The Socialist Republic of Vietnam (SNV)

The Preparatory Survey on Wastewater Management and Solid Waste Management for Da Nang City The Socialist Republic of Viet Nam

Final Report
Summary

November 2014

Japan International Cooperation Agency (JICA)

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JFE Engineering Corporation
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Figures and Tables

Abbreviations

AMPDC	Adjustment of Master Plan of Da Nang City to 2030 and Vision 2050
BOT	Build Operate and Transfer
CAPEX	Capital expenditures
DONRE	Department of Natural Resources and Environment
DPI	Department of Planning and Investment (of Da Nang)
DPC	Da Nang People's Committee
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPC	Engineering, Procurement, Construction
EVN	Electricity of Vietnam
FIRR	Financial Internal Rate of Return
JCM	Joint Crediting Mechanism
JPY	Japanese Yen
MBT	Mechanical Biological Treatment
MOE	Ministry of the Environment (of Japan)
MONRE	Ministry of Natural Resources and Environment (of Vietnam)
MPI	Ministry of Planning and Investment (of Vietnam)
O&M	Operation and Maintenance
OPEX	Operating Expense
PPP	Public-Private Partnership
GRDP	Gross Regional Domestic Product
SPC	Special Purpose Company
URENCO	Urban Environment Company (of Da Nang)
USD	United States Dollars
VND	Vietnamese Dong

Note on exchange rate

In this report, the exchange rate applied is:

100 JPY = 1 USD = 20,000 VND

Preface

This survey was initiated based on the contract signed between JICA and the Survey Team on 15 June 2012 with the objective to prepare for a PPP project on waste and wastewater treatment in Da Nang City. This objective was based on the Minutes of meetings on the mission for the preparatory survey on wastewater management and solid waste management for Da Nang city in the Socialist Republic of Vietnam which was signed between JICA and the People's Committee of Da Nang City on 28 December 2011.

However, as JICA and the People's Committee of Da Nang City agreed to exclude the wastewater treatment from the scope of the survey on 19 December 2012, the report on wastewater that were compiled before December 2012 could not be officially approved by the Da Nang City and thus was annexed to this report.

1 Da Nang City Profile

1.1 Natural Conditions

1.1.1 Geography

Da Nang is one of the major port cities in Vietnam (in addition to Ho Chi Minh city and Hai Phong), and the biggest one on the South Central Coast of Vietnam, on the coast of the South China Sea at the mouth of the Hàn River. It is the 4th biggest economic centre in Viet Nam after Hanoi, Ho Chi Minh, and Hai Phong. The city is 759 km south of Hanoi, and 960 km north of Ho Chi Minh City.

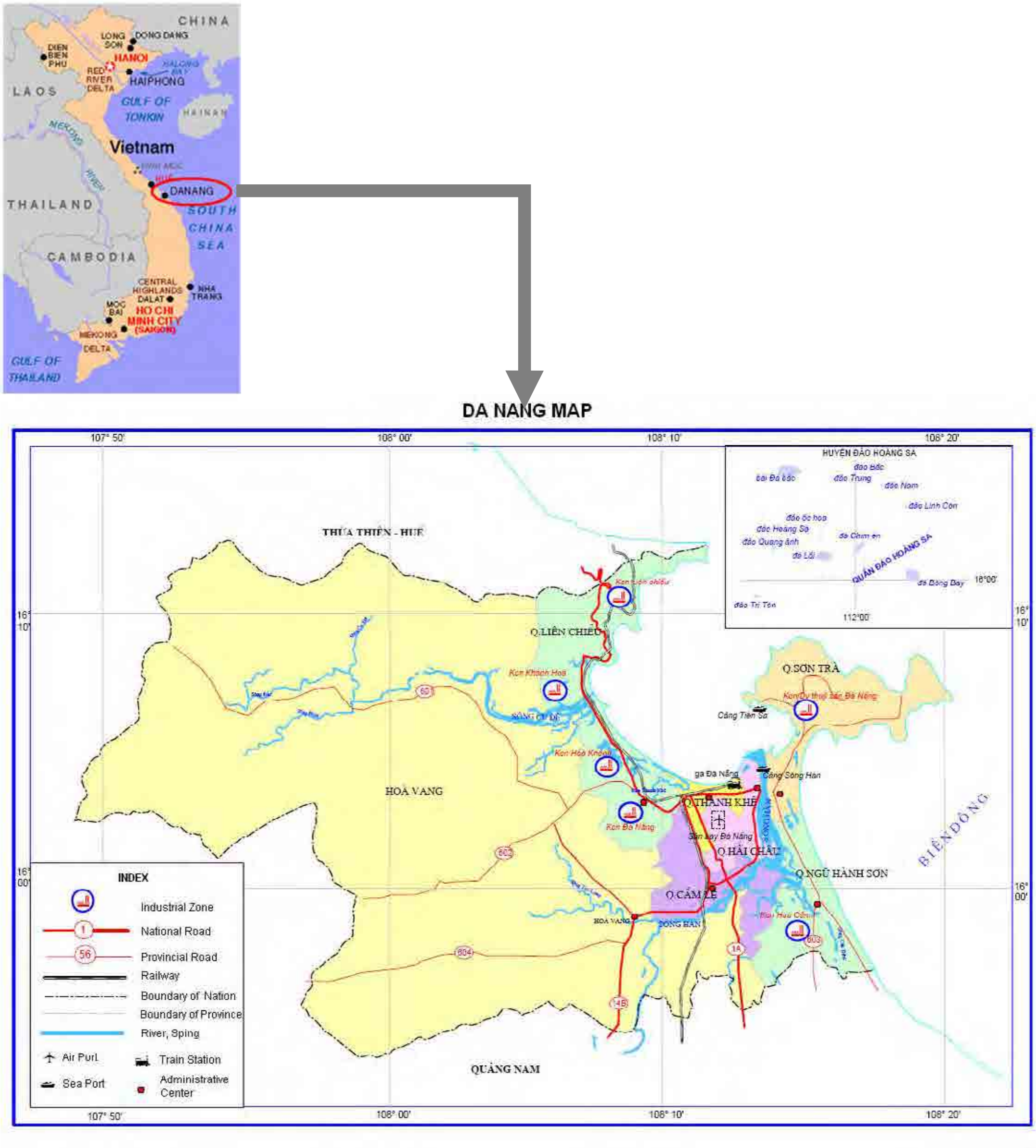


Figure 1-1: Geographical Location of Da Nang

1.1.2 Climate

Da Nang has a tropical monsoon climate with two seasons: a typhoon & wet season lasting from September through March and a dry season lasting from April through August. Temperatures are typically high, with an annual average of 25.2 °C in 2011. Temperatures are highest between June and August, and lowest between December and February. The annual average for humidity is 82.3% in 2011, with highs between October and February and lows between May and July.

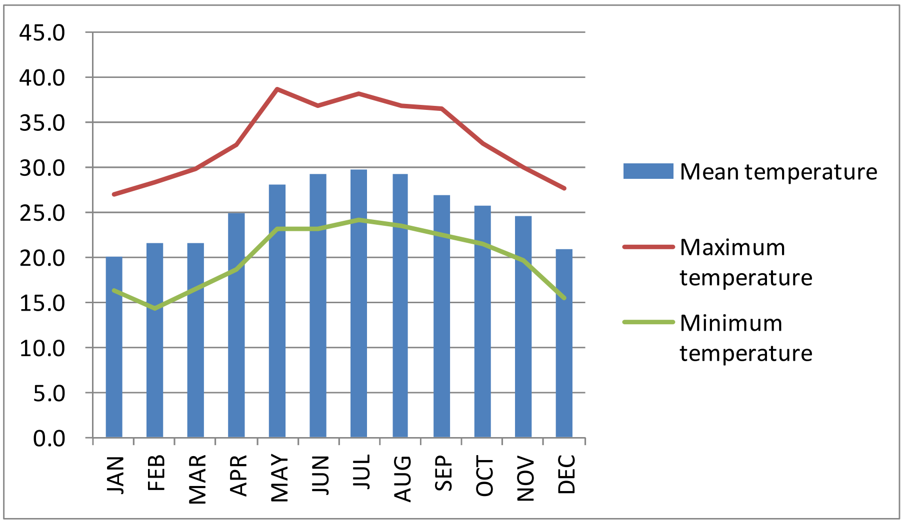


Figure 1-2: Monthly Temperature in Da Nang (2011)

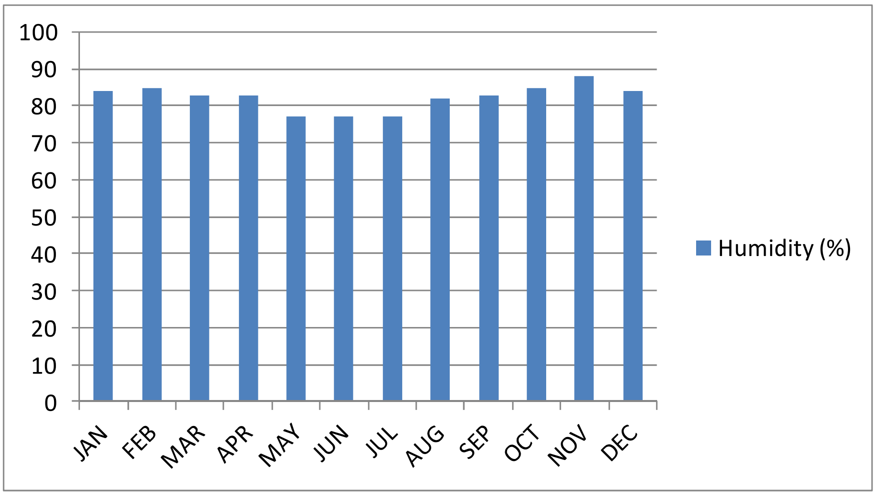


Figure 1-3: Monthly Humidity in Da Nang (2010)

Da Nang totally receives 3,716 mm of rainfall in 2012. Rainfall is typically highest between September and November (ranging from 810 to 1,241mm) and lowest between February and May (ranging from 0 to 36 mm). Da Nang receives an average sunshine hours of 2,013 annually during 2002-2011, with highs between 240 and 250 hours per month in May and July and lows between 80 and 100 hours per month in November and December.

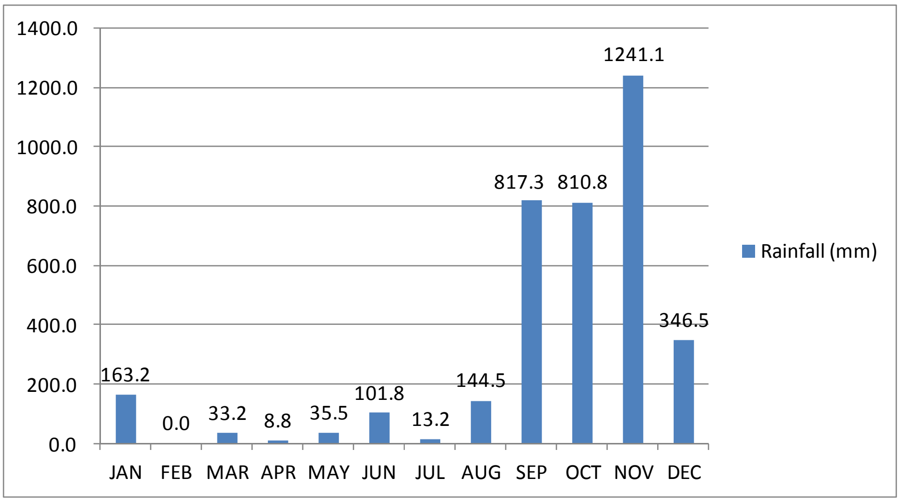


Figure 1-4: Monthly Rainfall in Da Nang (2011)

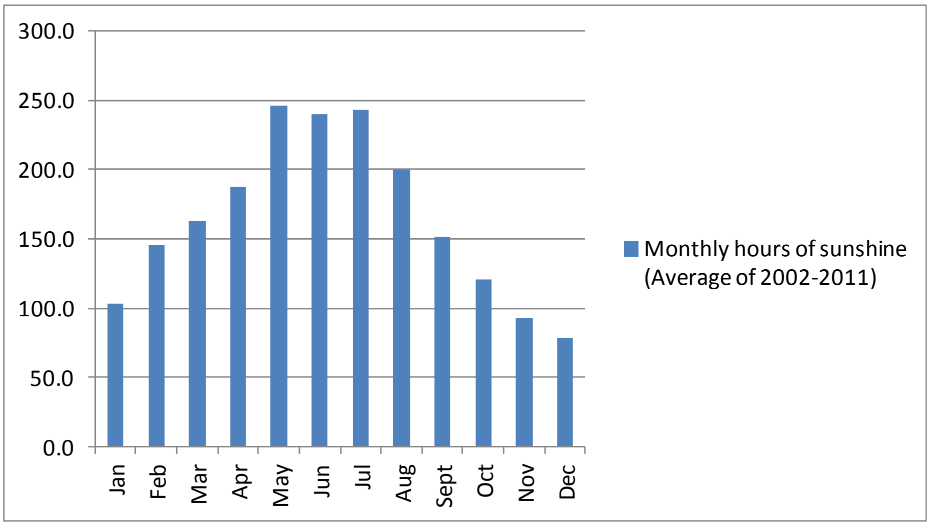


Figure 1-5: Monthly Hours of Sunshine in Da Nang (Average of 2002-2011)

1.2 Socio-Economic Conditions

1.2.1 Demography

According to the 2009 census, Da Nang is the fifth most populated city in Vietnam with a population of 887.4 thousand. The average annual population growth between the census of 1999 and 2009 is 2.6%, which is the 6th highest in the country behind Bình Dương (with 7.3%), Hồ Chí Minh City (3.5%), Kon Tum (3.1%), Bình Phước (2.9%), and Gia Lai (2.7%). The city has the highest urbanization ratio among provinces and municipalities in Vietnam, containing only 11 rural communes, the fewest of any province-level unit in Vietnam. As of 2009, 86.9% of Da Nang's population lived in urban areas; average annual urban population growth was 3.5%.

