Chapter 8
Development of a Municipal Waste Management System from Environmental and Economic Evaluation Perspectives: A Best Available System Methodology

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8.1 Introduction

Concern over waste management problems has heightened lately owing to the escalation of environmental issues. Meanwhile, the diversity of waste continues to increase due to the expansion of economic and social activities and associated lifestyle changes. Simultaneously, it is a trend that municipal solid waste (MSW) systems are becoming more diverse and better-equipped due to pressures owing to maintaining pressures from final disposal site, reducing dioxin, and conducting 3Rs (Reduce, Reuse, Recycle) policies [1].

Under these circumstances, and with the intention of encouraging the development of a recycling society, revising the MSW system is an urgent task from both environmental load and economic evaluation perspectives [2]. Recently, there are various Life Cycle Assessment (LCA) researches in the MSW system field. For instance, Tabata et al. [3] investigated the LCA efficiency based on statistical data of incineration facilities. And, they also offered integrated environmental influence evaluation of waste treatment scenario through DTT (Distance-to-Target) method [4]. Furthermore, Nakatani et al. [5] conducted integrated assessment based on cost-benefit analysis [6]. Meanwhile, Amano et al. studied on LCA evaluation of MWS system from GHG emissions and landfill disposal perspective. Besides, Matsuto et al. [7] developed a practical calculation program H-IWM, an Excel version, for simulating municipal waste treatment planning from treatment amount, cost, and energy consumption view. Other researchers analyzed waste energy recycling

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society using LCA and discussed the advantages and disadvantages of waste management regional expansion.

However, in the previous studies, both economic and environmental simulations with multiple cases (e.g., incineration, gasification melting, power generator, ash melting, fly ash recycle, crushing process) are hardly found, because plant makers' LCI databases are insufficient and literatures are mainly focusing on a single incineration plant, and it is seemingly found to be competent categories of technologies. In this research, we develop a LCI database through collecting data from 14 representative plant makers that occupy most market share in Japan and investigate on their intermediate process plants (e.g., incinerator, power generator melting, fly ash recycle).

Meanwhile, we develop a more accurate management system targeting MSW system through applying this database. In details, MSW management system, namely, Best Available System (BAS) methodology, is developed based on LCA (Life Cycle Assessment) and LCC (Life Cycle Cost) analysis. This BAS methodology aims to improve and sophisticate the MSW recycling system and provides quantitative indicators for evaluations from both environmental load and economic evaluation perspectives.

In the LCA analysis, we apply ELP (environmental load point), an index previously developed by the authors, which solves the single index issues of previous studies. And different with other integrated method, ELP reflects the changes of human environmental awareness with changes of time.

8.2 Concept of BAS Methodology

It has been necessary for municipalities to conduct quantitative environmental load evaluations and cost estimation when establishing waste treatment practices. Hence, the BAS methodology focuses on MSW agencies and provides analysis from their perspective by applying LCA and LCC. Meanwhile, it evaluates waste treatments (including collection and recycling, midterm treatment, transport, final disposal, and use) and the recycling system.

The environmental load evaluation is calculated using Technology Life Cycle Assessment (TLCA), which applies for technology and evaluates treatment and recycle based on LCA method. The TLCA is a quantitative assessment of input and output to the environmental load carried by humans and ecosystems. For instance, the assessment involves quantifying not only the recycling and waste management done by the plant but accounts for environmentally important metrics of the plant's actual equipment as well. The BAS has the following advantages:

1. It evaluates a series of MSW processes that range from collection and recycling to final use and disposal treatments.

2. The environmental load evaluation database of incineration and melting (e.g., input and output amounts at different treatment scales, power generation efficiency) is compiled based on the plant maker's design and estimated value.
3. It enables calculation of indices for recycling rate, energy expended in the recycling process, and final disposal treatment for different evaluation scenarios.
4. The BAS methodology makes it possible to develop the ELP (environmental load point), introduced by the authors in a previous study, into a more comprehensive system [8].

8.3 Outline of ELP Integrated Index

In the LCA field, expressing the impact category within a single index is called integrated evaluation [9]. The authors developed this integrated evaluation method based on the Panel Method in the previous study. The Panel Method suggests environmental improvement priorities and provides a comparison of the suitability of different decisions. The ELP is developed by setting up nine impact categories (e.g., energy depletion and climate change) and making weight values for each category by applying the survey results [10].

