WORKING PAPER

Municipal Solid Waste Management in Japan - Present Situation and Characteristics

Naohisa WADA

CIRIEC N° 2011/03

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Abstract

In Japan, more than 50 million tons of municipal solid waste were generated annually, but the rate has been in a downward trend in recent years. This paper has three objectives. First, it aims to explain the present situation of municipal solid waste management in Japan using concrete data. Second, it aims to highlight the challenges faced by individual municipalities by presenting case studies. Third, it aims to identify the characteristics of municipal solid waste management in Japan.

To illustrate the municipal solid waste management situation in individual cities, two case studies have been included. The challenges that individual cities have traditionally faced include the development of waste incineration plants, aimed at maintaining a 100% incineration capacity in the face of ever increasing municipal solid waste, provision of community welfare services designed to drum up community support for waste management facilities, and dioxin control. Newer challenges include the development of incineration ash melting facilities and private-sector outsourcing of various operations.

Three main characteristic can be identified in the Japanese approach to municipal solid waste management as a whole. First, the service is mostly funded on tax revenue. Second, incineration plays a central role in waste management. Third, all waste generated within an administrative district is incinerated and disposed of through landfill, in principle, within the same administrative district.

Key words: municipal solid waste management, waste treatment and recycling, power generation from waste incineration, environmental and technical aspects of refuse treatment.

Contents

Introduction

This paper aims to describe Japan's municipal solid waste management situation and identify its characteristics as compared to the European situation. Under Japanese law, municipal solid waste is referred to as "general waste". For the sake of simplicity, this paper uses the term "refuse" in place of "municipal solid waste".

As a first step to fulfilling the objectives stated above, the state of the refuse management service in Japan is examined in accordance with the Ministry of the Environment (2013): "Waste Management in Japan, FY 2013 Edition". Though based on 2011 statistical data, this report represents the latest comprehensive reference resource that is available as of March 2013. Then, to highlight the situations of individual municipalities, two case studies are presented, with challenges faced by them listed. As a conclusion, the characteristics of Japanese refuse management are summarized. In comparison with the European situation, the following three characteristics are identified: (1) tax revenue funding of the service, (2) incineration-centred refuse management, and (3) principle of same administrative district refuse management.

1. Present Situation of Refuse Management in Japan

The present situation of refuse management in Japan is described in accordance with the Ministry of the Environment (2013): "Waste Management in Japan, FY 2013 Edition".

(1) Refuse generation trends

Chart 1 shows Japan's refuse generation trends. After peaking at 54,199 thousand tons in FY 2002, refuse generation has been gradually falling. Though containing slightly different annual figures resulting from a different data compilation strategy, Chart 2 shows longer-term refuse generation trends.

The subheading "Planned amount of refuse collected" under the main heading "Total refuse generation" in the left most column of Chart 1 is the combined amount of refuse collected and processed by municipal governments and intermunicipal administrative cooperatives (hereinafter referred collectively to as "local governments"). "Amount of refuse delivered directly to facility" is the combined amount of refuse delivered to incineration plants by the generators. Although a small fraction of such refuse is residential refuse brought in by residents, most is business general waste (generated by companies, associations, etc. and managed by local governments) delivered by waste management contractors contracted by the generators. "Group recycling" is group collection of recyclable refuse organized by local communities covering, for example, school districts and neighbourhood associations. Until around the 1980s, proceeds from the sale of recyclable refuse provided local communities with sizable incomes, which, in turn, were used to fund community

activities, etc. Since then, however, the price of recyclable refuse has plummeted, sometimes even failing to attract a price at all, and this has led local governments to introduce incentive measures designed to promote group recycling.

Chart 3 shows trends in refuse generation per capita per day. It is clear that it has been gradually falling since 2000, when it peaked. The amount includes recyclable refuse. Opinion is divided as to whether the fall has been caused by a rise in environmental awareness or is simply attributable to the recession.

Chart 4 shows the residential/business breakdown of refuse generation in trend terms. The amount of business refuse generated has been falling much faster than that of residential refuse. Given that the generation of residential refuse peaked in 2001, overall refuse generation would have kept rising until 2001 if not for the large fall in the generation of business refuse. Looking at the movements of these two types of refuse, one is more inclined to support the recession as the cause of the fall in the overall amount of refuse generated.

Chart 1 – Refuse Generation Trends

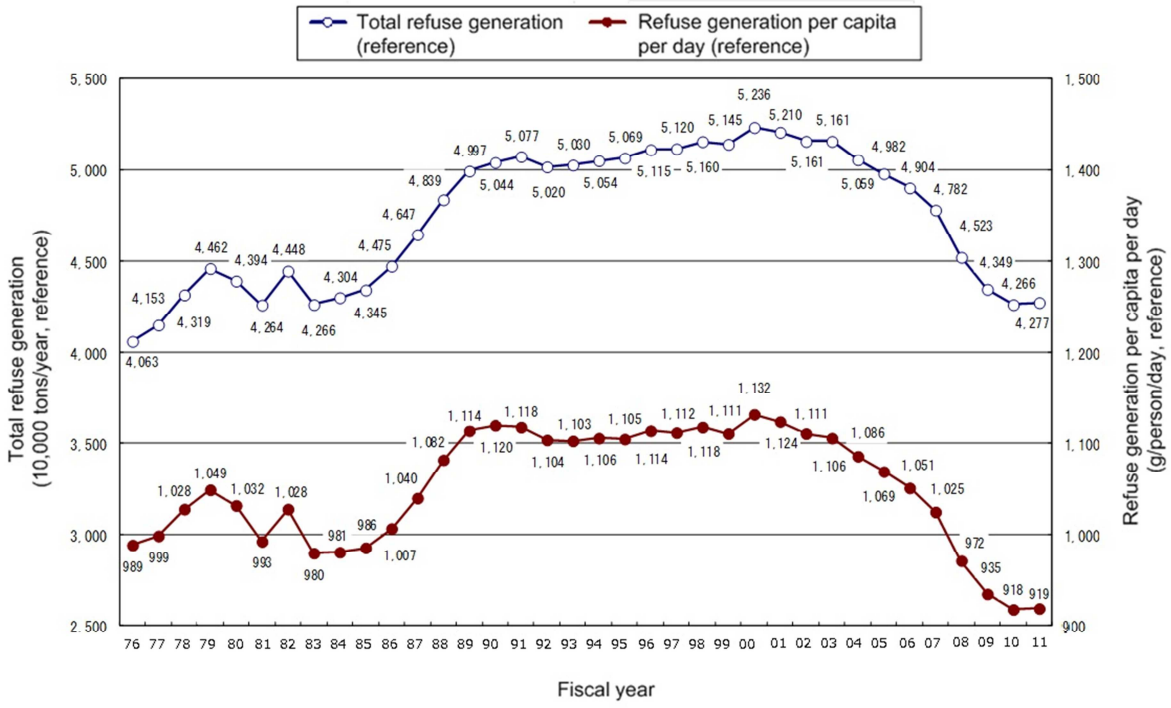
(Unit: 1000 tons/year)

Classification \ Fiscal year			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total refuse generation	Planned amount of refuse collected		46,202	46,044	45,114	44,633	44,155	42,629	40,946	39,616	38,827	39,014
	Amount of refuse delivered directly to facility		5,190	5,398	5,343	5,090	4,810	5,138	4,234	3,845	3,803	3,721
	Amount of refuse subjected to group recycling		2,807	2,829	2,919	2,996	3,058	3,049	2,926	2,792	2,729	2,650
	Total		54,199	54,271	53,376	52,720	52,024	50,816	48,106	46,252	45,359	45,385 49,743
		Residential refuse	37,118	37,321	36,838	36,471	36,220	35,724	34,104	32,974	32,385	32,343
		Business refuse	17,081	16,950	16,538	16,249	15,804	15,092	14,003	13,278	12,974	13,043
Amount of refuse managed in-house			218	165	130	92	74	56	45	31	28	37
Amount of refuse generated (reference)			51,610	51,607	50,587	49,815	49,040	47,823	45,225	43,492	42,658	42,772
Total population (1000)			127,299	127,507	127,606	127,712	127,781	127,487	127,530	127,429	127,302	127,147
Planned population with access to refuse collection service (1000)			127,136	127,365	127,526	127,658	127,727	127,439	127,490	127,406	127,279	127,123
Population subject to in-house refuse management (1000)			163	142	80	54	54	48	40	23	23	25
Refuse generation per capita per day (g/person/day)			1,166	1,163	1,146	1,131	1,115	1,089	1,033	994	976	975 1,069

Notes:

- In many municipalities, the amount of refuse managed in-house is believed to be an estimate.
- Amount of refuse generated (reference) = Planned amount of refuse collected + Amount of refuse delivered directly to facility + Amount of refuse managed in-house.
  Starting with the FY 2005 record summary, "Total refuse generation" is interpreted as identical to "Amount of general waste generated" (Planned amount of refuse collected + Amount of refuse delivered directly to facility + Amount of recyclable refuse subjected to group recycling), as defined in the Basic Guidelines for Comprehensive and Systematic Promotion of Waste Reduction and Other Appropriate Waste Management Measures based on the Waste Management Law.
- Refuse generation per capita per day = (Planned amount of refuse collected + Amount of refuse delivered directly to facility + Amount of refuse subjected to group recycling) ÷ Total population ÷ 365 or 366
- Figures in a FY2011 column, top is normal figure, bottom is include the earthquake refuse.

Chart 2 – Trends in Total Refuse Generation per Capita per Day



Note:

In calculating “Total refuse generation” and “Refuse generation per capita per day”, the sum of “Amount of refuse collected”, “Amount of refuse delivered directly to facility” and “Amount of refuse managed in-house” was used in line with the definition given in the FY 2004 record summary.

