes existing polish price levels of 33.000 zl/tonne residue. This rate may go up as more constraints are put on landfills.

Table H.5.3-6 Initial Investments for Incineration Plant, 18 tonnes/hour capacity

MODEL 1 Capacity: 18 tonnes/hour	PRICE LEVEL IN	
Mechanical and electrical equipment and civil works	WESTERN EUROPE MILL. USD	POLAND MILL. ZL
- Furnaces, boilers, semi dry flue gas cleaning systems incl. bag filters and blowers. Computerized operation/monitoring system:	18.0	
- Various machinery/cranes, shredder, weigh bridge, compressors etc.:	1.9	42,000
- Construction works incl. waste silo, buildings (approx 5000m$_2$), chimney, earth works, roads etc.: (a)		
- Design, supervision and training:	1.9	6,000
- Miscellaneous 10%:	2.2	7,000
TOTAL	24.0	55,000

Note: Investment for purchase of land and connection fees (sewerage, electricity, water etc.) are not included.

Table H.5.3-7 Operation Costs for Incineration Plant, 18 tonnes/hour capacity

MODEL 1: Capacity 18 tonnes/hour	Price level in Poland mill ZL/year
Operation costs, average for period 2000 to 2010	
- Labour Costs (40 persons):	2,500
- Lime, electricity etc.:	5,500
- Disposal costs of residues: (b)	1,300
- Maintenance:	5,500
- Administration (15%)	2,200
TOTAL: Annual operation costs	17,000

Note: Disposal costs assumes existing polish price levels of 33,000 zl/tonne residue. This rate may go up as more constraints are put on landfills.

6) Summary, Cost Estimates for Incineration Plant

Summary of cost estimates for the described incineration plants is presented in the tables below, including quantity of waste treated, output, investments and operation costs. Mixed collection is assumed:

Table H.5.3-8 Summary for Incineration Plant, Capacity 226,000 tonnes/year

Capacity of plant at 8.000 working hour/year		226.000 tonnes/year
Investment		41.0 mill. USD + 90.000 mill. ZL
Annual operation costs (average year 2000 to 2010)		29.000 mill. ZL
Year	Waste received (tonnes/year)	Heat for sale (GJ/year)
2001	164.000	571.000
2005	185.000	659.000
2010	221.000	806.000

Table H.5.3-9 Summary for Incineration Plant, Capacity 120,000 tonnes/year

Capacity of plant at 8.000 working hour/year		120.000 tonnes/year
Investment		24.0 mill. USD + 55.000 mill. ZL
Annual operation costs (average year 2000 to 2010)		17.000 mill. ZL
Year	Waste received (tonnes/year)	Heat for sale (GJ/year)
2001	84.000	460.000
2005	94.800	520.000
2010	113.000	620.000

Assuming segregated collection is introduced the quantity of waste received at the incineration plant will decrease, refer section H.1.2. The required capacity of the incineration plant will decrease corresponding to the reduced waste quantity. Cost estimates for the incineration plants are presented in the tables below, including quantity of waste treated, output, investments and operation costs. Segregated collection is assumed.

Table H.5.3-10 Summary for Incineration Plant, Capacity 200,000 tonnes/year

Capacity of plant at 8,000 working hour/year		200,000 tonnes/year
Investment		35.7 mill. USD + 79,000 mill. ZL
Annual operation costs (average year 2000 to 2010)		23,200 mill. ZL
Year	Waste received (tonnes/year)	Heat for sale (GJ/year)
2001	123,000	900,000
2005	142,000	1,000,000
2010	173,000	1,250,000

Table H.5.3-11 Summary for Incineration Plant, Capacity 100,000 tonnes/year

Capacity of plant at 8,000 working hour/year		100,000 tonnes/year
Investment		19.5 mill. USD + 45,000 mill. ZL
Annual operation costs (average year 2000 to 2010)		15,000 mill. ZL
Year	Waste received (tonnes/year)	Heat for sale (GJ/year)
2001	68,000	285,500
2005	78,500	329,500
2010	96,000	403,000

H.5.4 Composting Plant

1) Introduction

Composting has for a long time seemed to be an appropriate treatment method for Poland, because of the high contents of organic matters and moisture in municipal waste. The production of compost from waste means reuse and reduction of the waste quantity.

Despite the apparent advantages of composting, experience from Western Europe indicates difficulties in marketing compost produced from municipal waste. Due to contamination of municipal waste with heavy metals the market for compost is limited. Thus, a low content of heavy metals is required if the compost should be used for agricultural purposes.

Experience up to date indicates that if composting of municipal waste is to serve large towns and the compost is to be used for agricultural purpose a policy which demands a high level of source separation is required. Alternatively the use of compost should be restricted to garden use (not food), forests, cultivation of low grade soils and as a means of restoring old landfills or despoiled land. In this case the secondary environmental pollution such as soil deterioration with contamination of heavy metal might happen.