Da Nang's crude birth rate was recorded at 18.6 live births per 1000 persons; the crude death rate was measured at 6.7 per 1000 persons. Life expectancy at birth was estimated at 77.4 years for women and 72.4 years for men, or 74.8 years overall. The infant mortality rate was measured at 11.0 infant deaths per 1000 live births, less than two points above the nation's average for urban areas. In the same census, the city's immigration and emigration rates were measured at 10.06% and 2.4%, respectively, for a net migration rate of 7.7%. Da Nang's population is estimated to reach one million inhabitants by 2014. The figure below compares the population pyramids between the whole country of Viet Nam and Da Nang City.

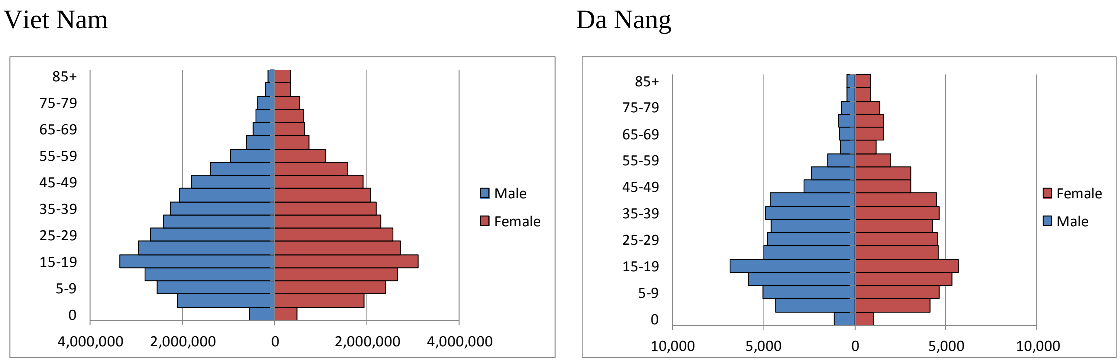


Figure 1-6: Population Pyramid (Viet Nam and Da Nang) in 2009

The city has the highest urbanization ratio among provinces and municipalities in Vietnam, containing only 11 rural communes, the fewest of any province-level unit in Vietnam. As of 2009, 86.9% of Da Nang's population lived in urban areas; average annual urban population growth was 3.5%.

1.2.2 Regional Gross Domestic Product (RGDP)

RGDP in Da Nang is 28,902 billion VND (Vietnamese dongs) at current prices (approx. 60.2 billion US dollars) in 2010. Per capita RGDP in 2010 is 35.87 million VND or about 1,700 US dollars. About 54% of RGDP in Da Nang comes from service industry, followed by manufacturing and construction (42%). The primary industry (Agriculture, forestry and fishing) only occupies about 4% of RGDP in Da Nang.

Table 1-1: RGDP by types of economic activities in Da Nang (2011)

Type of Economic Activities	Million dongs	%
Agriculture, forestry and fishery	**1,084,748**	**3.75**
Agriculture	383,128	1.33
Forestry	46,902	0.16
Fishery	654,718	2.27
Industry and Construction	**12,142,769**	**42.01**
Mining and Quarrying	123,015	0.43
Manufacturing	6,338,404	21.93
Electricity, Gas Supply	2,159,210	7.47
Construction	3,522,140	12.19
Services	**15,674,463**	**54.21**
Wholesale, retail and vehicles repair	3,467,463	12.00
Hotels and restaurants	1,220,702	4.22

Type of Economic Activities	Million dongs	%
Transport, storage and communication	4,622,118	15.99
Financial service	2,060,535	7.13
Scientific and technical services	34,499	0.12
Real estate, leasing and rental services	1,149,906	3.98
Public administration, defense and social security	466,250	1.61
Education and training	987,345	3.40
Health and social works	414,669	1.43
Culture and sporting activities	205,845	0.71
Party and membership organizations	41,895	0.14
Social and personal services	215,217	0.74
Private households with employed persons	25,569	0.09
Import duty	761,131	2.00
Total	**28,901,980**	**-**

1.3 Revenue and Expenditure of Da Nang

The local revenue of Da Nang City has been steadily increasing with the growth of local economy. It is estimated to reach 21.3 trillion VND (101 billion JPY or 1 billion USD) in 2011. Land use tax is the biggest source of local revenue with 5.5 trillion VND, followed by value added tax of import goods with 1.8 trillion VND. As to the local budget expenditure, it is estimated to be approximately 15 trillion VND in 2011, of which 7.6 trillion is capital expenditure for the city's development. Out of the total operation expenditure of 3.75 trillion VND, the expenditure related to environment protection is 96 billion VND in which the budget allocation for SWM of about 53 billion VND in 2011.

Table 1-2: Da Nang State Revenue and Expenditure during 2008-2011

(Unit: VND million)

Item	2008	2009	2010	2011(Est.)
GDP in the Province at current prices	20,255,442	24,388,881	30,754,765	39,021,725
Total Local Budget Revenue	12,509,500	14,109,700	16,580,800	21,318,600
I. Export and Import Duties	915,000	1,618,100	971,300	782,300
II. Value Added Tax of Import	1,431,900	976,600	1,134,100	1,805,600
III. Domestic Revenue	6,100,200	5,463,700	9,527,900	11,422,400
1. Revenue from Central Enterprises	117,600	108,100	108,900	146,900
2. Revenue from Local State Enterprises	707,100	731,300	880,700	840,500
3. Revenue from Foreign Investment	492,600	500,700	760,400	896,900
4. Revenue from Non-State Enterprises	633,400	676,700	1,280,400	1,674,300
5. Income Tax	136,900	232,600	435,900	538,100
6. Registration Fees	174,100	229,700	309,300	365,400
7. Other Fees	114,700	263,100	583,500	818,300
8. Land and Housing Taxes	3,408,200	2,322,400	5,055,200	5,506,200
(1) Land Use Tax	3,042,100	2,242,800	4,606,000	5,431,100
(2) Housing Tax	20,400	24,100	26,800	29,600
Total Local Budget Expenditure	6,299,500	7,988,300	10,474,300	15,056,400
I. Local Government Expenditure	5,897,700	6,877,900	9,304,200	11,436,100

Item	2008	2009	2010	2011(Est.)
1. Capital Expenditure	3,705,400	4,894,800	6,226,300	7,626,500
2. Current Expenditure	1,889,400	1,964,500	3,046,000	3,750,300
(1) Education/Training	525,300	586,100	827,100	1,002,400
(2) Health	404,100	331,000	716,500	909,000
(3) Science and Technology	8,400	13,900	14,000	25,200
(4) Culture and Information-gym, sport	45,500	57,800	88,500	102,900
(5) Social Welfare	149,300	113,500	208,000	285,100
(6) Economic Development	143,800	155,900	237,600	293,800
(7) Environment Protection	42,400	39,700	78,700	96,000
(8) Administrative Expenditure	345,200	420,900	545,800	677,000
(9) Miscellaneous Expenditure	126,400	159,300	222,400	214,800
3. Transfer to Financial Reserve Fund	5,000	10,000		20,000
4. Transfer to Next Year’s Budget			406,900	2,854,700
II. Additional Expenditure under Budget	401,500	469,500	543,600	750,600
III. Others	300	640,900	219,500	15,000

Source: Da Nang Statistical Yearbook 2011.

2 Solid Waste Management in Da Nang City

2.1 Generation Characteristics of Solid Waste

The solid waste in Da Nang city is mainly categorized into the following types:

- Municipal solid waste,
- Industrial solid waste
- Medical waste

The current conditions of the above solid waste are outlined below.

2.1.1 Municipal Solid Waste

According to the survey data of URENCO, Da Nang City collected about 268 thousand tons of municipal solid waste in 2013, and the collection rate for 2012 was 92%. Per capita waste generation in Da Nang City is 0.675 kg per day in 2010. Although the majority of municipal solid waste comes from households, the wastes from non-household sources such as hotels, restaurants, markets, and other business/commercial establishments also show significant growth their amount with the growth of economy in the city. Recently, the waste generated from coastal tourism and resort areas is also problematic in terms of keeping these areas clean and valuable for the domestic and foreign tourists.

Table 2-1: Waste Collection by URENCO (2007-2013)

Unit: tons/year

Type of waste	2007	2008	2009	2010	2011	2012	2013
Municipal solid waste	No data	No data	205,009	223,521	232,233	252,504	262,182
Industrial non-hazardous waste	No data	No data	2,914	3,242	3,917	3,723	4,199
Medical non-hazardous waste	No data	No data	1,257	1,372	1,553	1,889	2,216
Sub-total (non-hazardous)	No data	No data	209,180	228,135	237,703	258,116	268,597
Industrial hazardous waste	Not collected	Not collected	219	415	267	404	359
Medical hazardous waste	Not collected	Not collected	144	150	185	209	217
Sub-total (hazardous)	Not collected	Not collected	363	565	453	613	576
Total	**191,002**	**194,000**	**209,663**	**228,700**	**238,156**	**258,938**	**269,390**
Septic tank sludge	7,320	8,296	11,482	16,776	22,616		

Source: URENCO

Table 2-2 shows the result of URENCO's survey on composition of municipal solid waste in Da Nang. It clearly indicates its high domination of organic waste in Da Nang's municipal solid waste, which causes serious sanitary and environmental issues during collection, transportation and final disposal.

Table 2-2: Composition of Municipal Solid Waste in Da Nang City (2010)

Type of Waste	Percentage (%)
Papers/Cardboards	5.16
Food/garden waste	74.65
Wood waste	0.67
Fabric and textile waste	3.18
Leather waste	0.83
Rubber waste	1.29
Plastic waste (PET)	0.07
Plastic waste (PVC)	0.62
Nylon wrappers	11.58
Multi-component plastics	0.42
Scrap metals	0.19
Ceramic waste	0.55
Glass waste	0.74
Household hazardous waste (battery, spray cans, light bulbs, etc.)	0.03
Medical waste (needles, expired drugs, etc.)	0.02

Source: URENCO (2010)

Since the data in the table above is based on the analysis of waste at Khan Son landfill after removal of valuable materials by waste-pickers, the percentage of recyclable wastes such as scrap metals and plastics is very low except nylon wrappers (plastic bags).

2.2 Solid Waste Management Administration by URENCO

2.2.1 Organization and Human Resources

Municipal solid waste management in Da Nang City is the responsibility of the Urban Environment Company (URENCO) of Da Nang. URENCO consists of 1,130 employees under the organization structure shown in the figure below. The members of the management board are shown in the table below.

Table 2-3: Management Board Members of Da Nang URENCO

No.	Department	Number of officers
I	**Office Department**	67
1	**Board of General Director (1 General Director and 3 Deputy General Director)**	4
2	**Control Board**	1
3	**Professional Division**	
	Admin and Organization Division	18
	Investment and Planning Division	8
	Accounting- Finance Division	7
	Technique Division	10
	Environment and Technology Division	9
	Sales Division	10

No.	Department	Number of officers
II	**Subordinate units**	258
1	Inspection Board	20
2	Hai Chau 1 Environment Enterprise	23
3	Hai Chau 2 Environment Enterprise	24
4	Thanh Khe 1 Environment Enterprise	22
5	Thanh Khe 2 Environment Enterprise	19
6	Cam Le Environment Enterprise	20
7	Hoa Vang Environment Enterprise	13
8	Lien Chieu Environment Enterprise	18
9	Son Tra Environment Enterprise	20
10	Ngu Hanh Son Environment Enterprise	15
11	Service Enterprise No.1	13
12	Service Enterprise No.2	16
13	Transport Enterprise	11
14	Landfill Management Enterprise	18
15	Consulting Center for Environmental Technology Investment and Development	6

2.2.2 Current SWM Services by URENCO

According to the information and data provided by URENCO Da Nang, the recent record of solid waste collection is as outlined in the table below.

Table 2-4: Waste Collection by URENCO (2007-2013) (reproduction of Table 2-1)

Unit: tons/year

Classification	2009	2010	2011	2012	2013
Domestic Waste	205,009	223,521	232,233	252,504	262,182
Industrial Non-Hazardous Waste	2,914	3,242	3,917	3,723	4,199
Medical Non-Hazardous Waste	1,257	1,372	1,553	1,889	2,216
Sub-total	209,180	228,135	237,703	258,116	268,597
Hazardous Waste	363	565	453	404	359
Industrial Solid Waste	*219*	*415*	*267*	209	217
Medical Waste	*144*	*150*	*185*	613	576
Total (Hazardous + Non-hazardous)	**209,633**	**228,700**	**238,156**	**258,938**	**269,390**
Septic Tank Sludge	11,482	16,766	22,616	19.688	29.200

According to the latest information, the total amount of waste collected by URENCO reached about 270,000 tons in 2013, which means that about 730 tons of waste are daily collected and transported to Khanh Son Landfill daily. Waste collection service coverage by URENCO has reached 92% in 2012. Majority of Da Nang Province have access to SWM services except rural villages in mountainous areas.

2.2.3 Revenue and Expenditure of URENCO Da Nang

The table below shows the revenue and expenditure of URENCO Da Nang during 2008-2012. The total revenue in 2012 is approximately 132.4 billion VND, which is equivalent to 6.2 million US dollar. About a half of revenue comes from direct collection of SWM service fees from various sources of waste generation such as households, business/commercial entities, industrial establishments, medical facilities, and so forth. The remaining half of the revenue is provided from Da Nang City government as budget allocation.

Table 2-5: Revenue and Expenditure of URENCO (2008-2012)

Unit: million VND

Item	2008	2009	2010	2011	2012
1. Revenue	66,300	78,176	84,776	105,589	133,150
1.1 Public Service Fees	23,561	25,674	29,247	36,256	47,290
1.2 Operation Budget	34,880	41,801	43,033	53,416	67,256
a. Business contract	32,033	38,117	42,012	-	67,096
b. Other budget allocations	2,047	3,484	1,020	-	160
c. Septic tank collection	800	200	0	-	0
1.3 Services for industrial waste	7,265	5,192	6,365	8,735	11,321
1.4 Services for hazardous waste	594	5,508	5,982	6,080	6,536
1.5 Miscellaneous services	0	0	150	1,101	747
2. Expenditure	64,902	76,953	83,659	104,826	132,064

Item	2008	2009	2010	2011	2012
2.1 Materials	13,875	13,894	16,260	22,516	29,712
2.2 Labors	29,133	46,255	47,219	60,269	75,523
2.3 Service Consignment	1,306	1,670	1,520	4,231	4,144
2.4 Miscellaneous expenses	18,904	12,764	13,426	12,155	16,481

Source: URENCO Da Nang

According to "The 2012 Annual Report on Solid Waste Management in Da Nang City", which was prepared by URENCO Da Nang and submitted to Department of Construction of the Da Nang People's Committee, the municipal solid waste management cost is reported as shown in the table below.