Chart 3 – Trends in Refuse Generation per Capita per Day

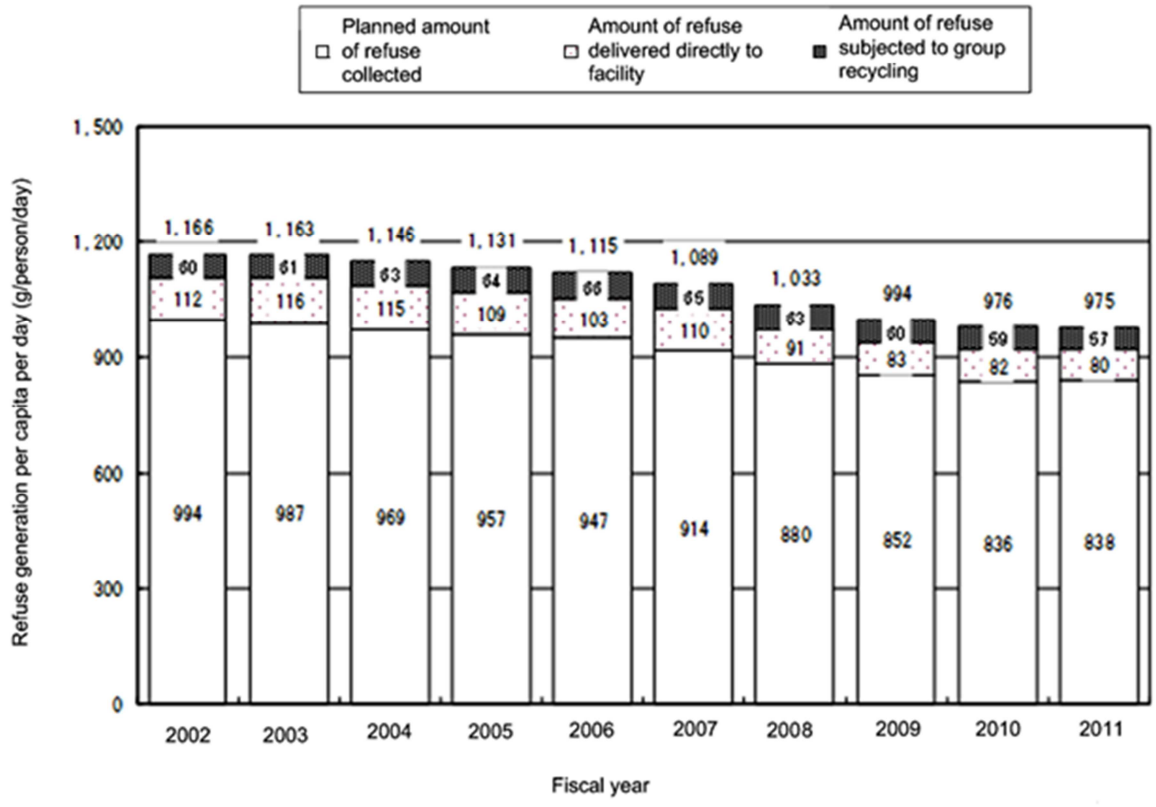
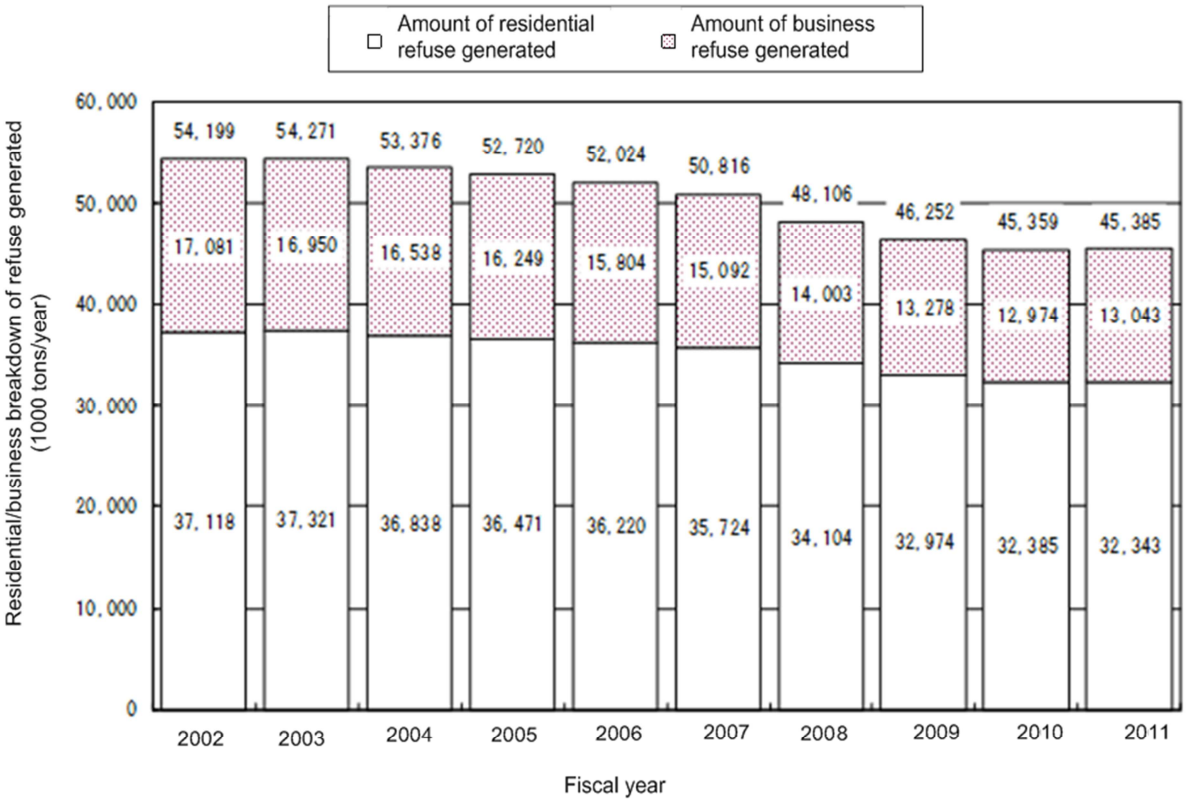


Chart 4 – Trends in Generation of Residential Refuse and Business Refuse



Note: "Amount of refuse subjected to group recycling" has been included in "Amount of residential refuse generated".

(2) Refuse management trends

Chart 5 shows how collected refuse is managed. In this chart, "Total" consists of "Planned amount of refuse collected" and "Amount of refuse delivered directly to facility", both subject to refuse management by local governments. In contrast, recyclable refuse collected through group recycling does not involve local governments as it is handed over to recyclers. The amount of refuse incinerated has consistently been more than three-quarters of the amount collected.

Chart 6 complements Chart 5 by showing refuse recycling trends. It can be seen that the recycling rate has been steadily rising. Chart 7 shows the breakdown of refuse recycling by item. Paper is by far the most dominant item in group recycling. As aluminum cans collected through group recycling attract relatively high prices, a number of unscrupulous residents have been tempted to sneak away with quantities of them, and this behaviour, at one stage, became a thorny issue in local communities.

Chart 5 – Refuse Management Trends

(Unit: 1000 tons/year)

Classification \ Fiscal year			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total amount of refuse managed	Amount of refuse directly incinerated		40,313	40,237	39,142	38,486	38,067	37,011	35,742	34,517	33,799	33,989 34,314
	Amount of refuse subjected to resource recovery and other intermediate treatments	Bulky refuse processing facilities	2,741	2,758	2,765	2,588	2,569	2,462	2,133	2,134	2,002	1,998 2,053
		Refuse composting facilities	(66)	(71)	(66)	99	115	129	136	152	165	162 184
		Refuse to animal feed conversion facilities	-	-	-	0.02	0.02	0	4	8	5	8 8
		Methanation facilities	-	-	-	21	24	25	23	21	22	32 32
		Refuse to fuel conversion facilities	379	589	692	755	726	712	693	690	676	695 794
		Other facilities engaging in resource recovery or other intermediate treatment	3,205	3,562	3,573	3,618	3,536	3,417	3,109	3,025	3,198	3,125 4,602
		Other facilities	187	187	174	202	197	156	135	132	93	94 193
		Subtotal	6,578	7,166	7,270	7,283	7,167	6,901	6,232	6,162	6,161	6,113 7,866
	Amount of refuse directly recycled		2,328	2,272	2,327	2,541	2,569	2,635	2,341	2,238	2,170	2,145 4,101
	Amount of refuse subjected directly to final disposal		2,227	1,863	1,774	1,444	1,201	1,177	821	717	662	593 916
	Total		51,445	51,538	50,513	49,754	49,004	47,725	45,136	43,634	42,791	42,840 47,198
Refuse reduction rate (%)			95.7	96.4	96.5	97.1	97.5	97.5	98.2	98.4	98.5	98.6 97.4
	Direct incineration rate (%)		78.4	78.1	77.5	77.4	77.7	77.6	79.2	79.1	79	79.3 72.7
	Intermediate treatment rate (%)		17.3	18.3	19	19.7	19.9	20	19	19.3	19.5	19.3 24.7
Direct landfill disposal rate (%)			4.3	3.6	3.5	2.9	2.5	2.5	1.8	1.6	1.5	1.4 1.9

Notes:

- "Amount of refuse directly recycled" is the amount of refuse delivered directly to a recycler, etc. without first being put through a resource recovery or other intermediate treatment process. This item was newly introduced in the FY 1998 refuse management survey.
- The amount of refuse subjected to intermediate treatment at "Other facilities" is deemed to include:

  Amount subjected to intermediate treatment performed solely as preparatory step to final disposal (with no regard to resource recovery) — FY 1998 and later

  Ditto plus Amount of refuse directly recycled — up to FY 1997
- Refuse reduction rate = (Amount of refuse directly incinerated + Amount of refuse subjected to resource recovery and other intermediate treatments + Amount of refuse directly recycled) ÷ Total amount of refuse managed × 100
- Direct incineration rate = Amount of refuse directly incinerated ÷ Total amount of refuse managed × 100
- Direct landfill disposal rate = Amount of refuse subjected directly to final disposal ÷ Total amount of refuse managed × 100
- Figures in parentheses shown in the "Refuse composting facilities" row represent the amount of refuse processed at fast composting facilities. In all fiscal years up to FY 2004, the amount of refuse processed at composting facilities other than fast composting facilities is included in the "Other facilities engaged in resource recovery or other intermediate treatment" row
- In all fiscal years up to FY 2004, the amount of refuse processed at refuse to animal feed conversion facilities and methanation facilities is included in the "Other facilities engaged in resource recovery or other intermediate treatment" row
- Figures in a FY 2011 upper figure is normal under figure is include the earthquake refuse.

