RECYCLING PLANTS IN JAPAN AND THE OPERATIONAL SUMMARY

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ABSTRACT

The purpose of this paper is to describe the status of recycling systems in Japan, using the Fukuoka Eastern Recycling Plant as an example. The Plant has maintained a continuous, stable operation for about 5½ years.

Crushed combustible is transferred to the existing mass burn plant and co-fired on the grate system. Recovered iron and aluminum are sold, and separated noncombustibles are landfilled.

INTRODUCTION

With the development of industrialization, economic growth and change of the life style of late, waste discharged from the household and industry has shown rapid increase in its quantity and changes in composition. Disposition of solid waste is now recognized as a serious social problem in Japan.

Japan is a small country, posing the problem of difficulty in securing land suitable for waste disposal. It has thus been the basic policy here to bury waste after incineration. The proportion of waste reduction by incineration is, therefore, of a level considerably higher than those in other countries.

With the recent increase in the quantity of waste, waste reduction has now reached the limit at the processing stage in spite of strenuous efforts, necessitating the need to cope with the problem on the whole community basis.

Under the above circumstances, reported herein are the actual conditions of waste recycling and an example of operational results at recycling plants in Japan.

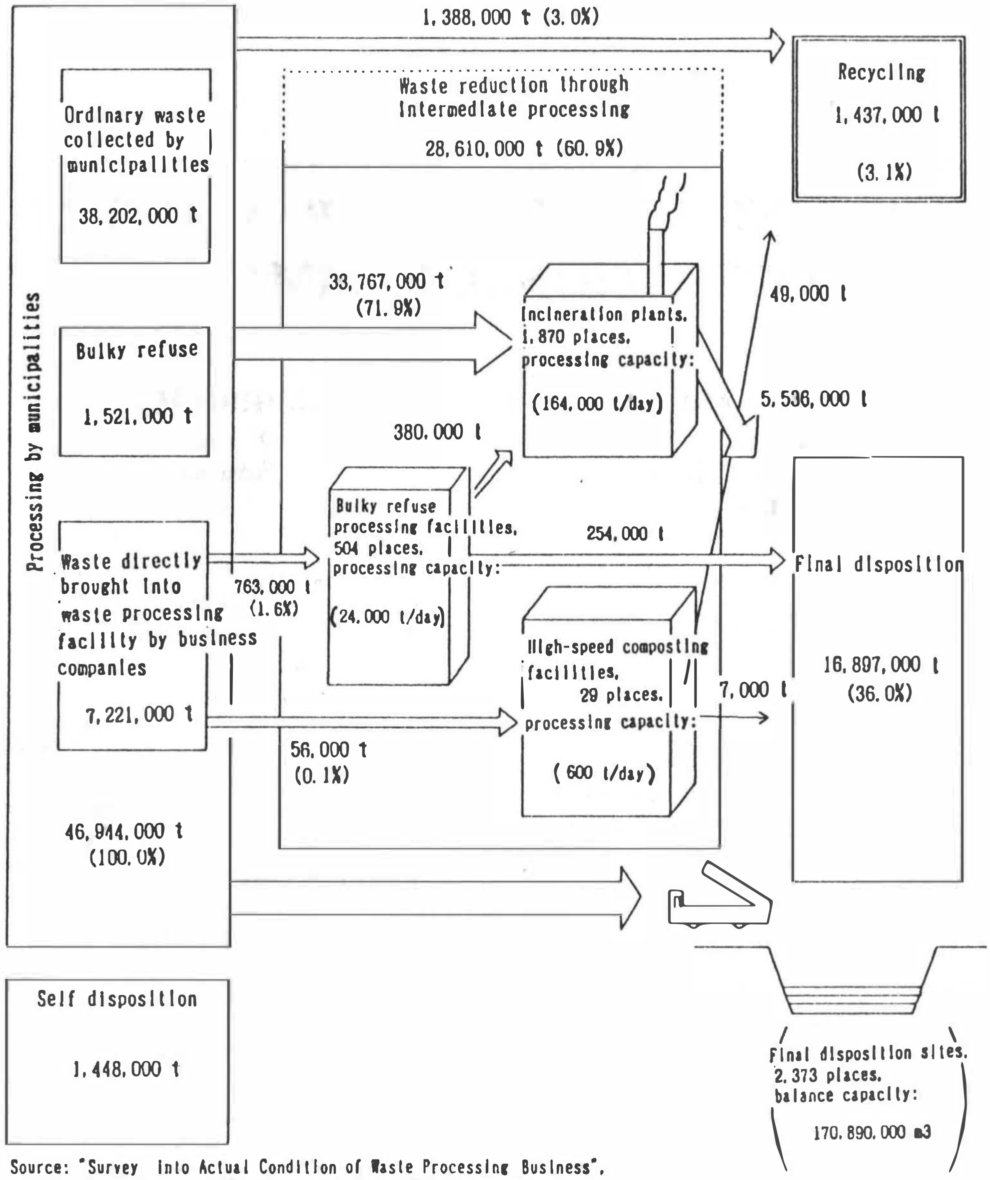
WASTE FLOW IN JAPAN

Waste discharged from the household and the industry are partly recycled, but mostly buried in final disposal sites via intermediate processing such as incineration. According to the results of waste disposal in 1988, a shade higher than 70% of the total waste, weighing approximately 46,940,000 tons, which was collected by municipalities, were incinerated into ash, while the balance of a little more than 20% was buried directly in final disposal sites without incineration (detail material flow is shown in Fig. 1).