As shown in Table 8.1, there are nine impact categories, and analysis of their characteristics is conducted in each by applying weight coefficients, sorted by importance of CO_2, NO_x, BOD, heavy metal, and so on. This allows us to estimate the index of each category and thereby conclude the degree of importance of each. The ELP integrated index is calculated by multiplying the outcome of the characteristic analysis with the degree of importance [11]. The formula is shown in Fig. 8.1.

In this method, assessing product pairs with different functional units such as automobiles and PET bottles becomes efficient.

Table 8.1 ELP impact category [12]

Impact category	Weighting coefficient	Target items
Energy exhaust	Low heating value/exploitable year (crude oil = 1)	5
Climate change	GWP100 × 1 (CO_2 = 1)	38
Ozon depletion	GDP (CFC-11) = 1 × 2	24
Air contamination	AP (Acid potential) (SO_x = 1)	7
Resource contamination	1/exploitable year (iron ore)	32
Air pollution	1/Environmental standard (SO_x = 1)	10
Ocean and water contamination	1/Environmental standard (BOD = 1)	37
Waste treatment issue	1 (weight conversion)	1
Ecosystem influence	ECA (ecotoxicological classification factor) (Cr = 1)	32

[ELP]

$$A_j = \sum_k (C_{j,k} \times TQ_k)$$

$$ELF_k = \sum_j (C_{j,k} \times W_j / A_j) \times 10^{16}$$

$$ELP_i = \sum_k (ELF_k \times Q_{i,k})$$

ELP: integrated index of product *i* (matter)

A_j: Total annual load of category *j*

$C_{j,k}$: Weight coefficient of project *K* in category *j*

TQ_k: Annual Input and output (kg) *

W_j: Important degree of category *j*

ELF_k: Integrated index of project *K* (ELP/kg)

$Q_{i,k}$: Input and output of project *K* for product *i* or other

***i*: Product or matter**
***j*: impact category**
***k*: environmental project**

*** Annual input and output is set based on Japanese and global value**

Fig. 8.1 ELP integrated index formula [12]

8.4 Methodology of BAS

8.4.1 Evaluation Flow

The BAS methodology integrates waste components and classifies collections based on the current state of the evaluation system. And it contains the collection, midterm treatment, and final disposal (recycle); see Fig. 8.2.

Meanwhile, the BAS methodology creates databases so as to categorize MSW systems. It also sets default values based on common designs and anticipated value from Japanese plant makers in case measured data is insufficient when evaluating the environmental load data (input and output). BAS methodology provides an evaluation outcome including cost, ELP integrated index, and specific index (e.g., GHG emissions, landfill reduction amount, energy consumption, SO_x, and NO_x). Besides, it offers comparable analysis among various cases through case studies. Furthermore, the BAS proposes recommendations for MSW system improvement and judgment of new system introduction based on users' financial situation and purposes.