Table 2-6: Municipal Solid Waste Management Cost by type of activities (2012)

<table>
<tr><th>City</th><th>Waste Collection (VDN/ton)</th><th>Waste Transportation (VND/ton)</th><th>Waste Treatment and Disposal (VND/ton)</th><th>Total Cost of Domestic Waste Management (million VND/year)</th></tr>
<tr><td rowspan="3">Da Nang</td><td>By hand carts: 116,055</td><td></td><td rowspan="3">25,473</td><td rowspan="3">58,838
(233,018VND/ton)</td></tr>
<tr><td colspan="2">By trash box collection with trucks 167,016</td></tr>
<tr><td colspan="2">By curbside collection with trucks 166,214</td></tr>
</table>

Remark: Waste treatment and disposal cost only covers the current running cost of Khanh Son Landfill.

The unit cost of municipal SWM carried out by URENCO is approximately 233 thousand VND (USD 11.7) per ton of waste handled including collection, transportation and disposal. The above table also shows that the cost of waste treatment and disposal is only 25,473 VND (or 1.3 USD) per ton of waste.

On the other hand, the budget allocated for municipal SWM to URENCO is approximately 157 billion VND in 2013, of which 58.754 billion VND is the direct collection of SWM fee from waste generation sources. The budget allocation from Da Nang City is 6,214 million VND while no budget allocation from the National Government of Viet Nam.

Table 2-7: Budget Allocation for Municipal SWM by Da Nang URENCO (2012)

Unit: million VND

Year	National Budget	City Budget	Income from waste management fee	In addition, income from service fee	Total budget for domestic waste management
2012	0	67,255	47,290	18,604	133,150
2013	0	74,388	58,754	24,155	157,298

Note:

(1) This data is the financial report in the end of 2012 and 2013 that has been done and stamped by audit department

(2) Da Nang allocated 67.2 billion VND for environmental management activities including waste management. The budget allocated for Khanh Son disposal site was 6.214 billion VND (only 10% of the total budget)

2.2.4 Operation of Khanh Son Final Disposal Landfill

a. **Outline of Khanh Son Final Disposal Landfill**
The table below summarizes the physical structure and current operation of Khanh Son final disposal landfill.

Table 2-8: Physical Structure and Current Operation of Khanh Son Landfill

<table>
<tr><th>Item</th><th>Contents</th></tr>
<tr><td>Period of use</td><td>From 2007</td></tr>
<tr><td>Address</td><td>No. 471 Nui Thanh St., Da Nang City</td></tr>
<tr><td>Landfill area and structure</td><td>Total landfill area: 13.83 ha (consisting of 5 cells)
<table>
<tr><th>Cell</th><th>Area</th></tr>
<tr><td>1</td><td>2.27 ha</td></tr>
<tr><td>2</td><td>2.73 ha</td></tr>
<tr><td>3</td><td>2.61 ha</td></tr>
<tr><td>4</td><td>2.85 ha</td></tr>
<tr><td>5</td><td>3.37 ha</td></tr>
<tr><td>Total</td><td>13.83 ha</td></tr>
</table>
NOTE: Area of cells were estimated by the JICA Survey Team through CAD drawing data</td></tr>
<tr><td>Facilities</td><td>▪ Leachate treatment facility
▪ Septic tank sludge treatment facility
▪ Incinerator for medical and hazardous waste
▪ Administration building</td></tr>
<tr><td>Waste received</td><td>▪ 736 tons/day on average in 2013.
▪ Landfill area Cell No.1 and 2 has been used for 5 years and have received approximately 1.2 million tons of waste.</td></tr>
<tr><td>Structure and method of landfill</td><td>▪ Structure: Controlled landfill with bottom liners, pipes for leachate collection, and regular soil cover.
▪ Planned height of landfill is 52 meter above ground level.
▪ Bulk density of disposed waste at landfill is regularly checked.
▪ Odor prevention chemical is sprayed twice per day.
▪ Insect prevention chemical is sprayed once a week on average, depending upon the condition of landfill.</td></tr>
<tr><td>Landfill equipment</td><td>▪ 3 bulldozers (40 ton, 30 ton and 20 ton capacity)
▪ No compaction is carried out.</td></tr>
<tr><td>Waste pickers</td><td>▪ There are approximately 200 waste pickers who registered themselves at Khanh Son Landfill.
▪ Waste pickers mainly collect materials such as papers, scrap metals, and plastics.</td></tr>
</table>

b. **Remaining Landfill Capacity of Khanh Son Final Disposal Site**
The Study estimated the total and remaining landfill capacity of Khanh Son final disposal site based on the result of measurement survey. The capacity was estimated with the assumptions that the target height of landfill is 52 meter with a gradient of 1:2.0. The total landfill capacity was estimated as 3.42 million cubic meter of which 880 thousand cubic meters has already been occupied. Its remaining capacity was estimated to be approximately 2.54 million cubic meters.

The table and figure below outline the above estimation.

Table 2-9: Estimation of the Total and Remaining Landfill Capacity of Khanh Son

Item	Volume (m^3)	Remark
Total landfill capacity	3,415,242	Estimated based on the result of measurement survey
Volume already filled by disposed waste	672,271	Ditto
Volume of covered soil	207,450	Thickness of midterm soil cover (50 cm) Thickness of final soil cover (1m)
Remaining landfill capacity	2,535,521	

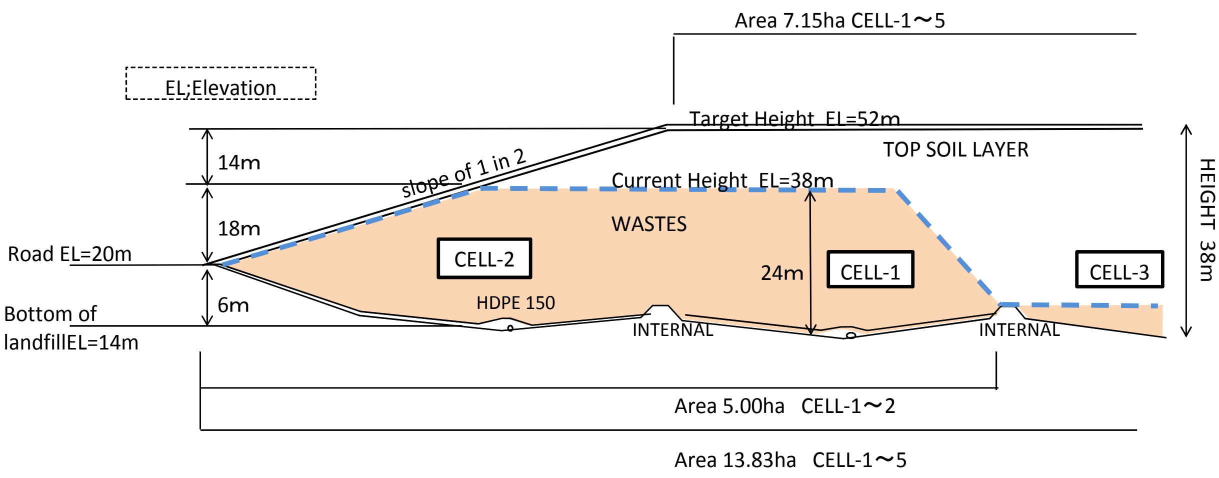


Figure 2-1: Cross-Section View of Khanh Son Landfill

3 Examination of Intermediate Treatment Facility (ITF) Options

3.1 Determination of SWM Service Area and Population Framework

Khanh Son final disposal landfill currently deals with all the municipal solid waste generated within Da Nang city. The planned ITF will also cover the same waste for intermediate treatment. The population covered by the planned SWM services is estimated below.

As to the projected population up until 2030, the Study adopted the figure of 1.2 million, which is provided in the "Adjustment of Master Plan of Da Nang City to 2030 and Vision 2050 (AMPDC)"

The population growth between 2030 and 2036 was estimated based on regression analysis of the growth during 2010-2030. The projected population in 2036 will reach 2.4 million, which 2.6 fold of the population in 2010.

YEAR	Population	Relative increase rate from previous year
2010	926,018	103.52%
2011	951,684	102.77%
2012	973,800	102.32%
2013	1,000,000	102.65%
2014	1,027,000	102.65%
2015	1,054,000	102.65%
2016	1,082,000	102.65%
2017	1,111,000	102.65%
2018	1,140,000	102.65%
2019	1,170,000	102.65%
2020	1,200,000	102.63%
2021	1,263,000	105.24%
2022	1,329,000	105.24%
2023	1,399,000	105.24%
2024	1,472,000	105.24%
2025	1,549,000	105.24%
2026	1,630,000	105.24%
2027	1,715,000	105.24%
2028	1,805,000	105.24%
2029	1,900,000	105.24%
2030	2,000,000	105.24%
2031	2,062,000	103.09%
2032	2,126,000	103.09%
2033	2,192,000	103.09%
2034	2,260,000	103.09%
2035	2,330,000	103.09%
2036	2,400,000	103.09%

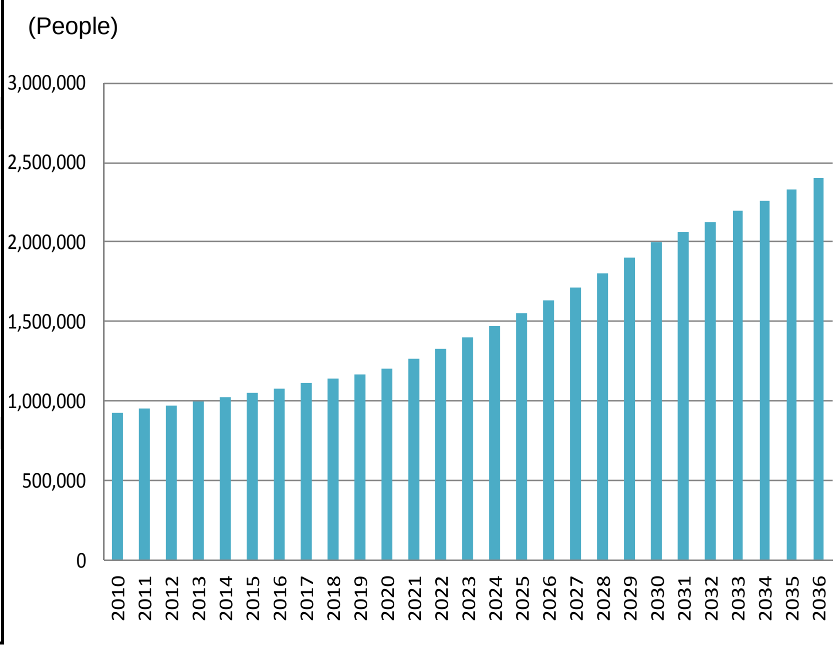


Figure 3-1: Projection of Population of Da Nang

3.2 Estimation of the Amount of Waste Generation and Treatment

3.2.1 Projection of Future Waste Generation and Treatment

The amount of future waste generation and treatment in Da Nang city is estimated as shown in the equation below.

(The amount of treatment)

= (Amount of waste generation)×(1.0 - Waste minimization ratio at sources)×(Collection coverage)

Where:

Amount of waste generation=(Population)×(Per capita waste generation)×(365 days/pear)

Collection coverage: The area or waste generation sources covered by waste collection service

Waste minimization ratio at sources: Percentage of waste reduced at sources by generators' efforts

Each factor defined in the above equation is assumed as shown in the table below.

Table 3-1: Assumptions in Estimating the future waste generation and treatment

Item	Assumptions
Per capita waste generation	According to the estimation on AMPDC, per capita waste generation in 2030 is set at 1.3 kg/day for urban area and 1.2 kg/day for rural area respectively. The average per capita waste generation in Da Nang city is 1.275 kg/day in 2030. Based on this estimation, the Study assumed that the average per capita waste generation will increase by 0.026kg/day every year during 2012-2030 while it will remain unchanged after 2030.
Collection coverage	Based on the target collection coverage of 97.5% in 2030 set in AMPDC, the Study assumed that it will proportionally increase between 2012 and 2030 to reach 97.5% and be kept after 2030.
Waste minimization ratio at sources	Waste minimization ratio at sources is assumed to increase by approximately 1.2%/year on average. It will reach 40% in 2030 and finally grow up to 50%. This waste minimization will be achieved by the following efforts at sources of waste generation: ▪ Waste reduction at sources ▪ Composting of organic waste at sources ▪ Separation of recyclable materials at sources

Table 3-2 shows the results of estimation on future amount of waste generation and treatment in Da Nang city.