RECYCLED ITEMS AND RECOVERY RATE

The conventional simple waste disposition method of incineration or landfilling has now reached the limit. Promotion of the recycling system is the urgent necessity for establishing new social and economic systems for waste reduction.

The Council on Industrial Structure, an advisory organ to the Minister of International Trade and Industry, submitted a report in December 1990, responding



Source: "Survey into Actual Condition of Waste Processing Business", Water Supply and Environmental Sanitation Department, Ministry of Health and Welfare

FIG. 1 FLOW OF REFUSE PROCESSING (1988 in Metric Tonnes)

to the request from the Minister for the measures to cope with waste and achieve waste processing and recovery system of the future.

Enumerated below are those related to the recovery items and recovery rate for recycling shown in the guideline in the report (see Table 1).

Recycling systems are classified into three routes of recovery: by manufacturers and distributors through retail stores; from households by scrap dealers; and recovery by voluntary groups such as children's group activities.

Separation and collection of noncombustible refuse is performed by the majority of municipalities, but separated collection of recyclable waste was carried out by only 683 municipalities in 1988. The recyclable waste recovered by municipalities or by citizen groups as-

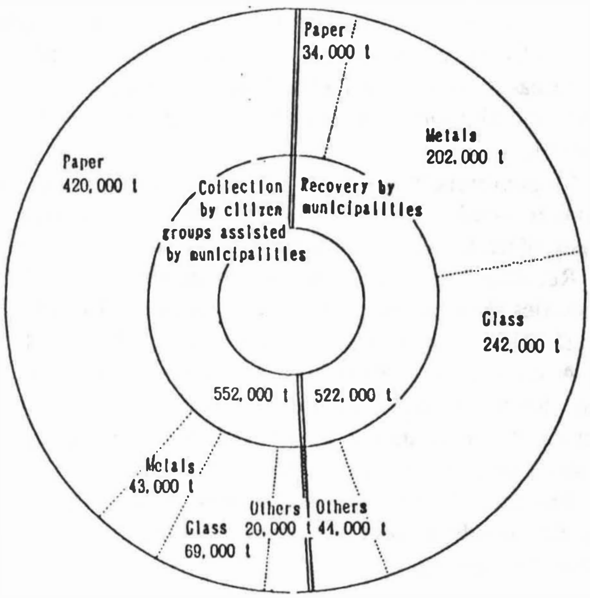


FIG. 2 RESULTS OF WASTE RECOVERY, 1988
(From "Survey into Actual Condition of Waste Processing Business," Water Supply and Environmental Sanitation Department, Ministry of Health and Welfare)

TABLE 1 GUIDELINE FOR GENERAL WASTE (Summary)