Chart 6 – Recycling Trends

(Unit: 1000 tons/year)

Classification \ Fiscal year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Amount of refuse recycled by municipalities	5,831	6,328	6,481	7,029	7,145	7,255	6,850	6,710	6,717	6,648 10,067
Amount of refuse recycled through resource recovery	3,503	4,056	4,154	4,488	4,577	4,620	4,509	4,472	4,547	4,503 5,965
Amount of refuse directly recycled	2,328	2,272	2,327	2,541	2,569	2,635	2,341	2,238	2,170	2,145 4,101
Amount of refuse subjected to group recycling	2,807	2,829	2,919	2,996	3,058	3,049	2,926	2,792	2,729	2,650
Total amount of refuse recycled	8,638	9,157	9,400	10,026	10,204	10,305	9,776	9,502	9,446	9,298 12,717
Total amount of refuse managed	51,445	51,538	50,513	49,754	49,004	47,725	45,136	43,634	42,791	42,840 47,198
Recycling rate (%)	15.9	16.8	17.6	19.0	19.6	20.3	20.3	20.5	20.8	20.4 25.5

Notes:

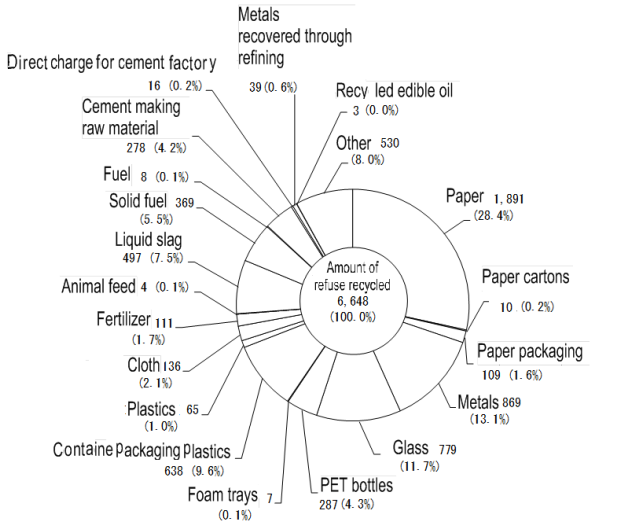
- "Amount of refuse recycled through resource recovery" is the amount of iron, aluminum and other resources recovered during the intermediate treatment of recyclable refuse, bulky refuse, etc.
- "Amount of refuse subjected to group recycling" is the amount of recyclable refuse collected by community groups registered with municipal governments under various municipal assistance programs, such as the loaning of tools and payment of subsidies.

  This amount was included in "Total refuse generation" for the first time in the latest summary.
- In all fiscal years up to FY 1997, "Amount of refuse directly recycled" is deemed to have been included in "Amount of refuse recycled through resource recovery".
- Recycling rate (%) = $\dfrac{\text{Amount of refuse directly recycled} + \text{Amount of refuse recycled through resource recovery} + \text{Amount of refuse subjected to group recycling}}{\text{Total refuse generation} + \text{Amount of refuse subjected to group recycling}} \times 100$
- Figures in a FY 2011 column, top is normal figure, bottom is include the earthquake refuse.

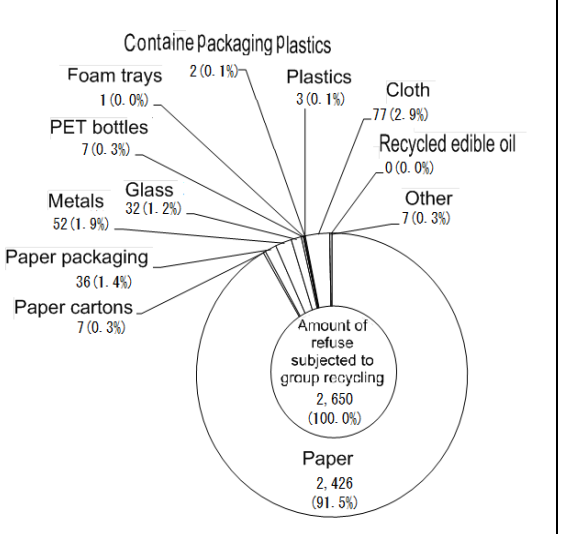
Chart 7 – Breakdown of Refuse Recycling by Item (FY 2011 Record)

(Unit: 1000 tons/year; ( ): %)

(1) Refuse recycling by municipalities



(2) Refuse recycling by communities



(3) Landfill disposal

Chart 8 shows final disposal trends. The term “final disposal” means landfill disposal. Given the limited availability of land suitable for use as landfill sites in Japan, final disposal is an issue always on the mind of everyone involved in refuse management. In 2011, 4,821 thousand tons of refuse was subjected to final disposal, a mere 53.4% of the amount taken to landfills in 2002, which was 9,030 thousand tons. This represents a reduction of more than 40% over a decade.

One of the greatest concerns of the refuse management community in Japan has always been the securing of landfill sites. For this reason, constant efforts are being made to reduce the amount of refuse subjected to final disposal. Chart 9 shows the breakdown of final disposal sites and remaining service lives in trend terms. Thanks to the construction of large-scale coastal landfill sites around Tokyo Bay and Osaka Bay, combined with the fall in the amount of refuse subjected to final disposal, the combined remaining service life of landfill sites has been getting longer. Still, many local governments agonize over the shortage of landfill sites, because other local governments are reluctant to accept their refuse due to the difficulty in securing community support, given that waste management has traditionally been a service provided on a local government by local government basis.

Chart 10 shows a refuse management flowchart (FY 2011) that covers refuse collection through landfill disposal as the last stage of refuse management.

Chart 8 – Final Disposal Trends

(Unit: 1000 tons/year)

Classification \ Fiscal year		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Amount of refuse subjected to final disposal	Amount of refuse subjected to final disposal after intermediate treatment	6,803	6,589	6,319	5,884	5,608	5,172	4,710	4,355	4,175	4,228 4,365
	Incineration residue	5,296	5,112	4,868	4,548	4,363	4,037	3,811	3,595	3,466	3,512 3,598
	Treatment residue from non-incineration facilities	1,508	1,477	1,451	1,336	1,245	1,135	898	760	709	715 767
	Amount of refuse subjected directly to final disposal	2,227	1,863	1,774	1,444	1,201	1,177	821	717	662	593 916
	Total	9,030	8,452	8,093	7,328	6,809	6,349	5,531	5,072	4,837	4,821 5,281
Total population (1000)		127,299	127,507	127,606	127,712	127,781	127,487	127,530	127,429	127,302	127,147
Amount of refuse subjected to final disposal per capita per day (g/person/day)		194	182	174	157	146	136	119	109	104	104 113

- Figures in a FY 2011 column, top is normal figure, bottom is include the earthquake refuse.

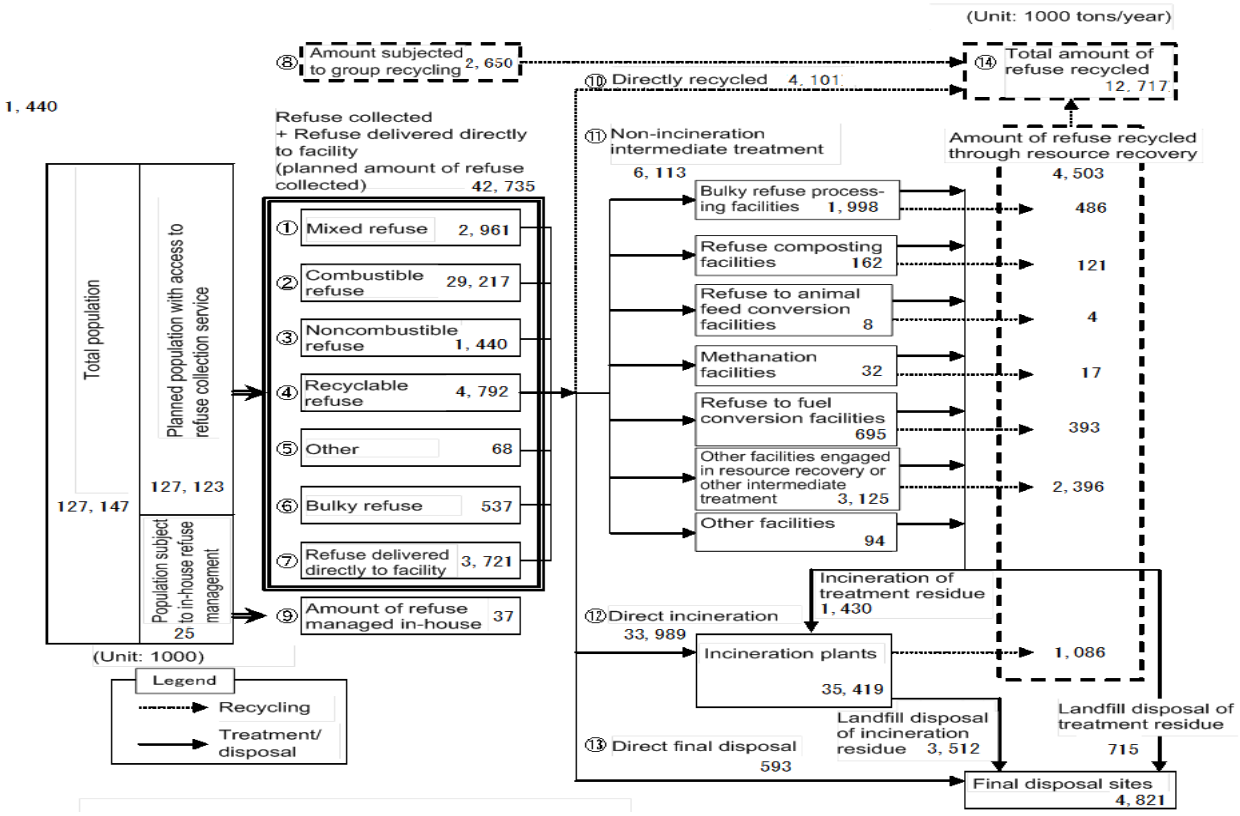
Chart 9 – Breakdown of Final Disposal Sites and Remaining Service Lives - Trends

Classification / Fiscal year	Number of final disposal sites					Combined area (1000 m^2)	Combined capacity (1000 m^3)	Combined remaining capacity (1000 m^3)	Combined remaining service life (years)
	Mountainous area	Coastal	Freshwater area	Plain	Total				
2002	1,499	28	19	501	2,047	48,609	469,400	152,503	13.8
2003	1,491	27	17	504	2,039	48,695	471,943	144,816	14.0
2004	1,464	25	16	504	2,009	47,554	449,493	138,259	14.0
2005	1,339	24	15	465	1,843	45,634	449,203	132,976	14.8
2006	1,346	25	13	469	1,853	45,972	457,217	130,359	15.6
2007	1,332	23	14	462	1,831	44,949	449,458	122,015	15.7
2008	1,321	26	11	465	1,823	45,237	455,788	121,842	18.0
2009	1,298	28	9	465	1,800	45,301	461,095	116,044	18.7
2010	1,281	26	10	458	1,775	45,059	460,610	114,458	19.3
2011	1,274	26	9	463	1,772	45,111	461,086	114,396	19.4
(Private sector)	70	16	1	30	117	12,961	192,243	60,776	15.4

Notes:

- With the exception of those included in the “Private sector” row, all final disposal sites have been built by a municipal government or intermunicipal administrative cooperative (including the Tokyo Metropolitan Government). Each new site is included in the fiscal year when its construction work began.
- “Private sector” final disposal sites include prefectural final disposal sites and those built by the Osaka Bay Regional Offshore Environmental Improvement Centre.
- Combined remaining service life is the length of time (years) over which refuse can be disposed of beyond the current fiscal year without building a new final disposal site on the assumption that the amount of refuse subjected to final disposal remains unchanged from the fiscal year concerned. It is calculated as: Combined remaining capacity ÷ (Amount of refuse subjected to final disposal ÷ Specific gravity of landfill refuse). The specific gravity of landfill refuse is assumed to be 0.8163.
- In FY 2005, final disposal sites underwent an aerial survey, etc., and “Combined remaining capacity” was revised upward. As a result, for all fiscal years up to FY 2004, “Combined remaining capacity” was increased by 7,737 thousand m^3, with “Combined remaining service life” recalculated on that basis. For this reason, figures differ from those released in the last fiscal year.