Table 3-2: Projected Amount of Waste Generation and Treatment

Year	Population	Generated w aste			Collection ratio	Recycle ratio	Waste to be treated		
		Annual amount	Daily amount	Per capita			Annual amount	Daily amount	Per capita
	persons	tons/year	tons/day	kg/capita/day			tons/year	tons/day	kg/capita/day
	(1)	(2)=(3)x365or 366	(3)=(4)x(1)	(4)	(5)	(6)	(7)=(8)x365 or366	(8)= (3)x(5)	(9)=(8)/(1)
2010	926,018	262,224	718	0.776	0.870	0.00	228,135	625	0.675
2011	951,684	271,661	744	0.782	0.875	0.00	237,703	651	0.684
2012	975,000	288,335	788	0.808	0.880	0.00	253,638	693	0.711
2013	1,001,000	304,714	835	0.834	0.885	0.00	269,735	739	0.738
2014	1,027,000	322,375	883	0.860	0.890	0.00	286,890	786	0.765
2015	1,054,000	340,853	934	0.886	0.895	0.03	297,475	815	0.773
2016	1,082,000	361,163	987	0.912	0.900	0.05	308,904	844	0.780
2017	1,110,000	380,031	1,041	0.938	0.905	0.08	318,280	872	0.786
2018	1,139,000	400,769	1,098	0.964	0.910	0.10	328,135	899	0.789
2019	1,169,000	422,418	1,157	0.990	0.915	0.13	338,355	927	0.793
2020	1,200,000	446,154	1,219	1.016	0.920	0.15	348,798	953	0.794
2021	1,263,000	480,340	1,316	1.042	0.925	0.18	366,460	1,004	0.795
2022	1,329,000	517,935	1,419	1.068	0.930	0.20	385,440	1,056	0.795
2023	1,399,000	558,815	1,531	1.094	0.935	0.23	404,785	1,109	0.793
2024	1,472,000	603,534	1,649	1.120	0.940	0.25	425,658	1,163	0.790
2025	1,549,000	647,875	1,775	1.146	0.945	0.28	443,840	1,216	0.785
2026	1,630,000	697,150	1,910	1.172	0.950	0.30	463,550	1,270	0.779
2027	1,715,000	750,075	2,055	1.198	0.955	0.33	483,625	1,325	0.773
2028	1,805,000	808,494	2,209	1.224	0.960	0.35	504,348	1,378	0.763
2029	1,900,000	866,875	2,375	1.250	0.965	0.38	522,680	1,432	0.754
2030	2,000,000	930,750	2,550	1.275	0.976	0.40	547,500	1,500	0.750
2031	2,062,000	959,585	2,629	1.275	0.976	0.42	547,500	1,500	0.727
2032	2,126,000	992,226	2,711	1.275	0.976	0.43	549,000	1,500	0.706
2033	2,192,000	1,020,175	2,795	1.275	0.976	0.45	547,500	1,500	0.684
2034	2,260,000	1,051,930	2,882	1.275	0.976	0.47	547,500	1,500	0.664
2035	2,330,000	1,084,415	2,971	1.275	0.976	0.48	547,500	1,500	0.644
2036	2,400,000	1,119,960	3,060	1.275	0.976	0.50	549,000	1,500	0.625

3.3 Estimation of the Remaining Capacity and Years of Khanh Son Final Disposal Landfill

Based on the current remaining capacity of Khan Son Landfill (2,535,521 cubic meter) at the time of October 2012 and the result of estimation on future waste generation and treatment above, the Study estimated the remaining years of Khan Son Landfill as shown in the table below.

Table 3-3: Projected Trend of Waste Disposal at Khan Son Landfill

Year	Annual solid waste amount (ton/year)	Annual sludge amount (ton/year)	Annual cover soil amount (ton/year)	Annual landfill amount (ton/year)	Annual landfill volume (m^3/year)	Remaining capacity of landfill (m^3)
2012	-	-	-	-	-	2,535,521
2013	268,597	2,920	16,291	287,808	287,808	2,247,713
2014	286,890	2,999	17,393	307,282	307,282	1,940,431
2015	297,475	3,078	18,033	318,586	318,586	1,621,844
2016	308,904	3,168	18,724	330,796	330,796	1,291,048
2017	318,280	3,244	19,291	340,815	340,815	950,233
2018	328,500	3,329	19,910	351,739	351,739	598,494
2019	338,355	3,416	20,506	362,277	362,277	236,217
2020	348,798	3,514	21,139	373,451	373,451	-137,234

Remark: Average specific gravity of waste is assumed at 1.0 ton/m3 based on the result of waste amount and composition survey conducted in the Study.

The Khan Son Landfill will be fully occupied by 2020 if all the waste collected is disposed without any treatment for volume reduction. The volume of landfilled wastes in Khanh Son disposal site and its lifetime is shown below.

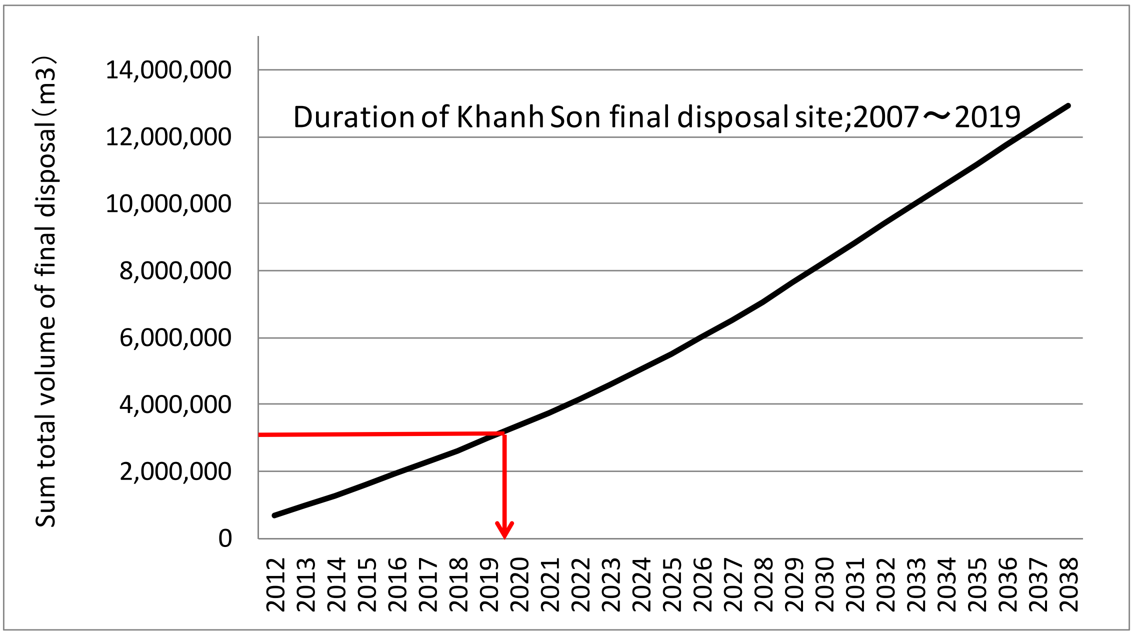


Figure 3-2: Lifetime of Khanh Son Disposal Site

3.4 Selection and Assessment of Intermediate Treatment Facility (ITF) Options

3.4.1 Selection of Intermediate Treatment Method

Intermediate treatment methods for wastes that are currently being commercialized are incineration, mechanical biological treatment (MBT or mechanical composting), and bio-gasification. These methods are compared in the table below.

Table 3-4 Comparison of Waste Intermediate Treatment Methods

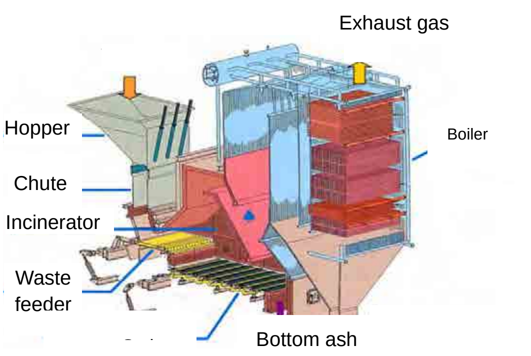
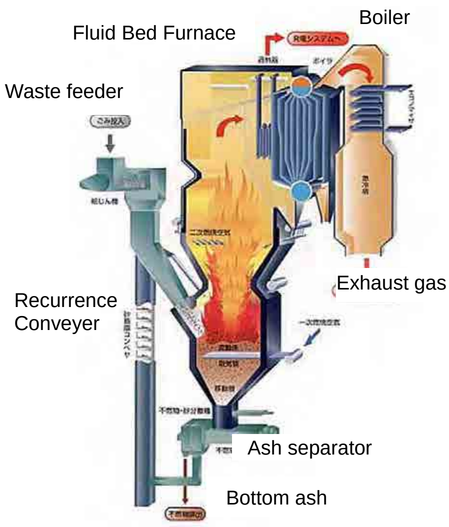
	Incineration and Power generation	Non-incineration	
		MBT (mechanical composting)	Bio-gasification
Waste to be treated	Municipal solid waste, industrial waste (there is no need for careful sorting or selection before incineration)	Mainly for organic wastes such as kitchen wastes or night soil treatment residue (careful sorting and selection is necessary at collection or before treatment)	Mainly for organic wastes such as kitchen wastes or night soil treatment residue (careful sorting and selection is necessary at collection or before treatment)
Recoverable resource	Electric power	Compost	Biogas (can be used as fuel)
Final residue	Bottom ash, fly ash	Residue after selection	Residue after selection
Advantages	• It can treat various types of wastes • It can flexibly adapt to change in waste characteristics • Large amount of wastes can be treated in large-scale plants • Technology is mature as many plants have been constructed and operated • The power needed for the operation can be self-supplied • Power generation efficiency can be improved by simple pre-treatment depending on waste quality	• It can be introduced in a small scale • It can treat wastes that are not adaptable for incineration such as those with high water content • It does not generate combustion exhaust gas • If an independent facility for this technology is to be constructed, its CAPEX would be lower than incineration facility	• It can be introduced in a small scale • It can treat wastes that are not adaptable for incineration such as those with high water content • It does not generate combustion exhaust gas • If an independent facility for this technology is to be constructed, its CAPEX would be lower than incineration facility
Disadvantages	• If it is introduced in a small scale, the cost-effectiveness will lower. • Cost is relatively high	• Facility to treat residue after selection must also be constructed. • The market price of compost will largely affect the revenue. • Production of high-quality product will require high-quality pre-treatment. • If an independent facility for this technology is to be constructed, as there would be no power generation facility, power would have to be purchased. • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities.	• Facility to treat residue after selection must also be constructed. • Safe operation will require high-quality pre-treatment • If biogas is to be sold instead of electric power (as selling biogas is generally more profitable than selling electric power), the bio-gasification plant would have to purchase electric power for its operation • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities.

As shown in the table above, the feasibility of MBT will greatly depend on the market price of compost. Furthermore, both production of high-quality compost and production of biogas in a safe manner will require high-quality pretreatment and thus bring high investment risk. In addition, as both of these treatment methods will require treatment facility for residues, there is little impact to prolong the lifetime of the current disposal site. For these reasons, feasibility of introducing treatment facilities for incineration was examined in this Study.

3.4.2 Incineration Methods

a. **Major Incineration Methods**
In Japan, there are mainly two types of incinerators, namely stoker furnace and fluid bed furnace. The outline of these furnaces is explained in the table below.

Table 3-5 Outline of Stoker Furnace and Fluid Bed Furnace

	Stoker Furnace	Fluid Bed Furnace
Conceptual diagram		
Outline	Wastes move slowly upwards on the moving stoker. The combustion air blows from the lower part of the stoker, and wastes are combusted for an extended time through three steps of drying, combustion, post-combustion. Finally, ash is left as residue. Although most of the incombustibles and the ash content in the wastes are emitted from the end of the stoker, a part of the ash flies into the combustion gas and collected by dust collector as fly ash.	Wastes are instantly combusted when they contact high-pressure combustion air blowing from the bottom of the furnace and the high-temperature fluid sand. The incombustible wastes such as metal and rubble are discharged from the fluid bed with the fluid sand, and the ash content flies into the gas with the combustion gas and collected by the dust collector. The sand that is emitted from the bed is later separated with the incombustible wastes and is put back in the furnace to be re-utilized.

b. **Selection of Incineration Method**

The characteristics of the two incineration are compared in the table below.

Table 3-6 Comparison of Incineration Methods

	Stoker Furnace	Fluid Bed Furnace
Waste to be incinerated	Many plants for incineration of municipal solid waste and industrial waste have been operated. Wastes with size of about 300mm can be incinerated.	It is especially suitable for incineration of sludge. The wastes should be crushed to about 50mm or smaller.
Final produce	Bottom ash, fly ash	Bottom ash, fly ash
Advantage	• It can treat various types of wastes. • It can flexibly adapt to change in waste characteristics. • Large scale plants can be constructed. • Technology is mature as many plants have been constructed and operated.	• It is especially suitable for incineration of sludge. • Operation can be easily stopped in a short time.
Disadvantage	• It cannot incinerate wastes with significantly high calorie (3,000kcal/kg or higher) • As stopping its operation will take longer time compared to fluid bed furnace, it is not suitable to be operated for intermittent operation such as 8 operation of 8 or 12 hours per day.	• Wastes must be crushed or shredded • There have been no large scale plants that have been constructed and cooperated • There is a large amount of fly ash as the sand which is the combustion catalyst flies • The temperature and pressure in the furnace will be affected by waste amount and quality as wastes will be instantly combusted. Thus, controlling of waste and oxygen will need special attention. Dioxin level will rise if combustion becomes unstable
Construction cost	There is no significant difference although it would depend on scale of facility	
Operation cost	There is no significant difference although it would depend on scale of facility	
Power generation	There is no significant difference although it would depend on scale of facility	
Largest capacity per furnace in Japan	600 t/d	315 t/d

The Study Team selected the storker furnace as the most appropriate option for thermal treatment of the municipal solid waste in Da Nang for the following reasons:

- Storker furnace has the most operation records in the world as the thermal treatment technology of municipal solid waste and
- Stoker furnaces have enough flexibility against a variety of size and shape found in municipal solid waste.

JFE Engineering Corporation, a member of the Study Team has built and operated about 150 storker-type incinerators while constructing them in China, Taiwan, and Thailand with enough capacity of design, construction and operation.

3.4.3 Necessity and Basic Requirement for Establishment of Intermediate Treatment Facility (ITF) Options

With its high growth of population at 42% during 2000-2012, the waste generation in Da Nang City also increases with high rate at 28% during 2009-2013. This high pace of increase in waste generation is expected to continue with the projected population growth in the future with the rate of 3.5% per year.

Currently, all the municipal solid waste generated in Da Nang City is collected and transported through 6 transfer station to Khanh Son Landfill, the only destination of final disposal waste in the city.

Although its landfill capacity is approximately 3,420 thousand cubic meters, if collected wastes are directly landfilled at the rate of 200 to 300 thousand tons per year, the disposal site will become full by 2020.