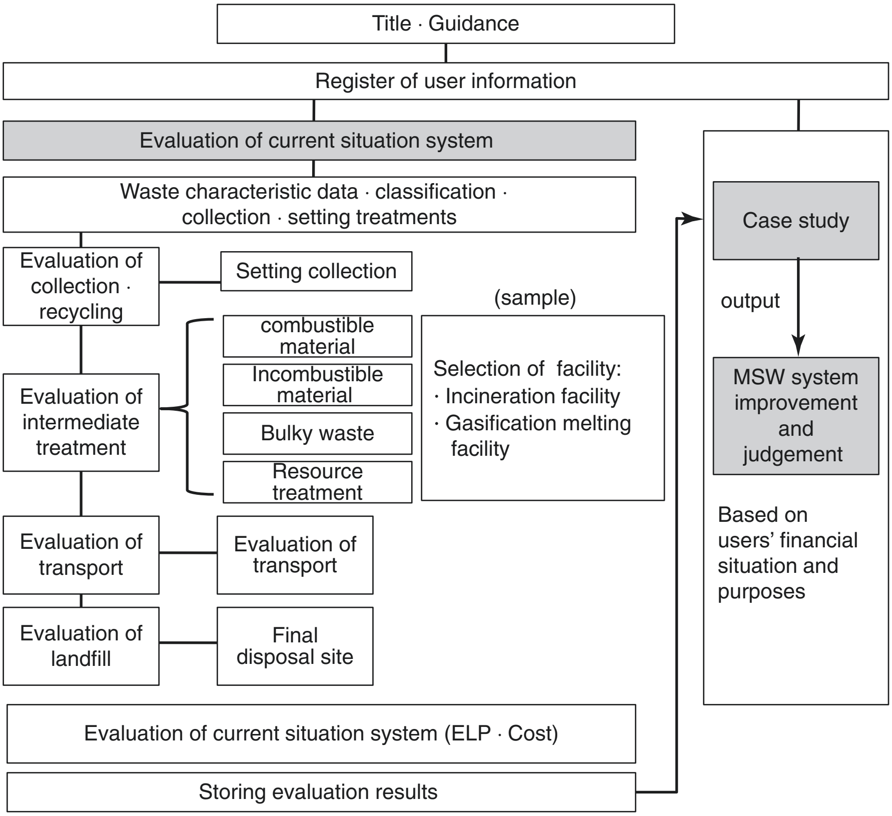

Fig. 8.2 Evaluation flow of BAS

8.4.2 *Waste Components and Chemical Elements Setting*

After setting the types and components of waste and inputting data of a target city, the BAS methodology enables us to calculate the amount of air supply for combustion, gas emission from combustion, heating value, and power generation from incineration treatment. In this method, heating value means low calorific value, which is the same as regular heat load calculation. Measuring data or using a similar value is required when applying the Steuer formula (8.1 for calculating combustibles' high heating value based on chemical element analysis [13]. Meanwhile, the low heating value is calculated using the following formula (8.2):

$$\text{Hh} = 339.4\left(c - 3\times\frac{o}{8}\right) + 238.8\times 3\times\frac{o}{8} + 1445.6\left(h - \frac{o}{16}\right) + 104.8s \ \left(\text{kJ}/\text{kg}\right) \qquad (8.1)$$

$$\text{Hl} = \text{Hh} - 25(9h + W) \tag{8.2}$$

Hh: Waste high heating value (kJ/kg)
Hl: Waste low heating value (kJ/kg)
h: Hydrogen content in Wetness waste (%)
W: Moisture content in Wetness waste (%)
o, *h*, *c*, *s*: Weight in combustible material (%)

The BAS develops a database of waste in 59 categories to cope with classifications in different municipalities. Hence, it is able to evaluate and set detailed waste components. For those municipalities whose data is insufficient, this study develops a default value database (Table 8.2) [6].

8.4.3 Building LCA Databases

Midterm and final disposal treatments (recycled) are shown in Fig. 8.3. The input, output, and cost are added, and environmental load is calculated using the ELP methodology. Contrasting with the ELP method, this research enables us to illustrate individual indices such as CO_2 emissions, primary energy consumption, final disposal amounts, etc.

This research participated in Osaka Science & Technology Center waste treatment technology LCA workshop, which compiles LCA and LCC databases based on MSW information collected from member companies. This research covers almost all plant categories through applying data (facility design and plan values) collected from 14 major Japanese MSW treatment plant designers. Nowadays in Japan, the number of waste incineration treatment facility has reached a peak, and there is a decreasing trend currently. Constructions of incineration facilities in large scale have started after conducting wide-area waste treatment plan (dioxins control countermeasures, 1997). In this study, we select incineration facility data between 2000 and 2006 considering the machines' working life. The evaluable technologies and building characteristics used in the BAS methodology are shown in Table 8.3.

As an example of a common MSW treatment, incineration technology's database building and default value setting will be described in detail.

8.4.3.1 Building a Database of Incineration Treatment and Setting Default Values

We have collected LCA data (1997–2006) from plant designers about incineration treatment, stoker-type incineration, ash melting, and gasification melting. The default values of incineration treatment are created based on the average values of these

Table 8.2 Database of waste component default values (excerpt)

		Three components			Chemical elements in combustibles					
		Combustibles (%)	Moisture (%)	Ash (%)	C (%)	H (%)	O (%)	N (%)	Combustibility (S%)	Volatility (Cl%)
Paper										
	Paper pack for beverage	78	20	2	44	6	49	0.2	0.02	0.4
	Carton box	78	20	2	44	6	49	0.2	0.02	0.4
	Other paper package container	75	20	5	44	6	49	0.2	0.02	0.4
	Other paper exclude package container wastes	70	20	10	44	6	49	0.2	0.02	0.4
Kitchen refuse (garbage)		18	78	4	42	6	34	3	0.1	0.3
Fibers		79	20	1	42	6	42	0.5	0.04	0.2
Plants (Grass and Woods)		52	45	3	46	6	40	0.9	0.02	0.2
Other combustibles		33	57	10	44	6	49	0.2	0.02	0.4
Plastic										
	PET	74	26	0	62	4	34	0	0.01	0
	Other plastic-made package container	71	26	3	74	11	11	0.2	0.02	3.9
	Other plastic waste exclude package container	71	26	3	74	11	11	0.2	0.02	3.9
Rubber and leather		72	14	14	66	8	18	1.1	0.33	4.7
Iron										
	Steel cans	0	5	95	0	0	0	0	0	0
	Other iron waste exclude package containers	0	5	95	0	0	0	0	0	0