Chart 10 – Refuse Management Flowchart (FY 2011 Record)



- Refuse collected = ① + ② + ③ + ④ + ⑤ + ⑥ = 39,014 thousand tons
- Refuse collected + Refuse delivered directly to facility = ① + ② + ③ + ④ + ⑤ + ⑥ + ⑦ = 42,735 thousand tons (planned amount of refuse collected)
- Total refuse generation = ① + ② + ③ + ④ + ⑤ + ⑥ + ⑦ + ⑧ = 45,385 thousand tons
- Per capita per day refuse generation = (① + ② + ③ + ④ + ⑤ + ⑥ + ⑦ + ⑧) / total population / 366 = 975g/person/day
- Total amount of refuse managed = ⑩ + ⑪ + ⑫ + ⑬ = 42,840 thousand tons
- Total amount of refuse recycled = ⑭ = 9,298 thousand tons

  Recycling rate = ⑭ / (⑧ + ⑩ + ⑪ + ⑫ + ⑬) = 20.4%
- Refuse reduction achieved through intermediate treatment
  = (⑪ + ⑫) – Amount recycled through resource recovery – Amount of residue disposed of through landfill
  = 31,372 thousand tons

* Figures in ( ) is include the earthquake refuse

* In FY 2011, 2.78 million tons of refuse was subjected to source-separated collection organized by municipal governments and others under the Containers and Packaging Recycling Law. Of this, 2.75 million was recycled and included in “Total amount of refuse recycled” (9.30 million tons). In FY 2011, 680,000 tons of four types of home electrical appliances subject to the Home Electrical Appliances Recycling Law were recovered. Of this, 560,000 tons was recycled, and, if this amount is included, “Total amount of refuse recycled” comes to 9.86 million tons.

Source: FY 2007 Record of Source-Separated Collection and Recycling by Municipal Governments under Containers and Packaging Recycling Law

Publication of Home Electrical Appliance Recycling Records by Home Electrical Appliance Manufacturers (FY 2011)

Office of Recycling Promotion, Policy Planning Division, Waste Management and Recycling Department, Minister’s Secretariat, Ministry of the Environment

(4) Refuse incineration plants

Chart 11 shows the breakdown of incineration plants by incinerator type and treatment capacities in trend terms. From this chart, it can be seen that incinerators have been experiencing a gradual shift towards fully continuous operation and large size, with dioxin control and improvement of incineration efficiency as its driving forces. Reflecting this trend towards large size, the number of incinerators has been falling. The reduction of the amount of refuse subjected to final disposal and detoxification of landfill refuse are two other important objectives of refuse incineration. Chart 12 shows the breakdown of incineration plants by treatment type and treatment capacities in trend terms. From this chart, it is clear that the proportion of incinerators geared towards achieving these goals has been increasing.

Chart 13 shows trends in waste heat utilization at refuse incineration plants. As incineration plants that utilize waste heat have a long history, the number of such plants has been falling with the fall in the overall number of incineration plants. The most common way of utilizing waste heat used to be the production of hot water and its use for the running of a swimming pool or public bath. Since incineration plants are rarely built in a high population density area, relatively few people use those facilities. For this reason, the introduction of power generation systems that take advantage of advances in power generation technology is now more favoured, and the number of incineration plants that incorporate such systems is increasing. Chart 14 shows trends in power generation as a way of utilizing waste heat at refuse incineration plants. From the chart, the upward trend in the number of incineration plants capable of power generation is clear.

Chart 11 – Breakdown of Incineration Plants by Incinerator Type and Treatment Capacities - Trends

Incinerator type / Fiscal year	Fully continuous		Semi-continuous		Mechanical batch		Fixed batch		Total	
	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)
2002	579	160,591	321	25,262	513	11,731	77	1,291	1,490	198,874
2003	588	159,537	300	23,573	447	10,289	61	458	1,396	193,856
2004	612	163,615	286	22,123	422	9,806	54	408	1,374	195,952
2005	618	160,186	269	19,961	380	8,899	51	412	1,318	189,458
2006	627	162,149	256	18,849	370	8,606	48	412	1,301	190,015
2007	642	162,733	245	17,931	353	8,151	45	329	1,285	189,144
2008	642	161,305	245	17,533	337	8,145	45	320	1,269	187,303
2009	644	162,024	235	16,824	317	7,035	47	323	1,243	186,205
2010	648	161,832	228	16,501	305	6,728	40	312	1,221	185,372
2011	658	163,574	221	15,889	296	6,574	36	219	1,211	186,255
(Private sector)	187	87,358	26	700	19	2,577	62	876	294	91,512

Notes:

- With the exception of those included in the “Private sector” row, all plants have been built by a municipal government or intermunicipal administrative cooperative. Each new plant is included in the fiscal year when its construction work began. Decommissioned plants are excluded.
- “Combined treatment capacity” for mechanical batch incineration plants has been calculated as follows: Batch type – Fixed batch type.

Chart 12 – Breakdown of Incineration Plants by Treatment Type and Treatment Capacities – Trends

Treatment type / Fiscal year	Incineration (not gasification melting, reforming, carbonization, or other)		Gasification melting or reforming		Carbonization		Other		Total	
	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)	Number of plants	Combined treatment capacity (tons/day)
2002	1,436	191,125	46	6,385	-	-	8	1,364	1,490	198,874
2003	1,329	184,195	58	8,178	-	-	9	1,483	1,396	193,856
2004	1,295	184,614	70	9,815	-	-	9	1,523	1,374	195,952
2005	1,230	177,283	77	11,119	2	90	9	966	1,318	189,458
2006	1,205	176,286	83	12,802	3	104	10	824	1,301	190,015
2007	1,185	174,631	87	13,828	3	104	10	582	1,285	189,144
2008	1,164	171,635	91	14,929	3	104	11	636	1,269	187,303
2009	1,133	168,566	92	16,338	4	164	14	1,138	1,243	186,205
2010	1,110	167,190	92	16,739	4	176	15	1,268	1,221	185,372
2011	1,096	167,701	95	17,011	4	176	16	1,368	1,211	186,255
(Private sector)	251	48,033	16	3,942	9	450	19	39,092	295	91,516

Notes:

- With the exception of those included in the “Private sector” row, all plants have been built by a municipal government or intermunicipal administrative cooperative. Each new plant is included in the fiscal year when its construction work began. Decommissioned plants are excluded.
- For all fiscal years up to FY 2004, carbonization facilities are included in incineration plants.

Chart 13 – Trends in Waste Heat Utilization at Refuse Incineration Plants

Classification / Fiscal year	Waste heat utilized								Waste heat unutilized
		Hot water use		Steam use		Power generation		Other	
		On-site use	Off-site use	On-site use	Off-site use	On-site use	Off-site use		
2002	1,035	966		244		263		85	455
2003	995	923		244		271		79	401
2004	992	907	279	227	96	281	171	81	382
2005	904	840	273	230	102	285	179	62	414
2006	877	812	264	235	103	292	186	63	424
2007	856	792	258	244	103	297	188	51	429
2008	823	783	251	242	105	297	193	49	420
2009	800	727	240	238	99	301	181	46	443
2010	792	720	238	240	100	304	189	44	429
2011	791	720	233	246	103	312	189	44	420
(Private sector)	119	13	6	58	9	56	18	23	176

Note:

- With the exception of those included in the “Private sector” row, all plants have been built by a municipal government or intermunicipal administrative cooperative. Each new plant is included in the fiscal year when its construction work began. Decommissioned plants are excluded.
- The number of plants does not add up to the total due to overlapping answers.

Chart 14 – Trends in Power Generation at Refuse Incineration Plants

Classification / Fiscal year	Number of power generation systems	Combined power generation capacity (MW)	Power generation efficiency (%)	Combined amount of electric energy generated (GWh/year)
2002	263	1,365	10.06	6,366
2003	271	1,441	10.23	7,100
2004	281	1,491	10.5	7,129
2005	286	1,512	10.7	7,090
2006	293	1,590	10.93	7,190
2007	298	1,604	11.14	7,132
2008	300	1,615	11.19	6,935
2009	304	1,673	11.29	6,876
2010	306	1,700	11.61	7,210
2011	314	1,740	11.73	7,487
(Private sector)	57	318	13.52	1,299

Note:

* With the exception of those included in the "Private sector" row, all plants have been built by a municipal government or intermunicipal administrative cooperative. Each new plant is included in the fiscal year when its construction work began. Decommissioned plants are excluded.

* Power generation efficiency is given by the following formula:

$$\text{Power generation efficiency (\%)} = \frac{860\ [\text{kcal/kWh}] \times \text{Combined amount of electric energy generated [kWh/year]}}{1000\ [\text{kg/t}] \times \text{Amount of refuse incinerated [tons/year]} \times \text{Calorific value of refuse [kcal/kg]}} \times 100$$

In this study, manufactures' specifications, nominal values, etc. based on standard refuse composition were used as much as possible. Where such data were not available, actual values were used.

(5) Refuse management service

Although the refuse management service has not been fully privatized in Japan, the private-sector outsourcing of individual operations is quite common. Chart 15 shows the refuse management outsourcing situation in 2011.