Item	Current condition and target	Countermeasures
Paper	Utilization factor: From 50% in 1989 to 55% in 1994	• Increase in mixing of used paper in all fields of paper products • Rearrangement of used paper recovery system from offices • Spread and enlightenment of use of products produced of used paper through promotion of green-mark and other activities • Promotion of easily recyclable paper pack
Steel can	Resources recovery rate: From 44% in 1989 to 60% in 1995	• Support to self-governing bodies introducing recovery equipment of steel can and others • Development of unmanned processing system • Clarification of marking of steel can
Aluminum can	Resources recovery rate: From 43% in 1989 to 60% in 1994	• Rearrangement and completion of recovery routes • Clarification of marking of aluminum can • Development of alloy and paint suitable for recycling
Glass bottle	Cullet use rate: From 49% in 1988 to 55% in 1995	• Adoption of bottles of uniform specifications • Installation of recovery equipment by inhabitants and scavengers • Marking for promotion of reutilization

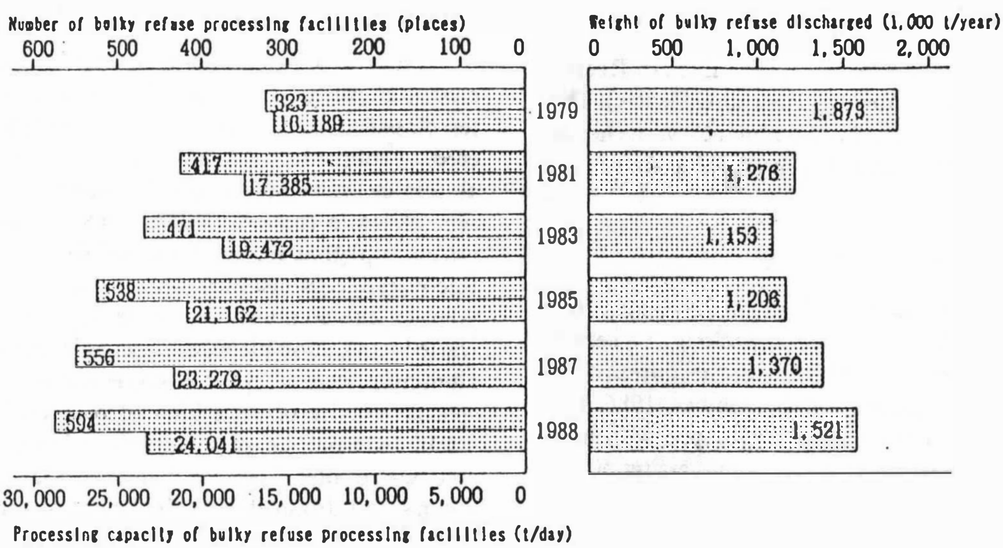


FIG. 3 TREND OF BULKY WASTE AND PROCESSING FACILITIES

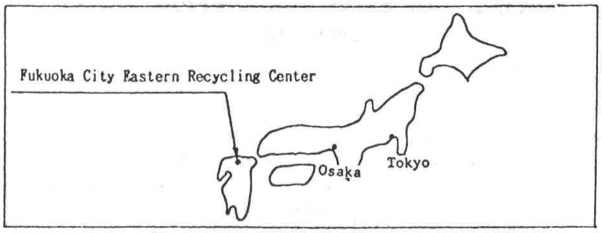


FIG. 4 LOCATION OF THE RECYCLING CENTER

sisted by municipalities accounts for only 2% of the total weight of waste discharged. Waste recovery as resources can be said to have just started (see Fig. 2).

NUMBER OF RECYCLING PLANTS AND THROUGHPUT

An example of recycling plants is a bulky waste processing facility. The number of the bulky waste processing facilities in Japan and their throughput are discussed in Fig. 3.

EXAMPLE OF RECYCLING PLANT OPERATION

Discussed here is the Fukuoka City Eastern Recycling Center (hereafter known as Recycling Center). This Recycling Center is located in Fukuoka City, the northern part of Kyushu Island, Japan (see Fig. 4).

OUTLINE OF THE FACILITY

The Recycling Center was built in the Eastern district of Fukuoka City in order to prolong the service life of final disposal sites and recover resources from waste, and started operation in September, 1986. It is a crushing and separation facility equipped with horizontal hammer crushers capable of processing 50 t/h × 5 hr bulky waste with two trains.

Figure 5 shows the flow chart of the Recycling Center. Noncombustible waste subjected to size reduction are collected household waste collected and waste taken individually.

After crushing, they are sorted into four categories: noncombustible by vibration screen (below the screen pitch); combustible by vibration screen (over the screen); iron by magnetic separator and aluminum by vibration conveyor with linear motor. Noncombustible waste thus sorted are carred out by trucks for landfilling. Combustibles are forwarded to the storage pit at the adjacent waste incineration plant by belt conveyors. Iron and aluminum are stored in respective stockyards for sale.