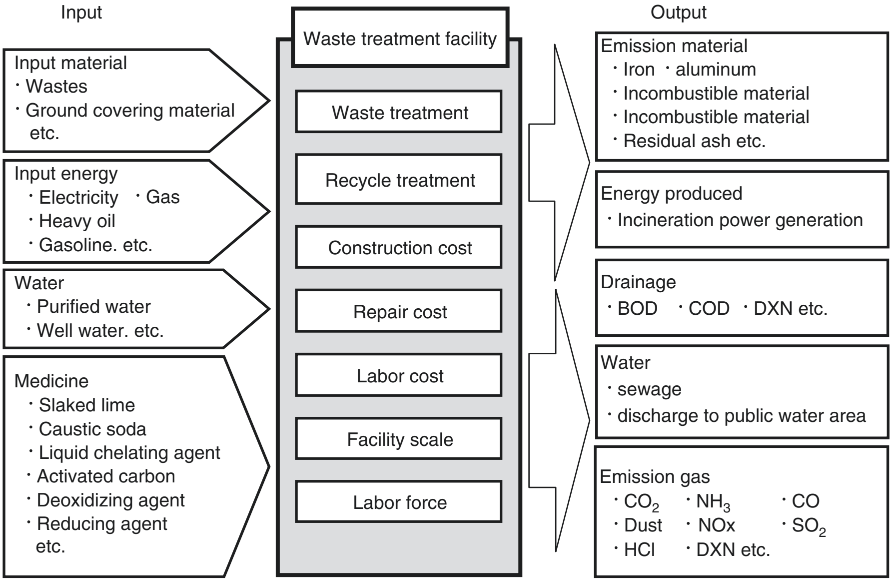

Fig. 8.3 Midterm and final disposal input and output

Table 8.3 Database of BAS methodology

Applicable treatment methods	Calculation of measured value	Default value DB
Simple incineration	○	○
Incineration power generation	○	○
Gasification melting	○	○
Ash melting	○	○
Washing ash	○	○
Fly ash recycle	○	○
Eco cement treatment	○	○
Crushing treatment	○	○
Waste paper	○	○
Cans	○	×
PET	○	○
Bottle	○	×
Waste cloth	○	×
Carbonization	○	×
Methane fermentation	○	×
Composting treatment	○	×
Ethanol treatment	○	×
BDF treatment	○	×
Waste plastic liquefying treatment	○	×
Waste plastic blast furnace fuel treatment	○	×
Dry battery	○	×
Fluorescence tube	○	×
Final disposal treatment	○	×

processes. Regarding the default values of stoker incineration and gasification melting, we assume waste input is 600 t/day and the heating value is 2400 kcal/kg. Meanwhile, the plant electricity consumption and fuel subsidy are decided by the waste input per ton. Emission gas treatment medicine and relative input amounts are decided by the type of treatments. Furthermore, the calculation of ash melting follows the ratio that the incineration's main ash is composed of 90% total ash, while incineration ash accounts for 10%. Details of incineration LCI defaults are shown in Table 8.4.