2) Design Data

Working Hours

It is assumed that the composting plant will be operated in two shifts i.e. 16 hours/day 5 days a week. Assuming a plant availability of 0.9, the annual working hours will be approx. 3,800 hours.

Waste Quantity

The quantity of compostable waste which is expected to be received at the composting plant has been estimated in Section H.1.2. The main figures appear in Table H.5.4-1.

Table H.5.4-1 Quantity of Compostable Waste from Poznan.

Year	Model 1 All suitable waste is composted (tonnes/year)	Model 2 Half of the suitable waste is composted (tonnes/year)
2001	159,000	79,500
2005	179,000	89,500
2010	212,000	106,000

3) Required Capacity

Assuming 10 % variation from month to month of the generated waste quantity and year 2010 to be the target year the overall capacity of the composting plant is calculated as follows:

$$\textit{Model } 1: \frac{212{,}000 \ x \ 1.1}{3{,}800} = 60 \ \textit{tonnes/hour}$$

or 2 treatment lines each 30 tonnes/hour.

Model 2: 2 treatment lines each 15 tonnes/hour

4) Technical Description

The proposed composting plant is equipped with a pre-sorting facility to increase the compost quality by screening out unwanted materials from the waste (metal, glass, plastics and other non-fermentable materials).

The pre-sorting facility is based on mechanical sorting. According to the experience of Western Europe, pre-sorting by manual sorting should not be used when the incoming waste is mixed waste containing dust and organic matters. Applying manual sorting for this type of waste has caused unacceptable working conditions and health problems for the staff as well as a low quality and quantity of the saleable output.

The conceptual lay-out of the proposed composting plant is shown in Fig H.5.4-1. The main installations are described below.

Reception and Storage

The capacity of the reception facilities should be designed for storing one day's waste. Thus, the waste could be treated during the night if the plant was shut down during the first shift. The capacity of the waste silo is calculated as follows:

$$Model\ 1: \frac{212{,}000 \times 1.1}{5 \times 52 \times 0{,}25} = 3{,}600\ cu.m$$

$$Model\ 2: \quad = 1{,}800\ cu.m$$

Overhead cranes are recommended for feeding the treatment lines. The cranes must as a minimum have a capacity corresponding to the design capacity of the composting plant. The cranes will also be used for mixing the waste before feeding and for removing of waste from the unloading area. These functions will require additional capacity. Estimated capacities of the cranes are as follows:

Model 1: 2 cranes, capacity 40 tonnes/hour or 80-100 cu.m/hour each crane.

Model 2: 1 crane, capacity 40 tonnes/hour or 80-100 cu.m/hour.