Conventionally, accidental explosion was considered fatal to crushing facilities of this kind. In fact, many cases of accidental explosion were reported in the past.

Recently, accidental explosions in those crushing facilities show a sharp increase in Japan: 111 cases in 1985; 175 cases in 1988; and 224 cases in 1989.

A method to prevent such accidental explosions is the steam anti-explosion system where steam is blown into a crusher as an inert gas to reduce oxygen concentration therein for prevention of explosion.

The Recycling Center has taken the safety measures against in adoption of the steam anti-explosion system to secure smooth operation.

COMPOSITION OF CARRIED-IN WASTE

Surveys were made into composition of carried-in waste by 24 units of packer truck annually (4 units × 6 times/year). Table 2 shows the average composition for the 3 years (1987–1989).

COMPOSITION OF RECOVERED WASTE

Surveys were made into composition of waste recovered after crushing and classification treatment (hereafter classified into recovered noncombustibles, recovered combustibles, recovered iron and recovered aluminum) simultaneously with the survey of composition of waste carried in. Recovered noncombustibles were sampled at the noncombustibles storage hopper. Recovered combustibles were sampled at the relay point of the combustibles unloading conveyor to the waste incineration plant. Recovered iron and recovered aluminum were sampled at respective stockyards. The specific gravity of each kind of recovered waste was calculated from the weight and the volume of the recovered waste after it was put in a container of known volume and dropped from the height of approximately 30 cm.

RESULTS OF SIZE REDUCTION

Figure 6 shows the ratio of waste recovered after crushing. Combustibles, noncombustibles, iron and aluminum show the recovery rates of 40–60%, 20–40%, 15–17% and 0.1–0.3% respectively. Noticeable

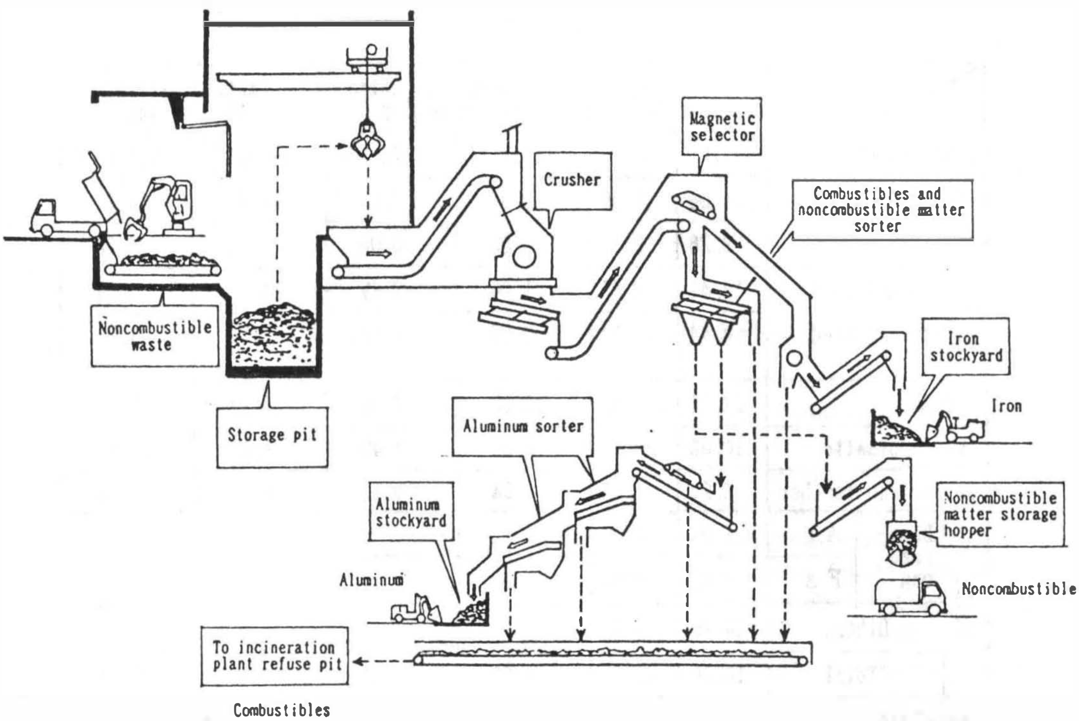


FIG. 5 FLOW CHART OF THE RECYCLING PLANT

in particular are fluctuations of the recovery rates of combustibles and noncombustibles.