Table 8.4 Incineration LCI default

Items			Unit	Incineration amount	Melting burned ash (main ash) + fly ash	Gasification melting
				2006	2006	2006
				Average of 5 companies	Average of 5 companies	Average of 5 companies
Input	Waste input		kg/day	6.00E+05	1.04E+05	6.00E+05
	Power consumption amount		kWh/day	7.23E+04	1.04E+05	1.10E+05
	Fuel (auxiliary)	Kerosine	kg/day	0.00E+00	1.06E+03	4.53E+02
		Coke	kg/day	0.00E+00	0.00E+00	6.00E+03
	Exhaust gas	Slaked lime	kg/day	9.64E+03	3.54E+02	6.00E+03
	Treatment	Active carbon	kg/day	2.81E+02	1.36E+01	2.69E+02
	Chemical	Ammonia	kg/day	1.18E+03	–	9.86E+02
		Urea	kg/day	0.00E+00	–	1.85E+03
		Caustic soda	kg/day	0.00E+00	–	0.00E+00
Output	Gas emission	CO_2	kg/day	6.27E+05	1.05E+04	6.44E+05
		NO_x	kg/day	2.37E+02	5.00E+00	3.27E+02
		SO_x	kg/day	2.64E+02	3.00E+00	2.77E+02
		HCl	kg/day	1.67E+02	3.00E+00	1.94E+02
		DXNs	kg/day	5.06E−05	5.65E−09	4.96E−05
		Dust	kg/day	4.84E+01	1.00E+00	5.03E+01
	Byproducts	Metal	kg/day	0.00E+00	3.15E+03	8.52E+03
		Slag	kg/day	0.00E+00	7.96E+04	6.81E+04
	Residue	Incineration ash	kg/day	8.91E+04	–	–
		Incineration fly ash	kg/day	2.56E+04	–	–
		Incineration unfit matter	kg/day	0.00E+00	–	–
		Melting fly ash	kg/day	0.00E+00	7.25E+03	1.89E+04
		Melting unfit matter	kg/day	0.00E+00	8.20E+03	1.02E+04
	Power generation		kWh/day	3.45E+05	–	3.27E+05

8.4.3.2 Building Database of Incineration Power Generation and Setting Default Values

To assess the power generation of incinerated waste, the survey “analysis of waste incineration facilities’ power generation efficiency” is conducted among plant designers. The LCI database is created based on this survey and the incineration power generation value. Efficiency is analyzed via relationships among treatment scale, steam conditions, and input heating values. For the 12 cases in Table 8.5, we conducted a survey about waste power generation. The outcome of the survey is presented in the database (excerpt) and shown in Table 8.6.

Based on the above survey, we analyzed the influence of treatment scale, steam conditions, and input heating values of waste power generation efficiency. Regarding treatment scale, efficiency will increase by 3% if the facility is 600 t/day, and by 4%

Table 8.5 Twelve case studies

Case	Scale of the facilities	Steam conditions	Input waste
1	100 t/day	300 °C × 30 ata	1600, 2000, 2400 kcal/kg
2		400 °C × 40 ata	
3		450 °C × 60 ata	
4		500 °C × 100 ata	
5	300 t/day	300 °C × 30 ata	
6		400 °C × 40 ata	
7		450 °C × 60 ata	
8		500 °C × 100 ata	
9	600 t/day	300 °C × 30 ata	
10		400 °C × 40 ata	
11		450 °C × 60 ata	
12		500 °C × 100 ata	

Table 8.6 Incineration power generation database (extract)

Eight targeted companies	Unit	2003 database in average			
Waste treatment amount	t/day	600			
Heating value of input waste	kcal/kg	2400			
Steam condition	°C	300	400	450	500
	ata	30	40	60	100
Purchasing power amount	kWh/day	0	0	0	0
Heating value of input waste	kWh/day	1.7E+06	1.7E+06	1.7E+06	1.7E+06
Heating value of input fuel	kWh/day	5.8E+04	5.8E+04	7.6E+04	8.9E+04
Total heat input	kWh/day	1.7E+06	1.7E+06	1.8E+06	1.8E+06
Power generation amount	kWh/day	2.9E+05	3.3E+05	3.6E+05	4.0E+05
Power generation efficiency	%	1.6E+01	1.9E+01	2.1E+01	2.2E+01
Plant consumption	kWh/day	1.1E+05	1.1E+05	1.1E+05	1.1E+05
Selling power amount	kWh/day	1.7E+05	2.1E+05	2.5E+05	2.8E+05
Power transmission efficiency	%	9.8E+00	1.2E+01	1.4E+01	1.6E+01

if. Regarding the steam conditions, it was found that the efficiency will be significantly improved under high temperature and high pressure. For instance, the efficiency will be 10–15% if under 300 °C × 30 ata and 14–21% if under 500 × 100 ata. The survey outcome also shows that the efficiency will drop sharply when the treatment scale is reduced.

The BAS methodology enables the calculation of the proportion interpolating according to the treatment scale and heating value of input waste.

8.4.3.3 Building Database of Emission Gas Treatment and Setting Default Value

A suitable emitted gas treatment is necessary because the gas emitted accounts for more than 50% of the environmental load during MSW's incineration process. Utility and cost databases were created based on a survey called "Emitted gas treatment and cost efficiency" about NO_x, SO_x, HCl, and DXN treatments. The investigated treatment is illustrated in Table 8.7. As a sample, the outcome of NO_x treatment (extract) is shown in Table 8.8.