Considering the growth of socio-economic development and urbanization of Da Nang city in the future, the city will need to acquire vast area of land in order to construct a new disposal site. Furthermore, environmental problems arising from the current Khanh Son landfill such as offensive odor, leakage and outflow of leachate especially in rainy season, and unsanitary conditions in the neighboring area will not be completely solved as long as the current direct disposal of waste without any treatment continues.

Therefore, when considering the waste treatment option for Da Nang city, it is most important that the amount of wastes to be landfilled and negative environmental impact decrease through introduction of intermediate treatment facility. In addition, the ability of the intermediate facility to provide energy is also a key element when considering the rising demand for energy and energy security.

Taking these issues into account, the followings options were considered based on the following evaluation criteria.

Intermediate treatment options

Option 0:	Direct landfill (business-as-usual scenario)
Option 1:	Introduction MBT facility
Option 2:	Introduction of incineration (and power generating) facility with treatment capacity of 1,000t/day
Option 2-1:	Introduction of incineration (and power generating) facility with treatment capacity of 1,500t/day
Option 3:	Introduction of incineration (and power generating) facility with treatment capacity of 300t/day and material recovery facility (MRF) for pre-treatment

Evaluation criteria

- Financial and economic feasibility taking into consideration the current budget for waste management
- Power generation potential
- Waste volume reduction rate
- Contribution to the solution of environmental issues arising from the current landfill

3.4.4 Intermediate Treatment Facility (ITF) Options

a. **Option 1: Mechanical Biological Treatment (MBT)**

a.1. Treatment Process

In this process, the received waste is first manually and mechanically separated into organic waste, recyclable materials (metal scraps, glass bottles, plastics, etc.) and other wastes. Separated organic waste is treated in aerobic condition to reduce its amount and produce compost-like material while the recyclables are to be sold to the dealers. The produced compost-like materials are to be used as soil (soil conditioner) in the park or roadside trees or cover soil of the landfill. Although the produced compost-like materials can possibly be sold as soil conditioner with limited use (since strict quality control is required for use of compost as fertilizer or soil conditioner to agricultural land.), the potential income from their sale is not accounted as the project revenue taking into account its high uncertainty. Remaining other wastes (inorganic non-recyclable waste) are disposed at landfill. The figure below illustrates the waste flow in this option.

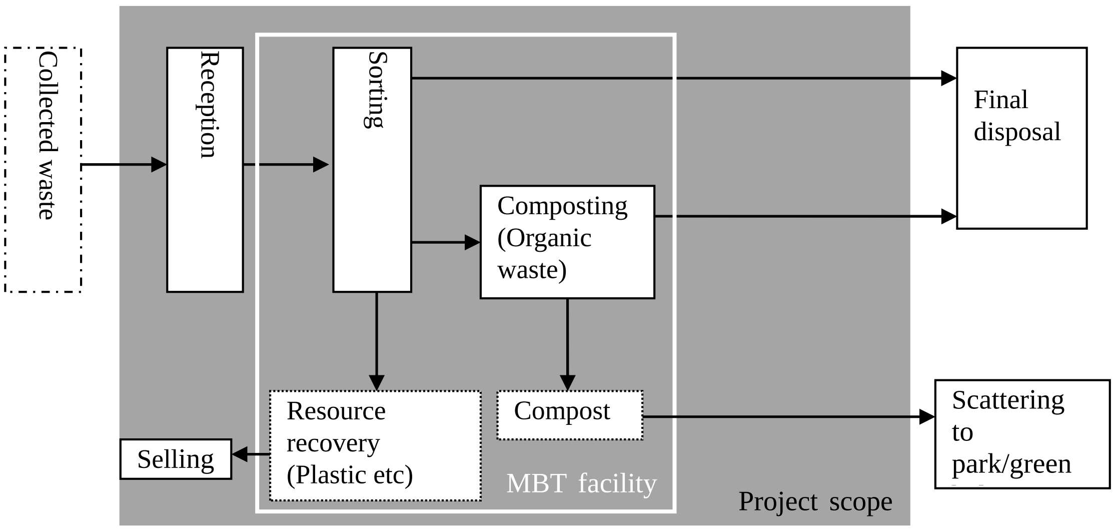


Figure 3-3: Waste Flow in Option 1

a.2. Outline of Facilities

Outline of the facilities under Option 1 is shown in the table and figure below.

Table 3-7: Outline of Facilities in Option 1

Facilities	Treatment Capacity	Outline Specification
Waste Sorting/Separation Facility	1,000-1,500 ton/day	▪ After removing the waste bags, the unloaded waste is put on the belt conveyor to manually separate recyclable, non-combustible and hazardous materials ▪ Remaining waste is mechanically shredded and screened to collect organic waste. Recyclable materials are again collected manually from the remaining waste. ▪ Separated organic waste will be brought into aerobic treatment (composting) process ▪ Remaining residues is disposed at landfill
Aerobic treatment (composting) facility	540-840 ton/day	▪ Mechanical composting with compost turners and shovel loader is applied.

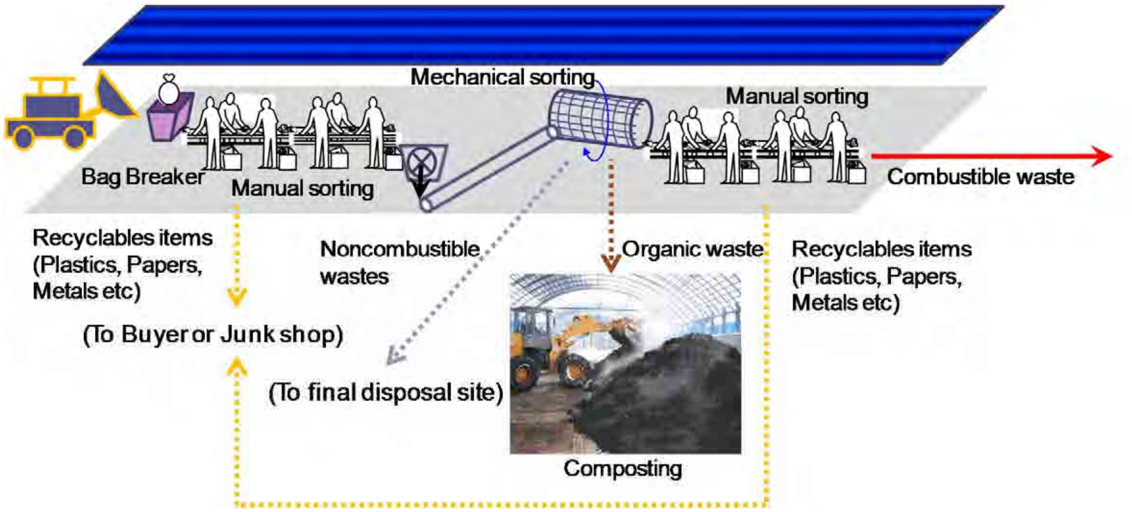


Figure 3-4: Image View of MBT Facility

a.3. Cost and Waste Reduction Rate of Option 1

The intermediate treatment cost of Option 1 is estimated to be 27.2 billion JPY (15.9 billion JPY for CAPEX[1] 11.3 billion JPY for OPEX[2]). Furthermore, the waste reduction rate by MBT facility (calculated by 100 – (landfilled wastes)/ (amount of wastes) x 100) is estimated to be approximately 40%.

b. Option 2: Waste-to-Energy (1,000 tons/day)

b.1. Treatment Process

Received waste is first placed at desiganted waste yard, where waste-pickers are allowed collect recyclable materials. Subsequently the remaining waste is incinerated while the heat produced are collected for power generation. Incineration residue will be disposed at landfill after proper treatment of hazardous materials. The figure on next page illustrates the flow of waste in this option.

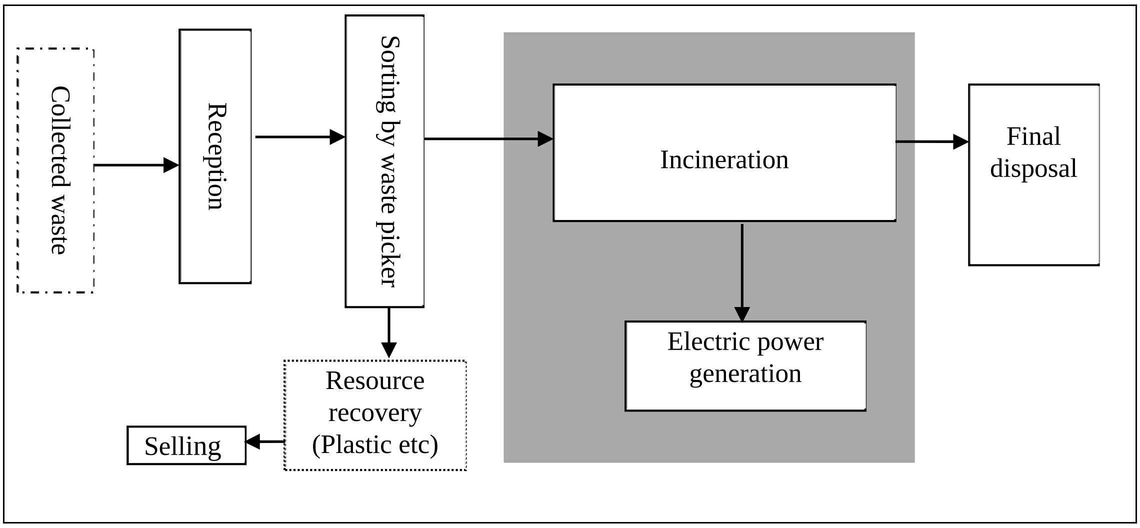


Figure 3-5: Waste Flow in Option 2

[1] CAPEX: Capital Expenditure

[2] OPEX: Operational Expenditure

b.2. Outline of Facilities

Outline of the facilities is shown in the table and figure below.

Table 3-8: Outline of Facilities in Option 2

Facilities	Capacity	Outline Specification
Waste-to-Energy Facility	1,000 ton/day (24hrs/day and 310-330 day/year operation) The amount exceeding 1,000 ton/day capacity will be directly disposed at landfill.	▪ 500 ton/day/unit * 2 units ▪ Power generation facility

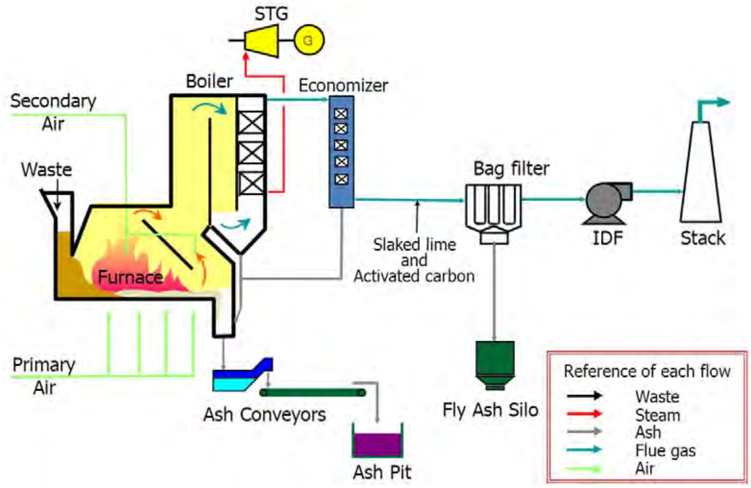


Figure 3-6: Image View of Waste-to-Energy Facility

b.3. Cost and Waste Reduction Rate of Option 2

The intermediate treatment cost of Option 1 is estimated to be 21.8 billion JPY (11 billion JPY for CAPEX and 10.8 billion JPY for OPEX). Furthermore, the waste reduction rate is estimated to be approximately 90% (as the receiving waste amount would exceed the treatment capacity, the reduction rate will become lower).

b.4. Cost and Waste Reduction Rate of Option 2-1

Under Option 2-1, an incinerator with treatment capacity of 500 t/day will be added to the facilities under Option 2. The intermediate treatment cost is estimated to be 30.5 billion JPY (16.7 billion JPY for CAPEX and 13.8 billion JPY for OPEX). The waste reduction rate is approximately 90%.

c. **Option 3: MRF (Material Recovery Facility) with treatment capacity of 1,000-1,500 ton/day + Waste-to-Energy (300 ton/day)**

c.1. Treatment Process

In this process, the received waste is first manually and mechanically separated into combustible wastes, recyclable materials (metal scraps, glass bottles, plastics, etc.), and other wastes. The recyclable materials would be sold to the middlemen who buy such items. Other combustible wastes are incinerated by the waste-to-energy facility. The incineration residue would be appropriately landfilled in the disposal site. Other wastes would be directly landfilled in the disposal sites. The figure below illustrates the treatment flow in this option.

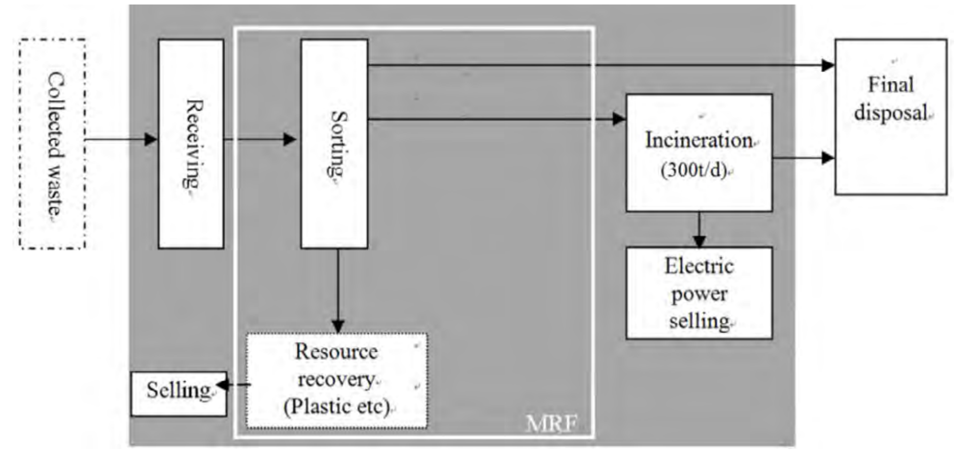


Figure 3-7: Waste Flow in Option 3

c.2. Outline of Facilities

Outline of the facilities is shown in the table below.