Chart 16 shows the refuse collection fee charging situation. While the table at the top offers detailed data, the graphs at the bottom are more useful in gaining an overview of the situation. Compared to business refuse, the fee-charging rate is quite low for residential refuse. Still, it has risen considerably in recent years, reaching just over 60% (excluding bulky refuse) in FY 2011.

Bulky refuse is out-sized refuse, which is too large for the regular refuse collection service. This type of refuse began attracting collection fees fairly early due partly to public acceptance that it was no ordinary refuse, and today boasts a high fee charging rate. Without bulky refuse, the overall fee-charging rate drops substantially.

Fee charging for business refuse started relatively early partly because it was not so politically sensitive, and this has led to a high fee-charging rate. The fee-charging rate for business refuse currently stands at some 83%, but the effective fee charging rate is even higher because some local governments do not collect business refuse at all.

Chart 17 shows trends in the refuse management service budget (revenue and expenditure). The budget, which stood at some 1.79 trillion yen in FY 2011, has been in a downward trend in recent years, with its peak coming in FY 2001.

This is attributable to the fact that the construction rush for new types of incinerators optimized for dioxin control has more or less subsided. Today, there is criticism that the hasty construction of those new types of incinerators may have put too much financial pressure on local governments.

Chart 18 shows trends in the refuse management service budget over the long term. Starting in 1976, the budget steadily increased for nearly 20 years, and plateaued from 1993 to 2001, followed by a gradual fall. This steep budget increase drew people's attention to refuse management costs.

Chart 19 shows the breakdown of general waste management service personnel. Along with budget size, staff size provides a rough guide to the scale of the service.

Chart 15 – Situation of Refuse Management Outsourcing (FY 2011 Record)

(Unit: tons/year)

Classification / Treatment type	Intra-prefectural outsourcing				Inter-prefectural outsourcing				Total amount subjected to outsourced refuse management
	Municipal government	Public corporation, etc.	Private contractor	Total	Municipal government	Public corporation, etc.	Private contractor	Total	
Incineration	721,046 (184)	157,600 (7)	905,720 (193)	1,784,366 (384)	117 (1)	314 (1)	92,753 (87)	93,184 (89)	1,877,550 (473)
Animal feed conversion Composting	2128 (9)	778 (1)	53265 (126)	56171 (136)	0 (0)	0 (0)	18868 (16)	18868 (16)	75039 (152)
Final disposal	872,478 (88)	146,880 (107)	209,470 (329)	1,228,828 (524)	16 (1)	123 (2)	280,246 (369)	280,385 (372)	1,509,213 (896)
Resource recovery	19,384 (73)	54,141 (13)	2,281,376 (2930)	2,354,901 (3016)	184 (4)	46 (3)	419,416 (1206)	419,646 (1213)	2,774,547 (4229)
Crushing/ shredding	8,060 (41)	88 (1)	75,384 (181)	83,532 (223)	0 0	0 0	5,067 (25)	5,067 (25)	88,599 (248)
Fuel conversion	23,077 (9)	16,625 (4)	86,941 (120)	126,643 (133)	1,065 (1)	0 0	8,607 (33)	9,672 (34)	136,315 (167)
Other	123 (5)	4161 (2)	240,928 (146)	245,212 (153)	0 (0)	0 0	70,835 (54)	70,835 (54)	316,047 (207)
Total	1,646,296 (409)	380,273 (135)	3,853,084 (4,025)	5,879,653 (4,569)	1,382 (7)	483 (6)	895,792 (1,790)	897,657 (1,803)	6,777,310 (6,372)

Notes:

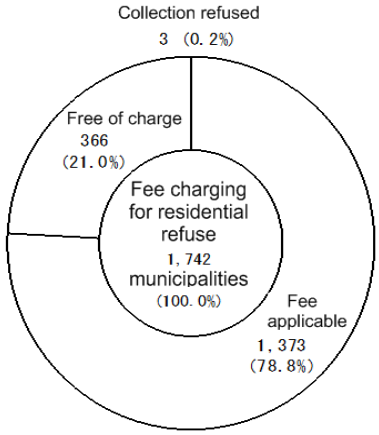
- The above table shows aggregate amounts of refuse subjected to outsourced refuse management from a municipal government or intermunicipal administrative cooperative to another municipal government or intermunicipal administrative cooperative or a private contractor.
- Figures do not include any amount of refuse managed by an intermunicipal administrative cooperative on behalf of one of its member municipal governments.
- Figures in parentheses represent the number of municipal governments or intermunicipal administrative cooperatives that outsourced refuse management. They do not add up to the total due to overlapping.
- Refuse management outsourced to the Osaka Bay Regional Offshore Environmental Improvement Centre is not covered.
- Standalone outsourcing of the management of a treatment plant owned by a municipal government is not covered.
- Recycling outsourced to the Japan Containers and Packaging Recycling Association is not covered.

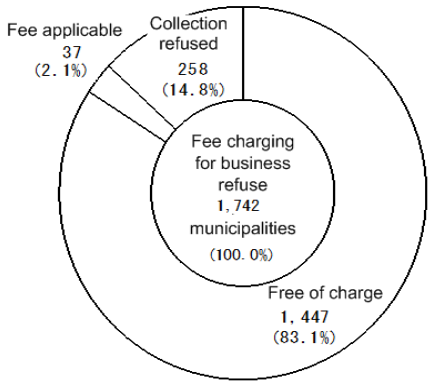
Chart 16 – Situation of Refuse Collection Fee Charging

(Number of municipalities)

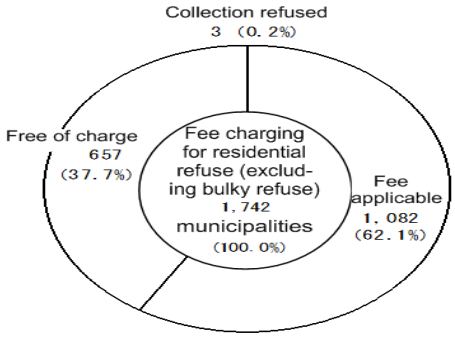
Refuse subject to collection fee \ Mode of generation		Residential refuse (collected refuse)			Business refuse (collected refuse)		
		Fee applicable	Free of charge	Collection refused	Fee applicable	Free of charge	Collection refused
Mixed refuse		44	29	1,669	58	6	1,678
Combustible refuse		1,026	658	58	1,393	43	306
Non-combustible refuse		800	820	122	1,075	68	599
Recyclable refuse	Paper (excluding paper cartons and paper packaging)	107	1,359	276	490	295	957
	Paper cartons	90	1,301	351	409	263	1,070
	Paper packaging	100	1,037	605	368	211	1,163
	Metals	367	1,275	100	699	227	816
	Glass	340	1,328	74	695	237	810
	PET bottles	334	1,362	45	631	249	862
	Foam trays	232	965	545	408	165	1,169
	Plastics (excluding foam trays)	289	807	646	366	132	1,244
	Cloth	173	346	1,223	229	63	1,450
	Kitchen garbage	104	768	870	248	98	1,396
	Used edible oil	113	145	1,484	160	33	1,549
	Pruned-off branches	24	412	1,306	67	77	1,598
	Other	57	147	1,538	115	13	1,614
Other		65	478	1,199	166	58	1,518
At least one of refuse types listed subject to collection fee		134	610	998	258	73	1,411
Bulky refuse		1,082	657	3	1,442	42	258
At least one of refuse types listed, including bulky refuse, subject to collection fee		1,072	394	276	826	39	877

(1) Situation of Refuse Collection Fee Charging, including Bulky Refuse (FY 2011 Record)





(2) Situation of Refuse Collection Fee Charging, excluding Bulky Refuse (FY 2011 Record)



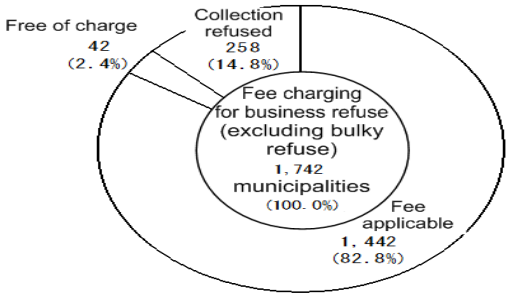


Chart 17 – Trends in Refuse Management Service Budget

(Unit: million yen/year)

Classification \ Fiscal year				2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total population (1000)				127,299	127,507	127,606	127,712	127,781	127,487	127,530	127,429	127,302	127,147
Revenues (municipal governments)	Total			1,975,961	1,750,387	1,709,195	1,683,421	1,862,654	1,859,902	1,823,476	1,832,022	1,838,976	1,790,511
	General revenue			1,480,046	1,411,268	1,353,531	1,357,926	1,350,754	1,345,236	1,343,986	1,340,785	1,352,056	1,293,130
	Specified revenues	National treasury disbursement		53,354	37,276	50,178	31,033	56,650	46,752	37,099	47,880	50,662	38,467
		Prefectural government disbursement		7,971	6,072	8,448	5,462	5,406	5,370	5,068	6,651	8,632	9,167
		Usage/handling fee		136,731	144,119	152,860	166,229	231,113	234,965	235,077	230,928	231,863	234,256
		Local bond		235,627	91,539	76,539	61,551	125,949	107,184	85,012	99,293	82,206	94,109
		Other		62,234	60,113	67,640	61,220	92,781	120,395	117,234	106,484	113,558	121,381
		Subtotal		495,915	339,119	355,665	325,495	511,900	514,666	479,049	491,236	486,920	497,381
Expenditures (municipal governments and intermunicipal administrative cooperatives combined)	Refuse management service costs			2,395,621	1,960,037	1,934,330	1,902,500	1,862,654	1,859,902	1,816,944	1,825,588	1,838,976	1,790,372
	Construction and improvement costs	Construction or improvement work costs	Collection and transportation facilities	—	—	—	—	26,182	3,130	1,873	3,037	1,539	1,176
			Intermediate treatment facilities	654	260,994	214,516	207,294	164,470	177,530	153,068	173,406	151,144	157,111
			Final disposal sites	80,074	62,110	71,692	62,040	42,114	23,966	17,096	19,356	24,031	23,323
			Other	23,874	12,844	12,117	10,276	7,302	4,777	4,230	5,071	8,483	5,158
		Investigation cost		7,484	6,104	3,450	2,796	4,277	3,188	3,430	3,356	3,769	4,782
		Subtotal		765,754	342,052	301,774	27,961	244,344	212,591	179,696	204,227	188,965	191,549
		Contribution to intermunicipal administrative cooperative (reference)		54,381	37,009	38,136	31,318	24,852	24,967	27,357	24,848	20,810	20,230
	Treatment, maintenance and other costs	Personnel cost		588,769	561,777	550	534,988	522,187	519,282	495,676	473,014	488,464	438,448
		Treatment cost	Collection and transportation facilities	79,309	77,212	79	75,538	67,048	71,687	65,967	63,975	64,792	61,618
			Intermediate treatment facilities	269,099	277,061	283	277,656	277,683	28,423	285,512	273,069	268,864	271,938
			Final disposal sites	42,994	36,770	36,140	28,825	29,817	31,756	34,624	33,288	36,714	34,693
		Vehicle and equipment purchase cost		11,902	10,105	7,702	8,016	7,329	5,933	6,792	7,959	4,855	8,066
		Outsourcing cost	Collection and transportation facilities	—	—	—	268,980	277,128	279,929	292,206	300,504	300,959	305,142
			Intermediate treatment facilities	—	—	—	238,779	254,516	264,068	279,650	287,098	294,342	298,755
			Final disposal sites	—	—	—	47,949	48,543	52,948	46,911	44,140	43,036	42,675
			Other	—	—	—	29,053	22,999	25,167	21,386	21,393	22,766	22,168
			Total	504,265	529,341	545,482	584,761	603,186	622,112	640,152	653,134	661,102	668,739
		Other		45,193	43,950	4,321	—	—	—	—	—	—	—
		Research and investigation cost		—	—	—	3,918	1,575	1,222	1,426	1,167	1,173	1,277
		Subtotal		1,541,531	1,536,216	1,544,591	1,513,702	1,508,825	1,536,223	1,530,149	1,505,606	1,525,964	1,484,779