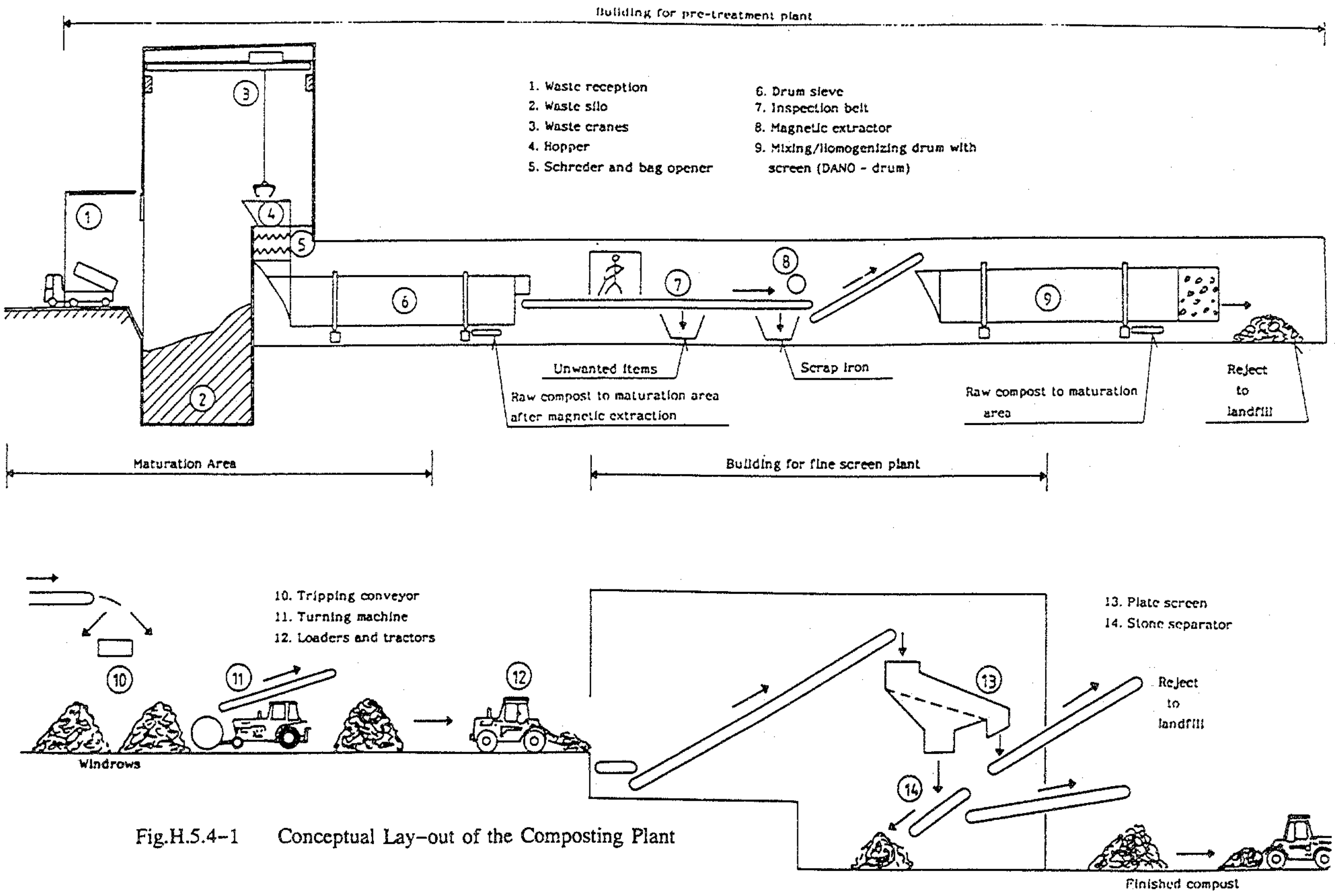


Fig.H.5.4-1 Conceptual Lay-out of the Composting Plant

Pre–Treatment Plant

The capacity of the pre–treatment plant should be divided into at least 2 lines. As estimated earlier, the required capacities are as follows:

Model 1: 2 treatment lines each 30 tonnes/hour.

Model 2: 2 treatment lines each 15 tonnes/hour.

The pre–treatment plant, which is installed in new building facilities, comprise the following installations:

- *Shredder and bag opener* placed on a platform behind the rear wall of the waste silo.

- *Drum sieve.* Experience has shown that the waste components may be separated using screens of different mesh sizes. The major part of the organic matters and the inert are smaller than 50 to 70 mm in diameter. Therefore, this fraction may be composted without any further treatment except removal of metals. Approx. 50 % of the incoming waste is expected to be taken to the maturation area after this screening.

- *Inspection belt.* At this belt the waste is inspected by personnel situated in a operation room next to the belt. Materials which are harmful to the compost can be removed by a pulling device operated from the operation room. A magnetic extractor is situated at the end of the inspection belt.

- *Mixing/homogenizing drum (DANO–system).* Applying this drum the remaining coarse material is going to be homogenized and reduced to smaller pieces. Basically, the remaining ballast materials like plastic sheets remain uncrushed and are separated by a screen situated at the end of the drum.

  The materials accepted by the screen are transported to the maturation area by means of conveyor belts, while the rejects are taken to a landfill.

Maturation Area

The required capacity of the conveyor belts for transportation of raw compost from the pre-screening plus the DANO-drum amounts to approx. 80 % of the incoming waste. Tripping conveyors are applied in order to form uniform windrows.

Assuming a maturation period of 9 weeks and assuming a maturation loss of approx. 50 % the required area of the maturation area is as follows:

Model 1: approx. 50,000 m^2
Model 2: approx. 25,000 m^2

The turning of windrows will be carried out every 2 to 3 weeks employing a special turning machine.

Fine Screen Plant

At the end of the maturation period approx. 30 % of the incoming waste will remain as mature compost that is transported to the fine screen plant by tractors with trailers. Loaders are employed for loading. The fine screen plant comprises the following equipment:

- Plate screen for extraction of smaller pieces of paper and plastic sheets.
- Stone separator for extraction of pieces of glass and stones.

Outcome from the Composting Plant

The estimated outcome from the composting plant appears from Table H.5.4-2:

Table H.5.4-2 Estimated Outcome from the Composting Plant, tonnes/year.

YEAR	MODEL 1 Capacity: 60 tonnes/hour			MODEL 2 Capacity: 30 tonnes/hour		
	Compost (30 %)	Metal	Residues	Compost	Metal	Residues
2001	34,000	5,000	53,000	17,000	2,500	26,500
2005	39,000	5,600	58,000	19,500	2,800	29,000
2010	48,000	6,600	65,000	24,000	3,300	32,500