In Fukuoka City, combustible waste showed abrupt increase since 1986. The Recycling Center was capable of adjusting the purity of recovered waste and the recovery rate, and sorting of recovered combustibles and recovered noncombustibles was thus adjusted in accordance with the overall situation of processing of combustible waste in the entire Fukuoka City. As the result, the weight of recovered combustibles and noncombustibles showed fluctuations as shown in Fig. 6.

The Eastern Waste Incineration Plant No. 2 Plant (capacity: 200 t/day) started operation in July 1990, thus increasing the total capacity of the incineration plant. Therefore, it is expected that the Recycling Center will exhibit its original functions in the future.

COMPOSITION OF CRUSHED WASTE

Table 2 shows the average composition of waste subjected to crushing. In household waste, combustibles such as paper, grass and wood, waste plastic, etc. occupy approximately 50%. In the case of the industry and public service waste, metals occupy approximately 50%, and combustibles were less than 10%. The household waste occupy approximately 90% of waste subjected to crushing, and then the ratio of combustibles is approximately 40% in weight and approximately 60% in volume.

Table 3 shows the composition of waste recovered after crushing. In recovered iron, iron content was 96.4%. Recovered aluminum consisted of aluminum cans (52.1%), aluminum including impurities (11.8%) and aluminum others (24.6%). Recovered noncombustibles contained much paper, grass and wood, and waste plastic, but "others" (not more than 5 mm in size) occupied as high as 42.2%.

Their crushing is expected to bring about considerable size reduction of glass and the like. Recovered combustibles contain paper (26.9%), grass and wood (14.8%) and waste plastic (11.3%), but they also contain "others" as high as 25.8%. It is possibly due to their belonging to the combustibles side as a result of deposition on paper, cloth, etc.

Table 4 shows the purity of waste recovered. Recovered iron and aluminum showed considerably high purity, but as to recovered combustibles and noncombustibles, fluctuations were wide. It is considered due to effect of adjustment of the purity and the recovery rate of recovered combustibles and noncombustibles and

TABLE 2 AVERAGE COMPOSITION OF CARRIED IN WASTE
(Unit: %)

Composition \ Source			House hold waste		Industry and public service waster		Waste subjected to crushing	
			Weight %	Volume %	Weight %	Volume %	Weight %	Volume %
Paper			14.04	20.35	0.87	2.04	12.40	18.36
Cloth			2.26	2.87	0.00	0.00	1.98	2.50
Grass and wood			12.43	12.86	1.29	2.47	11.10	11.64
Earth and sand, trush			6.44	1.80	0.76	1.79	5.72	1.89
Glass			22.01	8.56	12.60	5.28	20.84	8.19
Waste plastic			10.92	20.04	0.33	1.42	9.60	17.96
Rubber and leather			2.22	2.08	0.04	0.11	1.95	1.86
Metal	Beverage can	Al	1.00	2.50	—	—	—	—
		Fe	3.40	4.30	—	—	—	—
	Others		14.25	13.78	—	—	—	—
	Total		18.65	20.58	51.26	47.01	22.67	23.53
Household electric appliances			3.76	2.64	19.20	23.77	5.69	4.96
Furniture and bedding			3.04	4.86	5.01	9.81	3.29	5.42
General Incineration ash			1.39	0.50	0.10	1.53	1.23	0.62
Kitchen waste			1.37	0.82	0.06	0.02	1.20	0.73
Others			1.47	1.94	8.48	4.75	2.33	2.34
Total			100.00	100.00	100.00	100.00	100.00	100.00

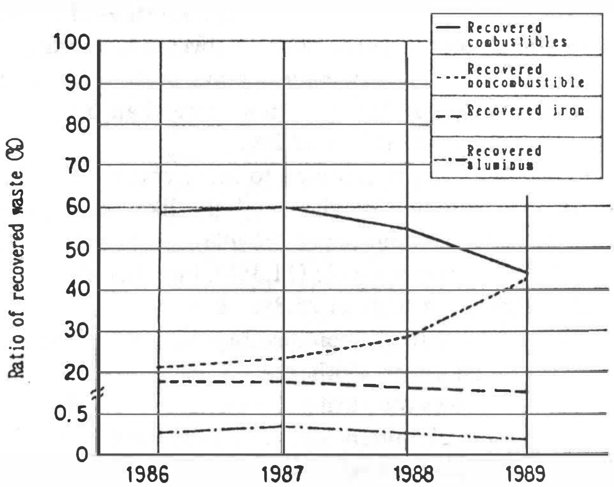


FIG. 6 RATIO OF WASTE RECOVERED AFTER CRUSHING

fluctuations of composition of noncombustible waste carried in.