Table 8.7 Target gas and treatment technology

Target gas for treatment	NO_x	SO_x	HCl	DXNs
Treatment technology	• Urea blowing method • Denitration catalyst method	• Slaked lime blowing method • Wet smoke gas cleaning method • Na series of medical blowing method		• Catalytic reaction tower • Activated carbon blowing method • Activated carbon absorption method • Catalytic reaction tower + Activated carbon blowing method

Table 8.8 Gas treatment database (extract)

Item		Unit	Seven companies in average
Treatment targe	NO_x	–	–
Treatment technology	Urea blowing method	–	–
No_x emission concentration	Concentration before treatment	ppm	1.4E+02
Medicine input	Reduced concentration	ppm	7.7E+01
	Urea	kg/year	8.8E+05
Cost	Waste among/t	kg/t	4.8E+00
	Construction cost	Yen	3.6E+07
	Repart cost	Yen/year	1.7E+06
	Urea	Yen/year	1.6E+07

This study found that facility fees and initial cost of denitration catalyst and wet smoke gas cleaning methods increase sharply compared with urea blowing and slaked lime blowing methods. Regarding running cost, NO_x and HCl increase 3–4 times.

8.5 Application of BAS Methodology in Municipalities

8.5.1 Evaluation Background

We conducted a case study and applied BAS methodology in municipality city A. The waste (excluding resource waste) treatments are conducted by an incineration power generation facility and a crushing facility. The incineration ash emitted from the incineration facility and incombustible residue from the crushing treatment facility were treated by landfilling in a final disposal site outside the city. In this research, we assess the current situation of the waste treatment system in city A and provide improvement proposals, which range from evaluating its collection (recycling) to its final disposal (use). In cases where data is insufficient to perform analyses, we apply BAS's default values.

8.5.2 Evaluation of Current Treatment

Table 8.9 summarizes the incineration facilities in city A. Figure 8.4 shows the calculation outcome of ELP based on the current treatment cost of different processes. It illustrates that the incineration power generation process is the process most expected to go down in cost as it has the highest cost and largest ELP. We recommend improving the level of detail in the classification of kitchen garbage. Besides, the final disposal treatment (landfill) of incineration ash also has a high cost and ELP. Hence, we suggest that city A introduce and apply melting technology to reduce the amount of incineration ash produced.

Table 8.9 Incineration facilities in city A

Operation year	1994
Processing capacity (t/day)	600
Treatment system	Stoker
Operation pattern	Continuous operation
Generation power (kW)	7000
Smoke control equipment	Electric precipitation
Annual throughput (t/year)	135,936
Operation rate	0.68

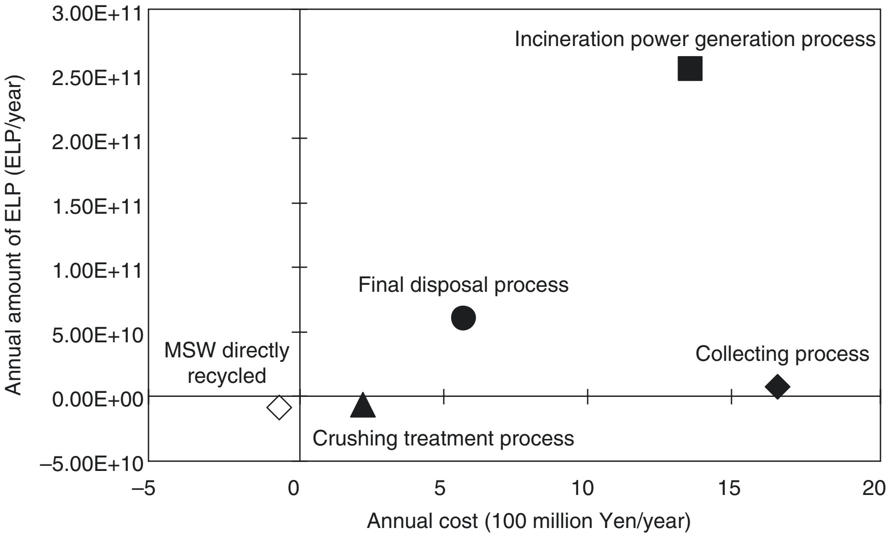

Fig. 8.4 ELP and cost in different processes

8.5.3 Case Study

The hypothetical scenarios in each case and their parameters are shown in Fig. 8.5. Through applying the BAS methodology, the ELP and cost database of input and output amounts for treatment processes are able to inform a variety of improvement scenarios. In this study, using kitchen garbage as an example waste type, we attempt to create a scenario following an incineration ash reduction policy, which is based on incineration output reduction perspectives and involves introduction of melting technology. Regarding the cost, we calculate it based on treatment expense (see Table 8.10). And about ELP, we calculate it based on BAS methodology databases.