		Contribution to intermunicipal administrative cooperative (reference)	285,904	272,923	250,682	241,279	243,117	247,728	249,676	234,946	236,950	285,904
	Other		88,336	81,769	87,964	106,392	109,485	111,088	107,100	115,756	124,047	114,043
Per capita refuse management service cost (yen/person/year)			18,800	15,400	15,200	14,900	14,600	14,600	14,200	14,300	14,400	14,100

Notes:

* "Contribution to intermunicipal administrative cooperative" is aggregate financial contributions made by municipalities to intermunicipal administrative cooperatives of which they are members. This is excluded from the total because it is the combined refuse management service cost of intermunicipal administrative cooperatives.

Chart 18 – Trends in Waste Management Service Budget (Expenditure)

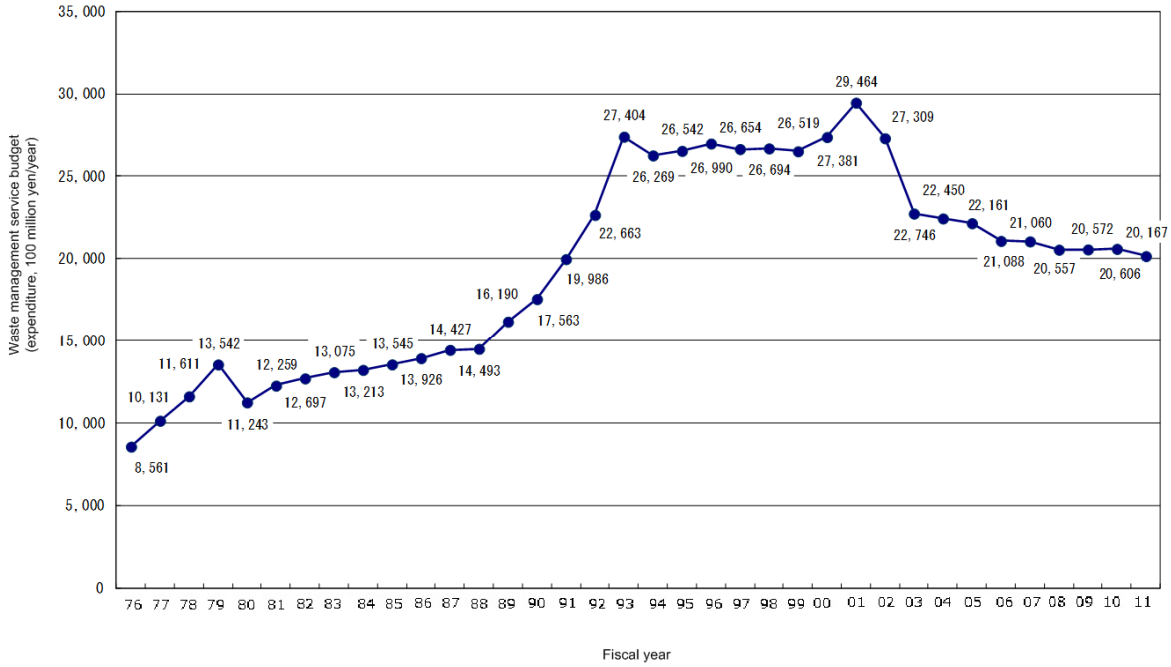


Chart 19 – Breakdown of General Waste Management Service Personnel

(1) Local government personnel (FY 2011 record)

(Unit: persons)

Classification \ Personnel	Regular service		Skills service				Total
	Administrative	Technical	Collection and transportation	Intermediate treatment	Final disposal	Other	
Refuse	14,423 (14,493)	6,185 (6,160)	26,675 (27,798)	9,393 (9,913)	966 (950)	987 (1009)	58,629 (60,323)
Sewage	2,841 (2,843)	1,305 (1,429)	1,052 (1,110)	1,299 (1,345)	50 (64)	67 (75)	6,614 (6,866)

Original note: Figures in parentheses are values recorded in the previous fiscal year.

(2) General waste management contractors and employees (FY 2007 record)

Number of contractors			Number of employees			
Refuse	Sewage	Total	Collection and transportation	Intermediate treatment	Final disposal	Total
19,456	4,345	22600 (22,764)	214,508	31,720	2,663	242047 (238,768)

Note: Figures in parentheses are values recorded in the previous fiscal year.
The breakdowns of contractors and employees do not add up to their respective totals because of the presence of multi-service contractors and multi-duty employees.

Notes:

1. Ministry of the Environment (2013). Released in March 2013, this report has been made available in electronic form. (For the Internet address, see the Bibliography.)

Bibliography

Ministry of the Environment (2013): "Waste Management in Japan, FY 2011 Edition"
Published in March 2013 by Office of Recycling Promotion, Policy Planning Division, Waste Management and Recycling Department, Minister's Secretariat, Ministry of the Environment

http://www.env.go.jp/recycle/waste_tech/ippan/h23/index.html
(as accessed on August 25, 2013).

2. Municipal Solid Waste Management in Individual Municipalities

(1) Case 1 – Kanazawa City, Ishikawa Prefecture

In the late 20th century, refuse incineration plants underwent major advances in the areas of offensive odour control, power generation, waste heat utilization, public disclosure, and the like. Kanazawa City's incineration plants are trailblazers of this change. Indeed, they are typical examples of Japanese refuse processing facilities in terms of, among other things, the challenges presented to municipal governments and their responses. The information provided below is based on an on-site survey of one of these plants conducted in November 2007. The survey report, which was first published as part of Sakushin Gakuin University (2008): "Sakushin Comprehensive Policy Research No. 8", pp. 63-78, has been revised (condensed, etc.) for inclusion in this paper.

Survey details

Date:	Friday, November 30, 2007,	10:00-12:00 (interview) 13:00-15:30 (inspection tour of plant and interview)
Place:	Kanazawa City Seibu Clean Centre, Office Kanazawa City has two incineration plants, and the survey destination was the one located in the western part of the city, called the "Kanazawa City Seibu Clean Centre"	
Interviewees:	Mr. Hitoshi Nakamura, Departmental Director in Charge of Seibu Clean Centre (also appointed as Director of Facility Management Division), Environment Bureau, Kanazawa City Government Mr. Shin'ichi Miyamoto, Director, Environmental Affairs Division, Environment Bureau, Kanazawa City Government	
Surveyor:	Naohisa Wada, Professor, Sakushin Gakuin University (author/editor, title shown applicable at time of survey)	

1) Incineration plant

(i) Incinerator and operational structure

The Kanazawa City Seibu Clean Centre features two incinerators, each with a treatment capacity of 175 tons/day. Equipment to monitor the state of operation was introduced in the 1980s. In 1994, the plant underwent a major refurbishment after two years of planning starting in 1992. It is operated by a team of three operators. (During the inspection tour, three operators were stationed in front of the monitoring equipment.) There are six of such teams. Responsible for operation and maintenance, they work on a rotational basis as follows: day shift, day shift, night shift 1, night shift 2, post-night shift rest, and day off.

There is another team responsible for the operation of refuse pit cranes. They work only during the day. Although refuse transportation from the pit to incinerators and feeding can be done automatically, refuse mixing (aimed at homogenizing refuse) and stacking (aimed at increasing the refuse holding capacity of the pit) rely on manual work. There are two cranes, and both can be operated simultaneously. Although one automatically controlled crane suffices for feeding the two incinerators, it is incapable of mixing. If two cranes are operated manually by two operators, mixing and feeding can be done simultaneously.

The cleaning of the cranes and related facilities has been outsourced, along with non-routine work. Four or five contractor workers are on site during the day.

(ii) Refuse pit

The Seibu Clean Centre's refuse pit is 400 m^3 in capacity, compared to 360 m^3 for the Tobu Clean Centre, which is located in the eastern part of the city. They are said to be capable of holding three and two days' refuse intake, respectively. However, the nominal holding capacity of a refuse pit is usually set conservatively, so that the actual holding capacity can be significantly increased by placing refuse evenly or stacking it. Taking this into consideration, the real combined holding capacity of the two pits looks more like seven days' refuse intake, rather than five.

During the inspection tour, one of the cranes was undergoing repairs (cleaning?). Since there are two cranes, the stoppage of one, due to a fault, inspection or any other reason, does not affect the operation.

(iii) White smoke suppression system

The incineration plant features a white smoke suppression system. When the flue gas released by an incineration plant contains steam, it turns white upon exiting the smokestack. As this sometimes makes local residents feel uneasy, the Seibu Clean Centre is provided with special equipment designed to suppress smoke (steam). (Author's comments: This kind of equipment is fairly widespread in Japan. It is one of the measures designed to win community

support. During the 20th century, municipal solid waste management was free of charge in many municipalities, and this kind of cost was paid with taxpayers' money).