EFFECT OF CRUSHING

Figure 7 shows the mass balance of waste based on the results of recycling in the past 3 years. In mass balance, the carried-in waste of 100% turned into the recovered combustibles of 50.8%, recovered noncombustibles of 30.7%, recovered iron of 16.5% and recovered aluminum of 0.2%. After crushing, the iron and aluminum were sold.

Those wastes finally subjected to landfill disposal were recovered noncombustibles and incineration ash of recovered combustibles bringing about weight reduction of approximately 50%. The weight of waste subjected to landfill disposal was approximately one-half of the conventional value, telling the large effect of crushing and classification treatment. In the volume

TABLE 3 AVERAGE COMPOSITION OF WASTE RECOVERED AFTER CRUSHING
(Unit: %)

Composition \ Waste		Recovered iron	Recovered aluminum	Recovered non-combustible	Recovered combustible
Paper		0.1	0.1	10.5	26.9
Cloth		1.1	0	2.4	3.9
Grass and wood		0.1	0.4	12.4	14.8
Earth and sand, rubble		0	0	3.3	0.3
Glass		0	0	12.2	4.5
Waste plastic		0.6	0.9	9.6	11.3
Rubber and leather		0.1	0.6	0.4	0.4
Iron		96.4	0.3	2.2	3.0
Copper, zinc, etc.		0.5	7.7	0.5	0.2
Aluminum	Cans	0	52.1	0	0.4
	Inc. Impurities	0.5	11.8	0	0.2
	Others	0.2	24.6	0.6	0.8
Household electric appliances		0	0	0	0
Cotton batting		0.2	0	3.6	7.5
Kitchen waste		0	0	0.1	0
Others		0.2	1.5	42.2	25.8
Total		100.0	100.0	100.0	100.0

Others are not more than 5 mm in size

TABLE 4 PURITY OF WASTE RECOVERED AFTER CRUSHING
(Unit: %)

Purity \ waste recovered	Recovered iron	Recovered aluminum	Recovered noncombustibles	Recovered combustible
Iron content	96.9	0.3	2.2	3.0
Aluminum content	0.7	96.2	1.1	1.6
Noncombustible content	0.2	1.5	57.7	30.6
Combustible content	2.2	2.0	39.0	64.8

balance, approximately 15% of the total volume of the carried-in waste was subjected to landfill disposal. This means the waste was reduced in volume by approximately 85%, an effect larger than weight reduction.

As described above, it is known that introduction of the Recycling Center has a large effect on prolongation of landfill life through selection and optimum processing of waste wholly subjected to landfill disposal conventionally. The figure shows the specific gravity of the recovered noncombustibles being 0.36%, but it was as a result of adjustment of purity and the recovery rate of the recovered matter in the process of crushing and classification because the screen pitches of vibration screens were adjustable based on the operational condition. The specific gravity can be 0.6–0.7 according to adjustment. In such a case, it is possible to achieve the weight and volume reduction effect of approximately 55% and 93% respectively. The authors wish to add that sale of recovered iron and aluminum amounted to approximately two hundred million yen (1.5 million U.S. dollars) during 1986–1989.

DISPOSAL EFFECT ON LANDFILL SITE

Figure 8 shows the mass balance (composition by weight) of noncombustible waste. The weight of noncombustible waste carried in was 83,600 t/year or 229 t/day. Viewing from the sources, 42.2% of the weight of waste carried in was household waste, and 57.8% was industry and public service waste.

The weight of waste finally subjected to landfill disposal was 76.4% of the total noncombustible waste. From this fact, it is known that approximately one-quarter of the weight of waste was reduced through intermediate processing and recycling in the Recycling Center, incineration plants, etc. (with no incineration residue taken into consideration).