Table 3-9: Outline of Facilities in Option 3

Facilities	Treatment Capacity	Outline Specification
Waste Sorting/Separation Facility	1,000-1,500ton/day	▪ After breaking the waste bags, the unloaded wastes are dumped on the belt conveyor. Recyclable, non-combustible and hazardous materials are manually removed. ▪ Remaining wastes are mechanically shredded and sorted. The combustible wastes are sent to the waste-to-energy facility as RDF. ▪ Other wastes will be landfilled.
Waste-to-Energy Facility	300 tons/day (24hrs/day operation)	▪ 300ton/day/unit * 1 unit ▪ Equipped with power generation facility

c.3. Cost and Reduction Rate of Option 3

The intermediate treatment cost of Option 3 is estimated to be 12.2 billion JPY (6.3 billion JPY for CAPEX and 5.9 billion JPY for OPEX). Furthermore, the waste reduction rate for MRF and waste-to-energy facility is 70% compared to the volume of received wastes and approximately 90% if only considering the waste-to-energy facility.

3.4.5 Comparison of ITF Options

Table below compares the ITF options mentioned above by several different criteria.

Table 3-10: Comparison of ITF Options

	Option 0	Option 1	Option 2	Option 2-1	Option 3
Treatment Process	Direct Landfill	MBT	Waste-to-Energy	Waste-to-Energy	MRF + Waste-to-Energy
Treatment Capacity	-	MBT: 1,000 to 1500 ton/day	Waste-to-Energy: 1,000 ton/day	Waste-to-Energy: 1,500 ton/day	MRF: 1,000 ton/day Waste-to-Energy: 300 ton/day
Amount of waste treated	927 to 1,500 ton/day	927 to 1,500 ton/day	850 to 900 ton/day	1,274 to 1,356 ton/day	850 to 900 ton/day
Annual working days	365 days	365 days	310 to 330 days	310 to 330 days	310～330 days
The expected waste reduction rate of waste disposed at landfill	0%	40%	Approximately 90%	Approximately 90%	Approximately 70% (If the focus is only on incineration facility, approximately 90%)
Required landfill volume until 2018	9.8 million m^3	3.6 million m^3	3.3 million m^3	1.0 million m^3	7.8 million m^3
Total cost for introduction of intermediate treatment facility (CAPEX and costs for 20 years between 2019 and 2038)	4.2 billion JPY	27.2 billion JPY	21.8 billion JPY (excluding income of 19 billion JPY from power sales)	30.5 billion JPY (excluding income of 23.2 JPY from power sales)	12.2 billion JPY (excluding income of 6.6 billion JPY from power sales)
Tipping fee (JPY/ton)	130 JPY/ton*	6,700 JPY/ton**	5,350 JPY/ton	5,360 JPY/ton※2	3,000 JPY/ton※2

* The actual unit price for treatment and disposal is 25,473 VND per ton of waste (approximately 1.3 USD)

** Economic Internal Rate of Return (EIRR) was assumed to be 18%

The cost of "Option 0: Direct Landfill" is estimated based on the cost records of construction and operation of the existing Khanh Son Landfill with the assumption that the new landfill can be built on same conditions. Therefore, it does not include the incremental cost of transportation due to further location of new landfill and compensation for the people who may be relocated to other places due to construction of new landfill.

Currently, Da Nang City does not have any concrete plan of new landfill construction with no activity of potential land identification. The future plan of new landfill will be examined after receiving assessing the proposals of intermediate treatment facilities from investors including the result of this Study.

Table 3-11: Total Unit Cost for Installation and Operation of New Landfill Site

Item	Unit Cost (JPY/waste ton)
Land Acquisition	110
Construction (Landfill area and Leachate treatment facility)	100
O & M cost for Landfill operation	130
O & M cost for Leachate treatment operation	90
Total	430

Source : estimated by the study team based on the existing data

Note : not include solid waste transportation cost and various type of compensation cost

3.4.6 Selection of Optimum ITF Option

The optimum ITF option for Da Nang City is selected in consideration of cost performance in accordance with the waste reduction rate and the tipping fee.

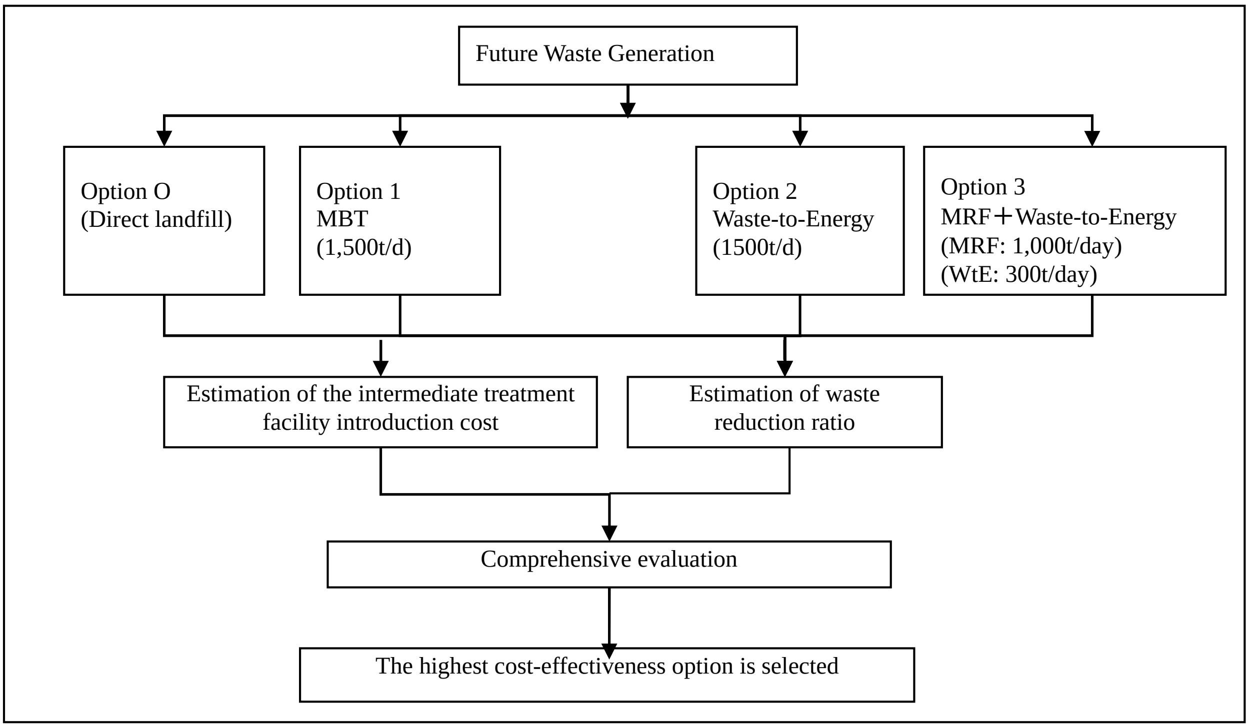


Figure 3-8: Procedure for Selecting the Optimum ITF Option

Considering the remaining capacity of the current Khanh Son disposal site and the vision of Da Nang city to become an "environmental city", introduction of large-scale waste incineration and power generation facilities under Option 2 (capacity of 1,000 ton/day) or Option 2-1 (capacity of 1,500 ton/day) is the best option. However, if the options are evaluated based on the cost effectiveness for reducing wastes, Option 3 would be the most cost effective, as it would reduce 1 ton of waste with the lowest cost.

Considering the current financial conditions of Da Nang city, the tipping fee under Option 2 and Option 2-1 which is 5,350 JPY/ton is believed to be too high. However, acquiring new land for a new disposal would be very difficult if not possible. Even if it is possible, it is clear that it would cause the same social and environmental problems that Khanh Son final disposal has caused such as bad odor, water pollution, and resettlement of residents.

Therefore, it can be said that the best option would be to first introduce Option 3 with the tipping fee of 2,500 JPY/ton in order to reduce the amount of final disposal and then to introduce Option 2 and Option 2-1 if financial capacity of Da Nang City improve.

The proposed tipping fee of 2,500 JPY/ton is considered reasonable in consideration of the maximum tipping fee set in the international bidding of "Waste-to-Energy" facilities in Jakarta and Bandung, Indonesia as shown in the table below.

Table 3-12: Comparison of Tipping Fees

City	Da Nang	Jakarta	Bandung
Treatment Capacity (ton/day)	300	1,000	700
FIT Power selling price	JPY 10/kwh	JPY 25/kwh	JPY25/kwh
Tipping Fee	JPY 2,500/ton	JPY4,000/ton	JPY3,750/ton

Source: Bisnis Indonesia (26 July 2013)

4 Preliminary design

4.1 Planning basis

Planning basis for this study is shown in below table.

Item	Unit	Option 2	Option 3
Treated Waste	-	Collected wastes	Collected wastes
Plant Capacity	-	1,500 t/d (500 t/d x 3 lines)	300 t/d (300 t/d x 1 line)
Average lower calorific value of waste	kJ/kg (kcal/kg)	6,700 (1,600)	6,700 (1,600) After treatment by MRF, 9,200 (2,200)
Flue gas emission regulation	-	QCVN30:2010/BTNMT (for industrial incinerator)	QCVN30:2010/BTNMT (for industrial incinerator)
Water quality regulation (waste water)	-	QCVN40:2011/BTNMT-B (for industrial wastewater)	QCVN40:2011/BTNMT-B (for industrial wastewater)

As for Option 2, there are two methods to arrange the third furnace.

(1) First plant (Option 2) is constructed with space for line No.3. If it is decided to add line No.3, the first plant is modified and No.3 line is added.

(2) Individual 1-line plant is constructed near the first plant.

Necessity of No.3 line greatly depends on several societal backgrounds such as future waste management policy, economic development and so on. And if enough extending life of existing final treatment facility (landfill) is confirmed by Option 2, it may be supposed to be supported by introduction of other process. Therefore, latter method having high flexibility in future was applied as basis of following study.

With regard to Option 3, 3 lines with treatment capacity of 350 ton/day would be installed. In order to prepare for the increased wastes in the future, space for 1 additional line would be secured.

4.2 Outline and specification of the planned plant

4.2.1 Outline of the plant under Option 2

This plant mainly consists of the following facilities: waste receiving and charging system, incineration furnace system, flue gas cooling and heat recovery system (boiler), flue has cleaning system, heat utilization system (electric power generation), and ash (bottom & fly) discharging system. Incineration process flow is shown by below figure, and outline of each major system is described in following sections.

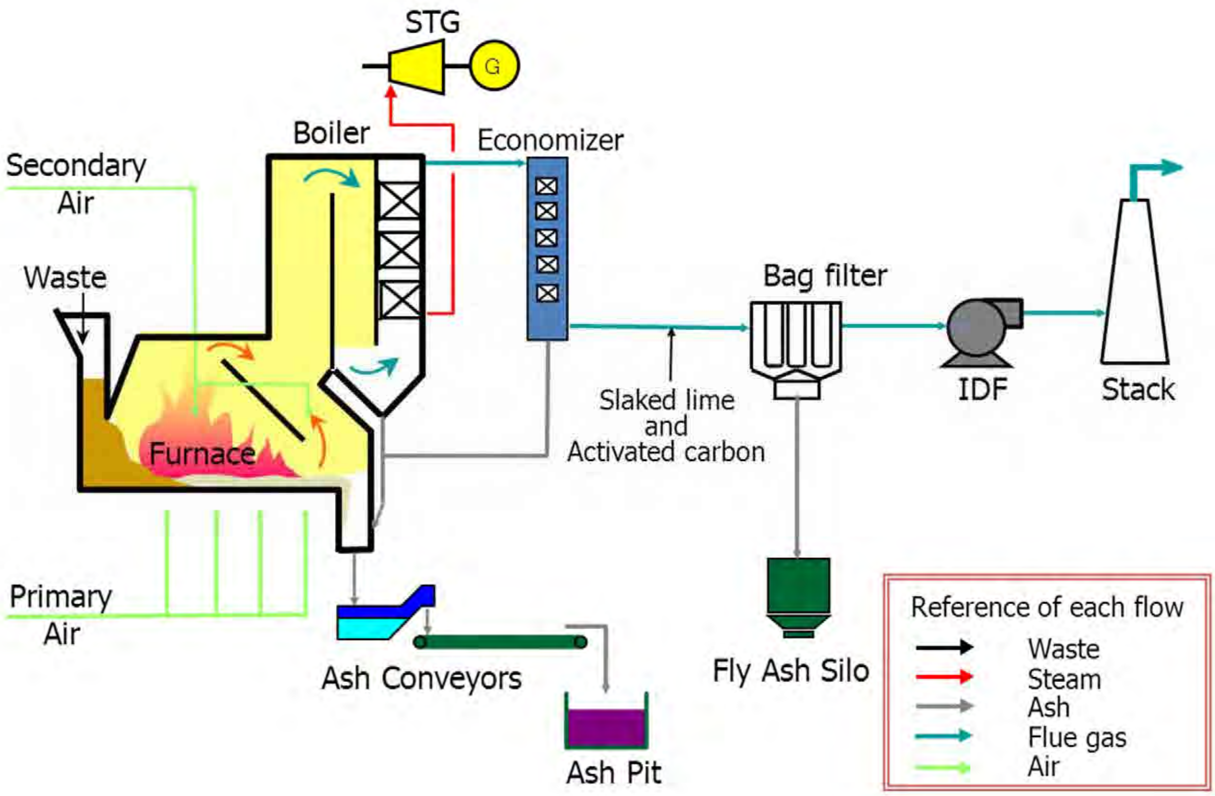


Figure 4-1 : Process Flow Sheet of Incineration System

a. **Waste receiving and charging system**
Waste is kept in waste pit temporarily after being weighted by truck scale. Waste pit has the volume for storing 3 days' furnace incineration capacity.
Waste inside pit is mixed up by waste crane and is charged into waste charging hopper.

b. **Incineration furnace system**

b.1. Waste charging hopper・chute

Waste charging hopper has a wide opening for not occurring bridges. With the combination of a waste chute having enough sealing height to prevent fire blow-off from furnace inside, it is able to bring waste into furnace smoothly.

b.2. Bridge-breakers are equipped inside the hopper for eliminating bridge.