(iv) Offensive odour control

A truck scale (weighing equipment) is placed at the entrance of the incineration plant to measure the weight of refuse delivered. Each time the door to the plant (for garbage packers) opens, an air curtain is drawn. It is placed before the door, and, when the door opens, an air flow is created from right to left to suck up the odorous air. As combustion air is drawn from the incinerator to apply negative pressure, odorous air does not leak outside. Namely, a triple layer of offensive odour control measures, consisting of a door, air curtain and negative pressure, has been employed. Many incineration plants do not operate the entrance door for this reason.

2) Non-incineration facilities

(i) Power generation equipment

Kanazawa City was also a pioneer in the area of power generation. Back in 1980, some incineration plants with 400 ton-class incinerators had power generation equipment, but Kanazawa was the only city that introduced power generation equipment for a 350-ton plant. In 1991, 250-ton power generation with a stable power output became possible, thanks to advances in computer control technology.

Kanazawa City operates a total of eight turbines. Given that power generation efficiency improves as the temperature and pressure of steam increases, the need to maintain the incinerator temperature at 850 to 900 °C to control dioxin emissions has contributed to the improvement of power generation efficiency. Kanazawa City's refuse is 50% paper and cloth, and its calorific value has been rising as the generation of paper waste continues to increase. Since the increase in paper waste has been accompanied by a decrease in household kitchen garbage, the odour from refuse has been alleviated.

(ii) Waste heat utilization facilities

In 1980, a bath and heated swimming pool were built as waste heat utilization facilities. Although the number of users fluctuates from year to year, the share of elderly users has risen from 1981 to 2007. Due to competition from the private sector, the heated swimming pool has seen a decline in clientele. Another contributing factor to the fall in the number of users has been the scheduling of the annual plant overhaul for February, which has been necessitated by the October overhaul of the other incineration plant. There is a limited window for an overhaul as it must be carried out when the level of refuse generation is low.

3) Plant staff

(i) Emphasis on technical skills

Kanazawa is the only city using a three-man crane operation team in this region (Ishikawa Prefecture), where such teams usually consist of four or five workers. Overall, the staff comprises 21 workers, divided into seven three-man teams, and two engineers. Besides, there are seven office workers, including maintenance, boiler, turbine and electrical engineering chiefs.

Crane operation requires a license. Kanazawa City encourages all non-administrative personnel to acquire a crane operator's license. The two division directors who guided the inspection tour had this license too. In other cities, crane operation is usually considered a special skill.

(ii) Automation and staff cuts

The automation of crane operation was pioneered by Kanazawa City. The introduction of automation equipment is usually opposed by the union because it accompanies staff cuts. In the case of Kanazawa City, however, the union actually instigated the move as a lower back injury prevention measure. As the new (current) plant operates around the clock, the number of operators has jumped from seven to eight before rebuilding to 18 afterwards. There was no objection from the union in this respect either.

Both in the morning and afternoon, an operator mixes refuse for two to three hours by manually operating a crane. Incinerators are fed with refuse only up to four times an hour, and refuse mixing is performed during waiting time. At night, the plant is operated automatically, so there is no refuse mixing.

4) Environment Bureau staff

(i) Staff cuts

The Environment Bureau began outsourcing certain tasks in 1999. Over the next eight years, the number of personnel working in the refuse collection sector fell from 260 to 200. To be more precise, the number of jobs lost was 56, but half of this cut was achieved through natural attrition. Starting in 2006, the bureau plans to hire two garbage collectors and a vehicle operator a year, but the actual outcome will be the hiring of collector-drivers. Although the public qualification for a vehicle operator is accessible to anybody, the equalization of qualifications and terms of employment (e.g. pay) is not a simple issue because of the involvement of the union.

(ii) Current staff levels

The Environment Bureau has about 350 personnel. The number of collectors has been cut by six to seven a year. The staff includes about 100 administrative personnel and a little less than 100 technical personnel. The personnel share of the Seibu Clean Centre is around 50, including 21 assigned to facility management and a few more charged with recycling, environmental protection

and other tasks. The Environmental Affairs Division has two chemical engineering personnel who provide guidance, conduct on-site inspections and perform other duties. More than half of Environmental Protection Division staff have a technical background, and perform duties such as screenings and inspections relating to global warming and environmental protection. There is no room for staff cuts here.

Amid ongoing staff cuts, managers hope there will be no more cuts in technical staff. They also want the number of administrative personnel to be increased. To maintain staff levels, the City Government has been rehiring retired employees.

(iii) Outsourcing

Repair work has been outsourced, along with civil engineering and architectural design. Kanazawa City used to do design and cost estimate work internally. Today, the number of workers who have rarely set foot on the plant floor and are incapable of performing cost estimates is increasing. Managers see the need to cultivate workers who can carry out those tasks.

From this point of view, the outsourcing of technical jobs is problematic. Each year, the City Government hires several mid-career technical personnel with recognized qualifications. In this respect, turning to private companies for advice often turns out to be futile because plant manufacturers themselves are desperately short of such workers. The situation is so bad that they resort to loaning designers from their subsidiaries. In fact, many workers at plant manufacturers do not know the key numbers that are essential to perform cost estimates as part of engineering design.

(iv) Collection

Refuse collection is an expensive operation. As of 2007, only 60% of the collection workers are city government employees, with the remaining 40% contractor employees. When city government employees retire or resign, they are replaced by contractor employees. Areas entrusted to contractors sometimes experience an increase in the amount of refuse generated. This is partly a consequence of the fact that areas where refuse is likely to increase tend to be given to contractors. As of 2007, 200 city government employees are working in the refuse collection sector. The City Government plans to reduce this to 140 by 2016.

Collection operations are outsourced on the basis of the number of garbage trucks (packers). Private contractors use truck crews of two workers instead of three as is the case with city government crews. For this reason, each time three city government workers retire or resign, the amount of work corresponding to one garbage packer (two workers) is outsourced. Until 2006, private-sector contractors too based their calculations on three-worker crews (one driver and two collectors). However, they changed to a two-worker crew system on the

assumption that drivers would also engage in collection work. Partly to appease the union, drivers take part in collection work on a rotational basis.

There are two types of garbage packers: 4-m^3 (2-ton) vehicles and 6-m^3 (3-ton) vehicles. Of these, 4-m^3 vehicles are common as they better suit Japanese conditions. In some areas, i.e. uncongested suburban areas, private contractors use 8-m^3 (4-ton) vehicles. The City Government plans to leave old built-up areas and other congested areas to city government crews, with suburban areas, which are likely to experience population increases and therefore require more collection staff, to be outsourced to the private sector.

Private-sector outsourcing is prone to giving rise to an overloading problem. This is another reason why the hollowing-out old built-up areas need to be kept in the hands of city government crews. As well as responding to disasters and other emergencies, city government crews can reinforce contractor crews during normal times, as necessary. For this reason, the City Government plans to retain some city government crews despite the steady outsourcing trend. Considering the need to provide refuse station guidance and monitor the way residents take out their refuse for collection, it puts the ultimate strength of city government crews at 30% of the total refuse collection work force.

(2) Case 2 – Aomori City, Aomori Prefecture

Aomori City's incineration plants are relatively old. One of them was surveyed in August 2006 as an example of old types of incineration plants. The survey report, which was first published as part of Sakushin Gakuin University (2007): "Sakushin Comprehensive Policy Research No. 7", pp. 103-114, has been revised (condensed, etc.) for inclusion in this paper.

(2)-1 Refuse Incineration Management Division, Incineration Service Centre, Environment Department, Aomori City Government

Date:	Friday, August 29, 2006, 10:00-12:00
Place:	Refuse Incineration Management Division, Incineration Service Centre, Environment Department, Aomori City Government
Interviewees:	Mr. Tatsuo Ogasawara, Division Director
	Mr. Mitsuo Takiguchi, Councilor, Incineration Facility Construction Preparation Office
	Mr. Shun'ichi Kasai, Councilor, Waste Recycling Team (Team Leader)
	Mr. Yuji Umehara, Senior Staffer, Waste Recycling Team
	Mr. Tsuyoshi Imamura, Senior Staffer, Management Team (inspection tour guide)
Surveyor:	Kyoitsu Yamamoto, Professor, Aomori Public College
	Naohisa Wada, Professor, Sakushin Gakuin University (author/editor, title shown applicable at time of survey)

1) Fee charging

On July 1, 2003, a fee was introduced for the collection of business general waste. The rate was 100 yen per 10 kg. Its effectiveness in promoting refuse reduction bore out in 2005. Around the same time, bulky refuse also became subject to a fee, 800 yen per piece. The collection system for such refuse is based on tickets sold at convenience stores, post offices, city office kiosks, and other places. To have bulky refuse collected, a phone reservation needs to be made with the coordination centre. Bulk waste is collected once a month, and a resident wanting to get rid of a piece of bulky refuse is required to write his/her name on a ticket and stick it onto the item. The collection of bulky refuse has been outsourced.

The city has 34 licensed general waste contractors, who are authorized to engage in refuse collection operations in the city. One condition that they must meet is that their office is located in the city. Eighteen of those contractors are members of an industry association aimed at advancing common industry interests, such as greater access to city government contracts.

In anticipation of the taking effect of the Home Electrical Appliances Recycling Law in 2001, FY 2000 saw a surge in the illegal dumping of home electrical appliances. Similarly, there was a rush to dispose of bulky refuse in the April-June period of 2003, giving rise to a jump in the amount of bulky refuse discarded. In April 2005, an anti-illegal dumping team was formed.

2) Incineration plants

Business refuse is processed at two sites: the Nashi-no-ki Incineration Plant (March 31, 1980) and the Sannai Incineration Plant (May 30, 1992). With truck scales introduced right from the beginning, the amount of refuse delivered was measured accurately in weight, rather than in terms of the number of trucks. From 2000 to 2002, both incineration plants underwent a major refurbishment for dioxin control purposes at a cost of 7-8 billion yen. Neither plant has power generation equipment.

In March 2006, a decision was made to build two new incineration plants by 2014. Their combined incineration capacity will be 400 tons/day. One of the plants will take on 90% of the total incineration load, with the other taking care of the remaining 10%. They will be built on new sites, complete with power generation equipment and a slagging facility. The new incineration plants are set to accept refuse generated in five Mutsu-area municipalities.

3) Refuse collection, etc.

Aomori City collects refuse on the basis of a refuse station system. Refuse stations are set up and managed by neighbourhood associations. Each station is required to cover at least 20 households. There are more than 3000 stations altogether. Given that there are 120,000 households in Aomori City, the average number of households per station is around 40.