The volume of waste finally subjected to landfill disposal was 31.1% of total noncombustible waste. In other words, as much as two-thirds of the total volume was reduced through intermediate processing facilities, and it was known that a very large volume reduction effect can be achieved.

Judging from the facts described above, a recycling facility or the like introduced for processing and treatment of noncombustibles can be very effective for prolongation of landfill life due to extremely large volume reduction in comparison with the days when all noncombustible waste was landfilled.

CONCLUSION

To show outline of recycling of waste and an example of operation of a recycling plant in Japan, we introduced the case of the Fukuoka Eastern Recycling Center. Introduction or installation of a recycling center was found to bring about large effect on recovery of valuable resources and extension of life of landfill sites by shredding and classification of waste conventionally subjected to landfill disposal.

Out of 37,998.9 tons (100%) of waste carried into the Center, 6,281.5 tons (about 16.5%) of iron and 72.4 tons (about 0.2%) of aluminum were recovered as valuable resources, as shown in Fig. 7. "Mass Balance of waste in Recycling Center," namely, the weight of

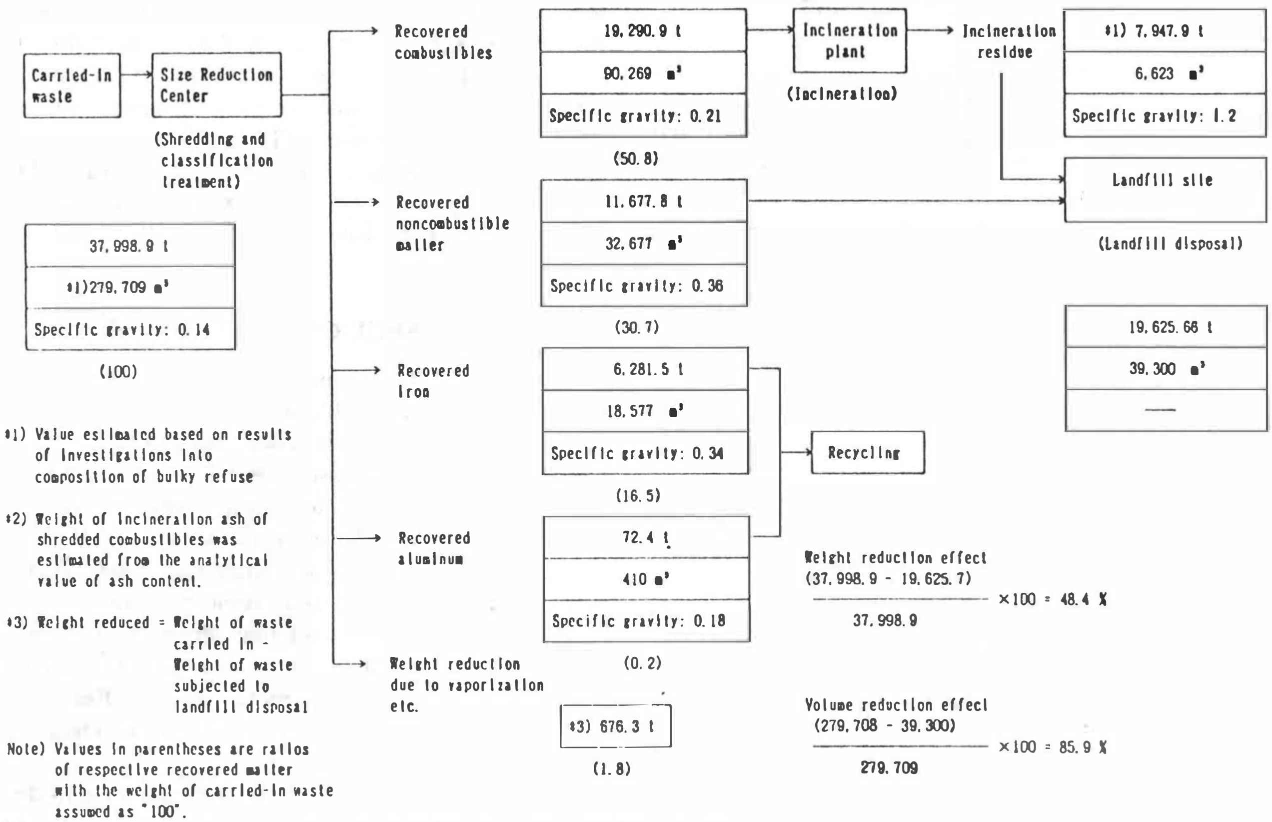


FIG. 7 MASS BALANCE OF WASTE IN RECYCLING CENTER

waste subjected to landfill disposal, was reduced to 19,625.66 tons (about 51.6%) for sufficient verification of effect on recovery of valuable resources and weight and volume reduction of waste.