The cost and ELP outcomes of each case are shown in Fig. 8.6. About the cost, it becomes larger than current situation (case 1) in cases 2–6 due to the introduction of ash melting and change of gasification melting. And about the fly ash recycle, it is found that there is almost no expense variation due to the little recycle amount. And, we also found that the cost is larger in case 6 than that of case 1, which is because the expense increases with recycling and bio-gasification treatment. However, the ELP in case 6 decreases significantly, which is smaller than that in cases 2–5 due to the decrease of final disposal, ash technology, and incineration amount. Hence, case 6 is the most effective one for ELP reduction if conducting bio-gasification, but the cost also increases relatively.

The ELP relative reduction effectiveness that represents ELP mitigation amount in step with increasing each cost unit is illustrated in Table 8.11. And we found out that ELP reduction effectiveness of CASE 5 is the highest.

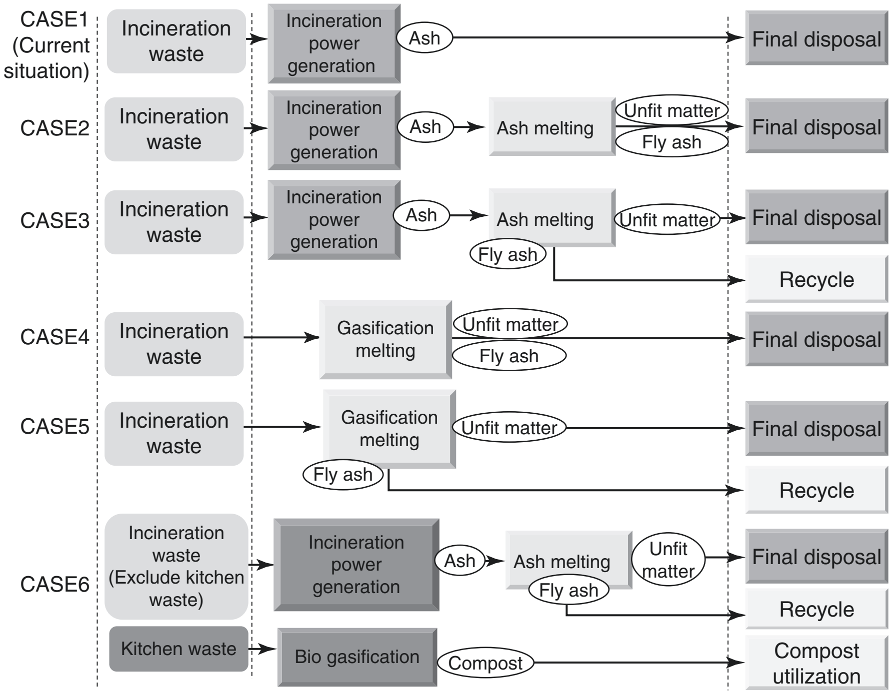

Fig. 8.5 Hypothetical scenarios in each case

BAS is an integrated evaluation method that analyzes the cost and ELP, and it also provides assessment value of material recycling, energy recycling, CO_2 emission, and final disposal amount. And comparisons among cases are shown in Table 8.12.

The material recycling is the process that collects iron, metal, and melting slag that come from facilities like crush treatment and direct recycling. Moreover, a trend of relation is also found from the outcome. In cases 2–6, the results demonstrate that the final disposal amounts decrease while the CO_2 emissions increase. And the scenario varied according to the preference for policies between landfill and CO_2 reduction. In this study, we are able to analyze and assess the trade-off factors by applying the BAS based on ELP, and it is proofed that the ELPs of cases 2–6 are more effective and integrated than the current situation (case 1).

However, the cost has to be increased in each scenario. Hence, it is necessary to conduct deep consideration of each system based on the municipal financial situations. And, corporations among neighboring municipalities are recommended so as to enlarge the scale merit and reduce the economic burden.