Combustible refuse is collected twice a week. As different districts are assigned different collection days, copies of a refuse calendar are distributed to inform the residents of the collection schedule. Stations located along main roads have some etiquette problems as residents from other districts sometimes use them to dump their refuse. At about 500 stations, refuse is just piled up on the ground. The remaining 2500 have a cage or other enclosure. The disposal of kitchen garbage through shredding and flushing down the sink has recently been approved after a long ban.

Residents' environmental awareness is high, so much so that presidents of neighbourhood associations have submitted a proposal for the introduction of a fee-based collection system for residential refuse (combustible refuse, etc.). Most cities in Hokkaido Prefecture have already introduced one. In Aomori Prefecture, Mutsu City and Hachinohe City have followed suit. Aomori City began studying the introduction of a fee in FY 2006.

4) Recycling

On April 1, 2000, the Containers and Packaging Recycling Law took effect, and Aomori City began collecting recyclable refuse on April 1, 2001. Today, bottles, PET bottles, returnable bottles and waste paper are collected throughout the city. Previously, the city did not have a recyclable refuse collection program, although it has been paying grants for group recycling for a long time. In October 1981, old (pre-merger) Aomori City launched a group recycling model project with the participation of six groups. On September 1, 1993, former (absorbed) Namioka Town launched the Namioka Town Recyclable Refuse Collection Grant Program. On April 1, 2005, Aomori City and Namioka Town merged. As of 2006, the level of grant payment was 3 yen per kg in the old Aomori City area and 4 yen per kg in the former Namioka Town area (excluding bottles). Today, group recycling takes place throughout the city. On April 1, 2002, the City Government began collecting glass bottles as recyclable refuse.

(2)-2 Inspection tour of incineration plant

Date:	Friday, August 29, 2006, 14:00-15:00
Place:	Nashi-no-ki Incineration Plant, Incineration Service Centre, Environment Department, Aomori City Government
Interviewee:	Mr. Hidetsugu Tateda, Director, Nashi-no-ki Incineration Plant
Surveyor:	Naohisa Wada, Professor, Sakushin Gakuin University (author/editor, title shown applicable at time of survey)

1) Facilities

Upon entering the incineration plant, a slight refuse odour was felt. As most municipal incineration plants the author visits are new or state-of-the-art and odourless, this odour stirred up nostalgia. The plant was built in 1981, so its vintage structural design seems to be limiting the effectiveness of odour control measures.

Since inauguration, it has had a total treatment capacity of 450 tons/day based on three 150-ton incinerators. There are six collection vehicles consisting of five 2.5-ton (5 m^3) vehicles and one 2-ton vehicle. Each collection vehicle crew consists of three workers, including a driver, who concentrates on driving and does not take part in collection work.

The incineration plant has 86 personnel. The personnel breakdown is as follows: collection management (collection vehicle crews) 18 (3 × 6 vehicles); delivered refuse guidance 5-6 – responsible for the inspection of refuse delivered to the pit; non-standard refuse collection 3-4 – responsible for the provision of guidance on the disposal of home electric appliances, bulky refuse, etc. as part of the refuse collection sector; two-shift incinerator operation 35 (five teams) – all city government employees (no contractor employees or workers placed by personnel agencies); crushing 5-6; transportation of aluminium, etc. 2; wastewater management 2; and facility maintenance staff - responsible for the maintenance and repair of electrical equipment, boilers and machinery.

2) Historical outline

Aomori City began incinerating refuse in 1933, and this became a full-fledged incineration service in 1955. Completed in 1976, the city's other incineration plant, the Sannai Incineration Plant, has been in service for 34 years. It has two 90-ton incinerators. The Nashi-no-ki Incineration Plant has been operational for 36 years. The combined capacity of the two incineration plants is 480 tons/day.

The Nashi-no-ki Incineration Plant is able to cope with the load with just two incinerators operating (one incinerator shut down). It incinerated 150,000 tons of refuse in 2000 and 130,000 tons in 2005. The interviewee, Mr. Hidetsugu Tateda, the plant director, remembered that there had been more refuse back in 1979, when he was transferred there. When the plant was completed, only two of the three incinerators were allowed to operate. When all the incinerators were out of service, refuse was taken directly to the landfill site, which today still has plenty of room to accept refuse, with a remaining service life of just under 20 years.

3) Operation

The current incineration plant does not have power generation equipment or an ash melting facility. Still, large boilers have been installed to generate steam. As there are no houses around the plant, there is no need for a community welfare facility, such as a heated swimming pool. The generated steam, therefore, is used for on-site heating and supply of shower water for staff.

This plant accepts refuse from Hiranai Town and other municipalities within the prefecture. The amount is negligible so there has been no objection from Aomori City residents. (It is not uncommon that the acceptance of refuse from other municipalities is fiercely opposed by local residents.) Such refuse is incinerated for a fee of 15,000 yen per ton. The unit charge (rate) for FY 2006 was calculated on the basis of the costs incurred in FY 2004. The fee that any of these municipalities is billed is the product of the unit charge and the amount of refuse accepted.

After an incinerator is operated for a month, it is shutdown for a week to remove clinker (a substance formed by ash left inside an incinerator as it melts and re-solidifies). Aomori City's incinerators are prone to clinker formation as they are old and operate at low incineration temperatures. Each year, incinerators are shut down for about a month to replace incinerator walls and carry out other repairs. The complete shutdown of all three incinerators lasts for about two weeks. The incinerators were built in 1976 and underwent a dioxin control refurbishment in 2002. Dioxin emissions were reduced from 80 ng per unit volume of flue gas to 1 ng by replacing the electric dust collectors with filter dust collectors. This was basically a replacement of flue gas treatment equipment, and no major change was made to the incinerators.

As a result of the refurbishment, the electricity bill increased by 30 million yen to 90 million yen. The filter cloth, which is replaced every four to five years, costs 30 million yen per incinerator. The refuse pit is capable of holding 4500 m^3 (1350 tons) of refuse. In winter (January to March), refuse intake is low. The pit lasts for about two weeks if it keeps accepting refuse without incineration. After being held in the pit, refuse is incinerated even in winter. The landfill site is far away, and, in winter, it takes about two hours to get there or return due to snow-covered roads.

This incineration plant undergoes an incinerator overhaul (boiler inspection) over two weeks in early July. The incinerator overhaul of the other incineration plant is scheduled for September. During this period, all refuse received is taken directly to the landfill site without incineration. The main driving force of the incinerated disposal principle prevalent in Japan is the minimization of refuse subjected to landfill disposal. Aomori City's action described above shows that its landfill site has a substantial remaining capacity. One may think that it is a better idea to conduct a boiler inspection during winter, when refuse intake is low. However, air temperature falls below 0°C in winter, so that shutting down

all the incinerators would lead to the freezing of water pipes. A heating arrangement other than steam from the boilers would also be necessary.

The incineration plant features a crushing facility. It processes items such as dishes, small home electrical appliances, iron cloth hangers, pots, and pans. After crushing, iron and aluminium (added later) are separated and recycled. Crushed refuse consists of 30% iron, 2% aluminium, 30% combustibles, and 40% non-combustibles. Non-combustibles are taken to the landfill site for disposal.

(3) Refuse management challenges faced by individual municipalities

For municipal governments, which are responsible for refuse management, it has traditionally been a major challenge to maintain a 100% incineration capacity in the face of ever increasing refuse. At the same time, they need to win community support for incineration plants, which have long been regarded as inconvenient facilities, leading to the construction of heated swimming pools and other community welfare facilities that use heat generated by incinerators.

In the 1990s, the control of dioxin emissions from incineration plants became a pressing task. To meet this challenge, all-out efforts were made at significant expense, including the construction of low dioxin-emission incinerators and dramatic improvement of the performance of flue gas treatment equipment. At new incineration plants, incinerators and flue gas treatment equipment cost about the same. The thoroughness of such dioxin control measures is illustrated by the following statement made by the Utsunomiya City Government to the participants of inspection tours of its incineration plants: “The flue gas dioxin concentrations of our incineration plants are lower than atmospheric dioxin concentration”.

Today, the construction of ash melting and slagging facilities, aimed at reducing the amount of refuse subjected to landfill disposal and minimizing landfill site pollution, is spreading. As this slag is theoretically harmless, its use as a sand-substitute construction material is making progress.

The private-sector outsourcing of refuse collection continues unabated. Due to the need to give consideration to vested interests and trade union stance, the main approach to privatization has been the gradual transfer of operations through natural attrition. Although recycling is being promoted as a means to reduce the amount of refuse incinerated, too much idealism sometimes makes people lose sight of how effective it actually is. Admittedly, however, the author may be in the minority in this regard.

Although more and more municipalities are introducing a fee-based refuse collection system, fees are still quite low, and refuse management costs are, for the most part, still paid with taxpayers’ money. The author believes that the introduction of a fee-based refuse collection system with fees high enough to self-support the refuse management system as a whole is the most logical way to run the service. However, on this point too, the author’s view is in the minority.

3. Characteristics of Municipal Solid Waste Management in Japan

In comparison with the European situation, the characteristics of the Japanese approach to refuse management can be summarized in the following three points: (1) tax revenue funding of the service, (2) incineration-centred refuse management, and (3) principle of same administrative district refuse management.

(1) Tax revenue funding of services

In Japan, the refuse management service is, for the most part, funded by taxpayers. This has been so since the pre-WWII days. Records show that Osaka City applied for the charging of fees, but was turned down by the Ministry of Interior, although the reason for this decision is unknown. Today, despite the growing fee revenue share of the budget, fees are still far too low to self-support the refuse management system.

(2) Incineration-centred refuse management

Refuse management in Japan relies mainly on incineration. This seems to be attributable to the fact that modern refuse management has its roots in disease control in major cities. As Japan's residential areas have a high population density, they tend to have limited access to land suitable for use as landfill disposal sites. During the post-WWII high economic growth period, refuse generation exploded, and this made incineration extremely important as a means to reduce the load on landfill disposal sites (refuse reduction).

(3) Principle of same administrative district refuse management

While NIMBY has become a worldwide phenomenon, it is most pronounced in the community attitude towards refuse management facilities in Japan. The principle of same administrative district refuse management, which demands that refuse generated in a municipality (including any of Tokyo's special wards) be disposed of in the same municipality, is an extension of this community attitude. Despite being informal and obscure in origin, this principle exerts a powerful influence. Indeed, the principle of same administrative district refuse management is delaying the progress of the regionalization of refuse management.

This concludes the author's attempt to describe the overall refuse management situation in Japan, present case studies, and identify the characteristics of the Japanese approach to refuse management.

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