Waste feeder

Charged waste is efficiently and smoothly fed to the furnace by a hydraulic driven pusher-type waste feeder. Waste amount fed by this feeder is controlled and/or set by automatic combustion controller or remote operation.

b.3. Combustion system (Combustion stoker)

Combustion system consists of movable grates and fixed grates. The type of grate is JFE-Hyper Grate, it has cooling fins inside grate piece, and therefore each grate piece can be cooled down efficiently through combustion air (primary air) blowing in.
Speed of movable grates driven by hydraulic devices are controlled and/or set by automatic combustion controller or remote operation.
In addition, there are separated blocks to supply air for drying and combustion under the grates, and those supply air flow is controlled and/or set by automatic combustion controller or remote operation.

b.4. Furnace

In this plant, JFE Two-Way Flue Gas Stoker Furnace which has intermediate ceiling is proposed. Since Two-Way Flue Gas Stoker Furnace can accommodate stable waste combustion against wider calorific value of waste, it is optimum for Vietnam;

- Where has large difference of calorific value of waste between rainy season and dry season.
- Where increasing of calorific value of waste is assumed by economic growth.

Main combustion chamber consists of water cooling wall of boiler in order to maximize waste heat recovery. Inside furnace is lined with high heat resistant refractory, and for those parts where clinker relatively easily adheres, a structure of air cooling wall or water cooling wall is designed.

The intermediate ceiling divides flue gas into 2 streams which flow through flue gas main path and sub-path, and then turbulently mix up in secondary combustion chamber. Therefore, it is able to promote complete combustion by this raged confluence, while able to reduce generation of dioxins and NOx during combustion. And also, because this ceiling brings combusting waste effective thermal radiation, bottom ash quality is kept good condition, then it's possible to greatly reduce environmental impact to final landfill.

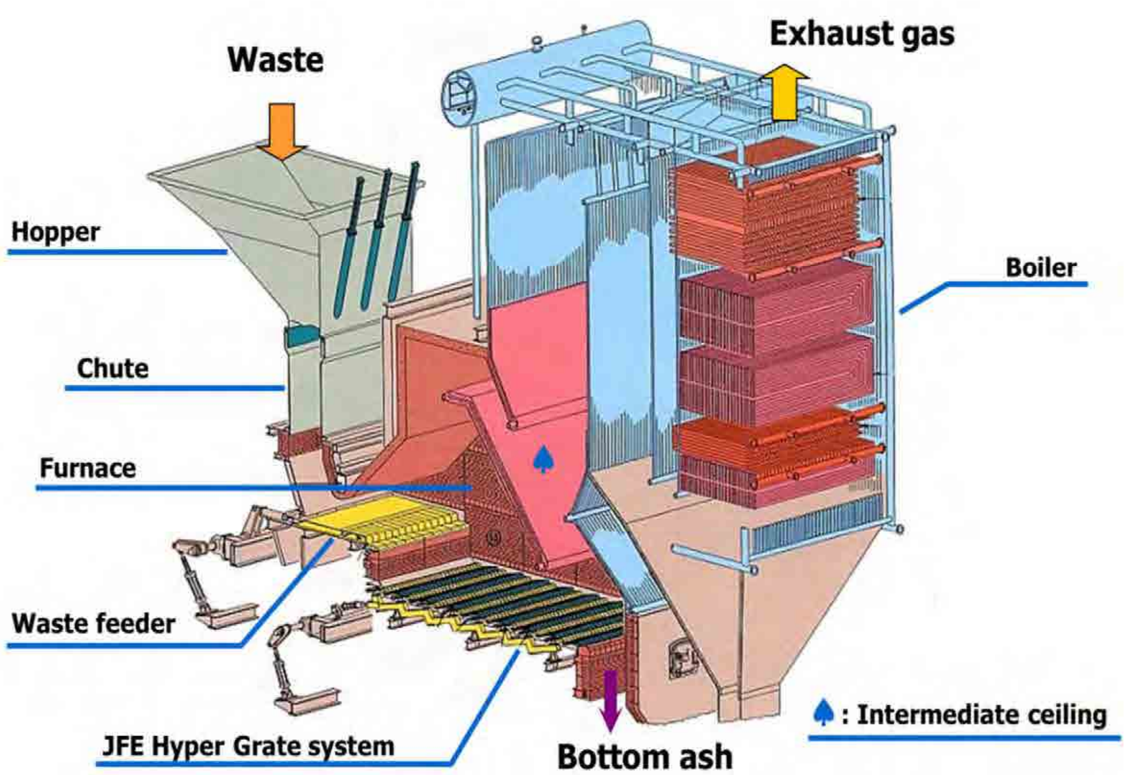


Figure 4-2 : Structure of JFE Two-Way Flue Gas Stoker Furnace

c. **Automatic combustion control (ACC) System**

Conventional automatic combustion control system was for keeping stability of combustion condition by feedback control which adjusts each operation values based on control value from waste incineration process.

Although feedback control is responsive to long-term change, it cannot be responded momentary change enough.

So JFE developed Hybrid ACC system which is able to respond momentary change by combining fuzzy control with conventional ACC system.

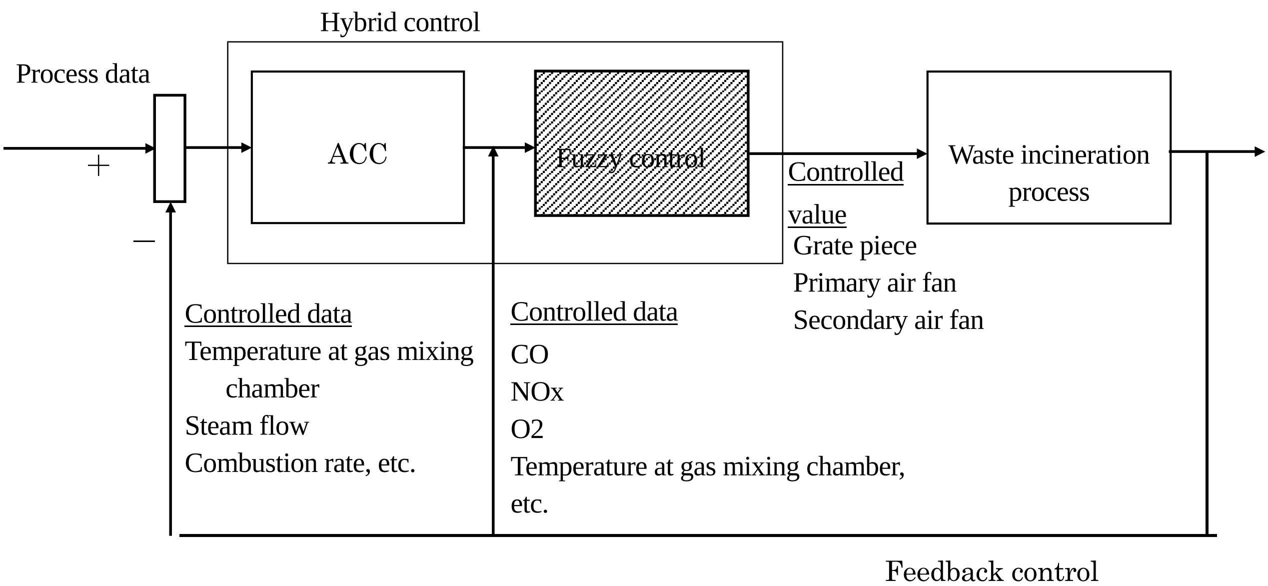


Figure 4-3 : JFE Hybrid ACC Concept

d. **Flue gas cooling・Waste heat recovery system**

Boiler is installed for cooling flue gas and for recovering waste heat to produce steam efficiently. A natural circulation boiler with single drum is applied for this planning.

Boiler drum is fed high temperature water which being deaerated in de-aerator and being pre-heated in economizer. Boiler water flows down in distribution pipe through falling down pipe by natural circulation, after being heated by heating pipe, heated water rises due to different specific gravity. Finally it returns to boiler drum, and then steam and water are separated.

High pressure saturated steam from boiler outlet is heated in super heater, and superheated steam is transported to steam turbine for power generation.

This boiler is operated under three component control: feed water flow, water level in boiler drum and produced steam flow, so it is excellently controllable, therefore this operation is especially optimum for a boiler adopted for a furnace which is selected for incinerating waste with variable calorie in wide range. These controls run automatically by setting steam flow.

Dust adhering to the surface of heat transfer pipes is cleaned by steam blow (soot-blower).

Surrounding equipment and ancillary equipment are also included in heat recover system, such as de-aerator, demineralizer, boiler chemical dosing unit, continuous blow-down unit, boiler water monitoring unit, etc.

e. **Flue gas cleaning system**

e.1. Acid gas (HCl: Hydrogen chloride, SOx: Sulfur oxide, HF: Hydrogen fluoride) removal equipment

Dry type system, slaked lime powder is injected into an inlet duct of a bag filter by high pressure air from an injection blower, is applied for this planning. This system consists of slaked lime silo, slaked lime feeding device, injection blower, etc.

Calcium chloride 〔$CaCl_2$〕 and calcium sulfide 〔$CaSO_4$〕 which are produced from HCl, SOx removal systems are powdery and captured in bag filter.

e.2. Dioxins removal equipment

Dry type system, activated carbon powder is injected into flue gas duct with slaked lime powder, is applied for this planning.

Activated carbon powder absorbs gaseous dioxins contained in flue gas. And these powders and dioxins particles are captured by bag filter.

Because JFE Two-Way Flue Gas Stoker Furnace is possible to restrain dioxins' generation by only adequate combustion control, it greatly contributes to decreasing activated carbon consumption.

e.3. Dust removal equipment

Bag filter is applied for this planning and removes dust including all solid products which occur in above mentioned harmful gas removal process.

Pulse jet method is adopted for removing those dusts sticking on the surface of filter cloth, which is realized by injecting compressed air through blow tubes every fixed time.

Removed dusts are discharged from bottom hoppers by bag filter conveyors, after that, those are transferred to a fly ash silo by fly ash conveyors.

e.4. Nitrogen oxides (NOx) removal equipment

Since JFE Stoker Furnace for this planning effectively promotes reduction reaction of NOx by two-way flue gas flow, it is possible to comply with the present environmental regulation by only appropriate furnace operation.

Therefore there is no plan about this equipment.

f. **Waste heat utilization system**

f.1. Steam turbine

Heat generated by waste incineration is recovered as steam, and steam is used for power generation by steam turbine.

Condensing extraction steam turbine is applied for this planning, and extraction steam is used for process equipment such as de-aerator.

f.2. Low pressure steam condenser

This is the equipment to cool and condense all exhaust steam from the steam turbine. Air cooled type condenser, which is not necessary to use large amount of cooling water, is applied for this planning,

g. **Ash discharging system**

g.1. Bottom ash

Completely combusted ash falls into bottom ash conveyor (water bath type) from bottom ash chute. Extinguished and humidified ash is temporarily stored at ash pit and is transported to final landfill by trucks at stated periods.

g.2. Fly ash

Fly ash discharged from bag filter is temporarily stored in fly ash silo. In this planning, fly ash is transported to outside (other stabilization facility or hazardous waste treatment facility) by bulk transporter without solidification and/or stabilization.

4.2.2 Outline of the plant under Option 3

This plant mainly consists of MRF facility composed of bag-breaking and sorting facilities and incineration facilities. The outline of MRF facilities are shown below. The wastes that are received are weighed and stocked in the waste pit. The capacity of the waste pit would be for receiving three days of wastes or more in order to adapt to the fluctuation of the wastes amount. The wastes in the waste pit are taken by the crane and discharged into the bag-breaker.

After the waste bags become broken in the bag-breaker facility, the wastes are discharged on the trommel screen and sorted by size. Wastes such as organic wastes would drop through the screen and the larger wastes such as plastics and paper would be left on top of the screen.

The wastes that are left on top of the screen are then discharged to the hand-sorting conveyor belt and the recyclable materials such as metals and glass are removed manually. After these materials are removed, the remaining wastes are sent to the incineration facilities as RDF. With regard to the wastes that have dropped through the screen, they would be landfilled in the final disposal site after removal of metals by magnetic sorter. The outline of the incineration facilities is the same with that under Option 2.

5 Business Plan

5.1 Selection of the Project

Taking into consideration the remaining landfill capacity of the current Khanh Son disposal site and the vision of Da Nang city to become an environmental city, the best options are large-scale waste incineration and power generation facilities under Option 2 (treatment capacity of 1,000 ton/day) and Option 2-1 (1,500 ton/day). However, in order to lower the tipping fee to 30 USD/ton as requested by Da Nang city, MRF and waste incineration and power generation facility (treatment capacity of 300 ton/day) should be introduced. Under the assumption that negotiations among Da Nang city, plant operator, and investors would continue, the current project outline for each option are shown in Table 5-2.

With regard to Option 2-1, as the loan conditions and construction costs in the future cannot be easily calculated at the moment, this option is omitted in this table.

Table 5-1: Comparison of Options

	Option 2	Option 3
Treatment process	Waste incineration and power generation	MRF + Waste incineration and power generation
Treatment capacity	Waste incineration and power generation facility: 1,000 ton/day	MRF: 1,000 ton/day Waste incineration and power generation facility: 300 ton/day
Average Daily treatment amount (Daily treatment amount × annual working days/365 days)	850 ton/day	850 ton/day
Waste reduction rate by introduction of intermediate treatment facility	Approximately 90%	Approximately 70% (If the focus is only on incineration facility, approximately 90%)
Total cost for introduction of the intermediate treatment center (CAPEX and cost for 20 years between 2019 and 2038)	21.8 billion JPY (excluding income of 19 billion JPY from power sales)	12.2 billion JPY (excluding income of 6.6 billion JPY from power sales)
Tipping fee (JPY/ton)	5,350 JPY/ton	2,500 JPY/ton
Remaining lifetime of Khanh Son disposal site	18 years	14 years

5.2 Project Outline

The proposed project is intermediate treatment of solid wastes and power generation under public-private partnership in Da Nang city. The details are as shown in the table below.