With increase in recovery of valuable resources by citizens who discharge waste, we consider that efforts should be rendered for weight reduction of waste and effective reutilization of resources through introduction of such facilities as introduced here so that more accurate processing and treatment of waste be made in the future.

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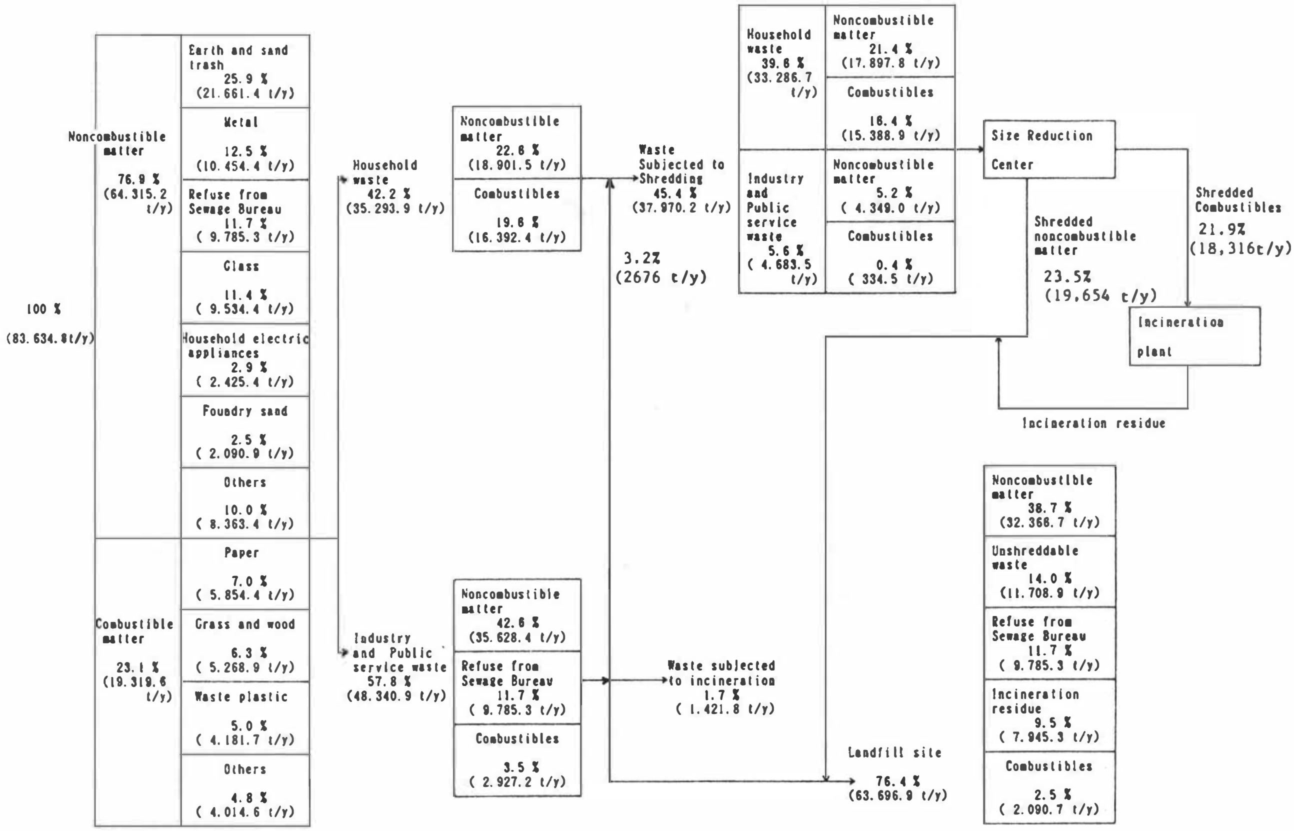

FIG. 8 MASS BALANCE OF NONCOMBUSTIBLE WASTE
(By Weight)