8.6 Summary

The development of evaluation tools for MSD treatment systems' ELP and cost and verification of their applicability is summarized in the following points:

Table 8.10 Calculation of treatment cost[a]

Items	Incineration power generation	Ash melting	Gasification melting	Incineration power generation (exclude kitchen waste)	Fly ash recycle	Final disposal	Kitchen waste bio-gasification
Treatment amount t/year	135,936	10,091	135,936	97,154	–	–	–
Construction fee[b] 1000 yen/year	1,000,000	171,008	1,026,353	588,235	–	–	–
Labor cost[c] 1000 yen/year	140,000	105,000	210,000	140,000	–	–	–
Utility cost 1000 yen/year	123,665	132,536	183,918	84,315	–	–	–
Maintenance cost[d] 1000 yen/year	600,000	102,605	615,812	600,000	–	–	–
Power selling income 1000 yen/year	−504,898	0	−394,674	−549,209	–	–	–
Total 1000 yen/year	1,358,766	511,148	1,641,409	863,340	–	–	–
Treatment/consign unit 1000 yen/t	10.0	50.6	12.1	8.89	50.0	27.9	35.0

[a]Hearing survey from whom it concerned
[b]The construction fee is calculated considering lifespan of 20 year
[c]The number of workers are set as: 20 people for incineration generation,15 people for ash melting, 30 people for gasification melting
[d]Calculation by using 3% construction fee

1. We developed a Best Available System (BAS) methodology using LCA and LCC.
2. By applying the BAS in a municipality, we found that it is able to assess ELP and cost of current MSW treatments. Furthermore, the BAS' applicability is verified through a case study.

Moreover, through the case study, we found that it is necessary to understand ELP and cost of treatment processes so as to offer detailed improvement proposals for municipalities. Regarding ELP reduction, this study indicates that the cost will increase when the ELP decreases, which is conceptually comprehensible. However, this

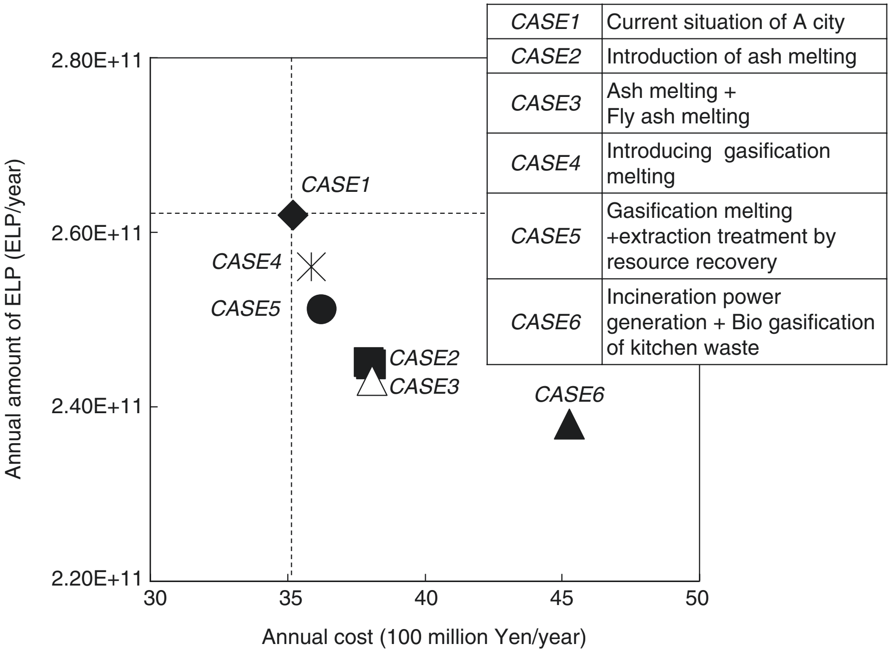

Fig. 8.6 ELP and cost in different cases

Table 8.11 ELP relative reduction effectiveness in each case

Case	2	3	4	5	6
ELP relative reduction effectiveness	−0.83	−0.90	−1.06	−1.43	−0.32

Table 8.12 Effect comparisons among specific index in each case (relative)

Case	ELP	Cost	Final disposal amount	Material amount	Energy recycling amount	CO_2 emissions
1 (current situation)	100	100	100	100	100	100
2	93	108	32	121	100	102
3	92	108	26	121	100	102
4	98	102	40	118	95	103
5	96	103	27	118	95	104
6	90	131	30	121	126	101

research provides quantitative data and emphasizes the significance of assessing the importance of recycling in more nuanced ways. Besides, with strained municipal finances, reducing the ELP and cost is a crucial issue. Hence, it is urgent and necessary to consider applying the BAS methodology so as to achieve the minimum cost and a society where recycling is the norm. We expect this debate to be resolved soon and the BAS methodology be selected among a large number of LCA evaluation approaches.

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