Table 5-2: Project Outline

Item	Contents
Implementing organization	Consortium between Japanese private consortium and Vietnamese partner (details are explained in the following sections)
Service to be provided	1. Treatment of solid wastes ▪ The project will incinerate and reduce volume of wastes generated in Da Nang City ▪ Target wastes are municipal solid wastes, non-hazardous industrial wastes, and waste water sludge that does not include hazardous substances emitted from households and businesses. 2. Electric power generation (waste-to-energy) ▪ The project will generate electric power through incineration of wastes and supply the generated power through public electric network.
Project site	Khanh Son waste final disposal site in Da Nang City
Project period	20 years
Capacity of facilities	(1) Waste incineration and power generation facility (1,000 ton/day) <u>Incinerator</u> - Treatment capacity: 1,000 ton/day - Number of operation days : 310 days/year - Waste reduction rate (by weight): Approximately 90% <u>Power generator</u> - Power generation capacity (per unit): 16MW - Annual power sales (per unit): 94,860 MWh/year (2) MRF + Waste incineration and power generation facility (300 ton/day) <u>MRF</u> - Treatment capacity: 1,000 ton/day - Number of operation days : 310 days/year <u>Incinerator</u> - Treatment capacity: 300 ton/day - Number of operation days : 310 days/year - Waste reduction rate (by weight): Approximately 70% <u>Power generator</u> - Power generation capacity (per unit): 6.4MW
Total project cost	(1) Waste incineration and power generation facility (1,000 ton/day) - Approximately 21.8 billion JPY - Initial investment: approximately 11 billion JPY - Operation and maintenance for 20 years: 10.8 billion JPY (approximately 0.54 billion JPY/year) (2) MRF + Waste incineration and power generation facility (300 ton/day) - Approximately 12.2 billion JPY - Initial investment: approximately 6.3 billion JPY - Operation and maintenance for 20 years: 5.9 billion JPY (approximately 0.3 billion JPY/year)
Financing method	(1) Waste incineration and power generation facility (1,000 ton/day) - Capital: 3 billion JPY - Joint Crediting Mechanism (JCM) Subsidy from Ministry of the Environment, Japan: 2.5 billion JPY - JICA Private Sector Investment Finance: 5.5 billion JPY (2) MRF + Waste incineration and power generation facility (300 ton/day) - Capital: 1.5 billion JPY (25% of initial investment) - Joint Crediting Mechanism (JCM) Subsidy from Ministry of the Environment, Japan: 2.5 billion JPY - JICA Private Sector Investment Finance: 3 billion JPY(including interest during construction period)
Expected revenue source	1. Solid waste treatment fee (expected be 30 USD/ton average although it would depend on the external financing option) 2. Electric power sales revenue (expected to be near 10 JPY/kWh)

Table 5-3 Project Schedule

	Project Preparation Period				Year 1				Year 2				Year 3				Year 4			
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Negotiation regarding governmental offtake agreement and SPC-related contract	■	■																		
Preparation to apply for JICA Private Sector Investment Finance and JCM Grant		■	■																	
Creation of SPC for PPP Project			■	■																
Bidding for PPP Project					■	■														
Preparation regarding finance							■	■												
Investment approval, power purchase agreement, operation contract									■	■										
Signing of contract with Da Nang City									■	■										
Bidding for plant construction											■									
Construction of plant												■	■	■	■	■	■	■		
Project implementation (20years)																			■	■

5.3 Implementing organization

This Project will be implemented by a Special Purpose Company (SPC) which would be composed of the Japanese private consortium which would be composed of JFE Engineering Corporation and Sumitomo Corporation and Vietnamese local partner (candidate partner is Da Nang URENCO) when the following conditions are met.

Table 5-4: Conditions for Implementation of the Project (Vietnamese Side)

Item	Condition
Payment guarantee from the Vietnamese central government	Payment of the tipping fee and electric power sales is guaranteed by the Vietnamese central government.
Guarantee of waste amount	Waste amount to be received by the facility and the compensation for the lost revenue (i.e. tipping fee and electric power sales) if the waste amount does not reach the agreed amount are guaranteed.
Guarantee of waste quality	Compensation for the lost revenue if the plant is forced to stop or its efficiency is lowered due to reception of unacceptable waste (i.e. incombustible wastes, bulky wastes, hazardous items, etc) are guaranteed.
Guarantee of minimum calorie of wastes	Compensation for the lost revenue if the monthly average waste calorie measured at the incineration plant is lower than the agreed minimum calorie is guaranteed.
Application of feed in tariff	Decision on “SUPPORTING MECHANISM FOR DEVELOPMENT OF POWER GENERATION PROJECTS USING SOLID WASTE IN VIETNAM” issued on 5 May 2014 is applied.
Signing of contract	Concession agreement regarding waste incineration and power purchase agreement (PPA) for the project period are signed.
Land use of the project site	Land use of the project site and use of basic infrastructure (water supply, sewage, gas, road, etc) are secured.
Long-term lease contract of the project site	Land Lease Agreement with the legitimate land owner throughout the project period is signed.
Tipping fee based on capacity to pay	Tipping fee is Capacity Payment based on “Bring or Pay”.
Power transmission network	“Right-of-Way” to the power transformer station and sufficient power transmission capacity are secured.
Payment for power sales based on Available Capacity Payment	Available Capacity Payment would be payable by EVN or other relevant authorities for as long as the power generation facility is available as declared.

Table 5-5: Conditions for Implementation of the Project (Loan Conditions)

Item	Condition
Long-term project finance	Tenure: More than 18 years Door-to-Door (More than 16 years after COD) Combination of Japanese Yen or Us dollar with denominated local currency Fixed interest rate Non-recourse base

The percentage of investment by each party is to be discussed, but the capital needed by the SPC for starting the operations is expected to be 25% of the initial investment. The contribution from the Vietnamese partner should basically be monetary contribution.

5.4 Project Implementing Method (Implementation Scheme)

The implementation scheme of this project is shown in the figure below. However, it should be noted that the expected SPC members would be as follows.

(1) Waste incineration and power generation facility (1,000 ton/day):

JFE Engineering, Sumitomo Corporation, Vietnamese partner

(2) MRF + Waste incineration and power generation facility (300 ton/day):

JFE Engineering, other Japanese corporation, Vietnamese partner

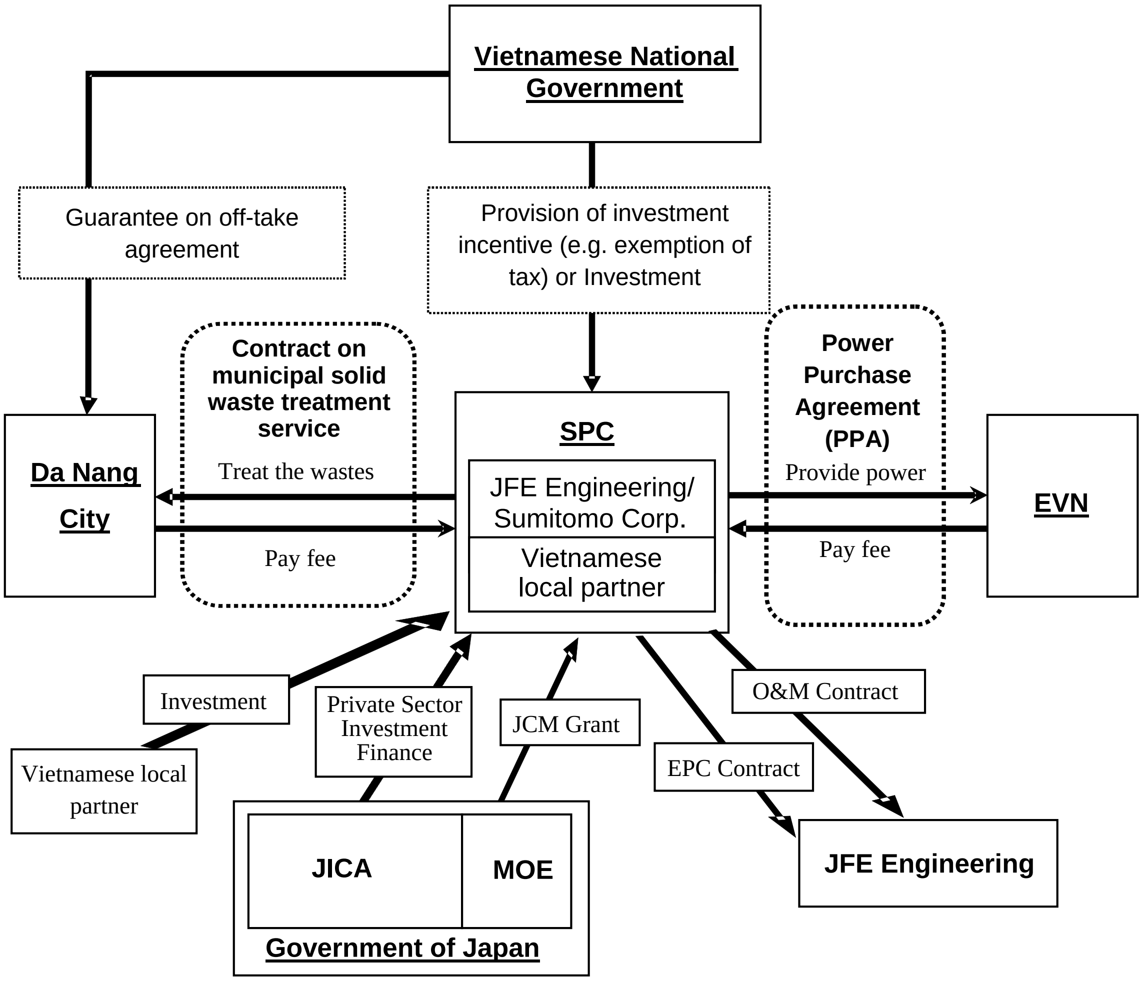


Figure 5-1: Project Implementation Scheme

In order to assure financial feasibility and sustainability of this project, the actors involved must sign numerous contracts in order to clarify details on the revenue and expenditure, financing method, and responsibilities of each actor. The required contracts include those listed below.

a. **Joint venture agreement on establishment of SPC**
In establishing the SPC which will be the implementing organization of this project, the Japanese and Vietnamese partners must sign a memorandum of understanding that would include information relevant to the issues below.

- Mission of the SPC and the roles and responsibilities of participating organizations
- Organization structure of the SPC

- Capital, financing, and distribution of revenue
- Standing rules of the company
- Operation of business (including rules regarding EPC by SPC, operation and maintenance contract)
- Arbitration
- Any other issues that need agreement among participating entities

b. **Contract between Da Nang City and SPC regarding "municipal solid waste treatment service"**
The most important contract in relation to project revenue is this contract regarding municipal solid waste treatment service between Da Nang City and SPC. This contract should clarify the following issues so that project revenue would be secured.

- Basic information (e.g. contracting party, period of contract)
- Amount and quality of the wastes to be received by SPC (e.g. guarantee of minimum waste amount, quality standards, method of evaluation, measures to be taken when standards are not met)
- Tipping fee (method of tipping fee calculation, agreement on tipping fee)
- Tipping fee payment method (currency of payment, mode of payment, time of payment)
- Standard of service to be provided by SPC (treatment method, treatment capacity, treatment standards, handling of treatment residues)
- Role and responsibilities of Da Nang City and SPC
- Measures to be taken when contract is breached or not fulfilled
- Accounting method (during or after the contract period)
- Conflict resolution

c. **Contract between EVN and SPC on "power purchase agreement (PPA)"**
Another important contract for securing project revenue is this power purchase agreement (PPA) between SPC and EVN. This contract must clarify the following issues so that the project revenue would be guaranteed.

- Basic information (e.g. contracting party, period of contract)
- Conditions regarding networking the power generating facility of SPC and the grid electricity (e.g. conditions on power supply, role, responsibilities and cost-sharing regarding constructing and operating grid electricity facilities)
- Selling price of electric power (Unit price and calculation method of payment amount)
- Payment method of electric power sales (currency of payment, payment method, time of payment)
- Role and responsibilities of EVN and SPC
- Measures to be taken when contract is breached or not fulfilled
- Accounting method (during or after the contract period)
- Conflict resolution

d. **Contract with Ministry of the Environment, Japan regarding JCM subsidy**
In order to be granted with the JCM subsidy, the SPC should sign a contract with the MOE Japan as required by the said Ministry. In order to be granted with this subsidy, the SPC must measure, report, and register with the approval of a third-party the amount of GHG reduction that would be realized by this project and handover the reduced GHG to the Japanese Government through MOE Japan. If the contents of this contract become clear and concrete, the profitability and sustainability of this project

would be guaranteed, and SPC would be able to start the official procedures to realize this project through the JICA Private Sector Investment Finance scheme.

e. **“EPC contract” and “O&M contract between SPC and JFE Engineering**
It is planned that EPC and O&M would be contracted from SPC to JFE Engineering. In these contracts, the followings issues should be clarified.

- Contract sum and paying conditions
- Contracting period and constructing period or O&M period
- Technical specifications
- Emission standards to respect (either Vietnamese standards or standards specified by the SPC)
- Scope of work (including scope of construction works, Force Majeure, and scope of insurance
- General conditions (including measures to be taken when there is breach of contract)

Furthermore, JFE Engineering would be subject to “transfer pricing taxation” depending on the stake of JFE Engineering in the SPC. Therefore, from the stage of creating the SPC, consultations should be made in consideration of the transfer pricing taxation.

6 Risks and Security Package

6.1 Risks at the project preparation stage

The risks that could be expected at the stage before the actual construction, maintenance, and operation are expected as follows.

6.1.1 Risks in relation to EIA

In preparation for this project, special attention is paid to the EIA process and two meetings will be organized total to explain to the local residents about the project during this survey. However, as people generally do not wish to have waste treatment facilities are often facilities in their neighborhoods (not-in-my-backyard or NIMBY syndrome), it should be noted that building the consensus of the local residents to implement this project may take much time and money.

However, as the project site would be inside the Khanh Son disposal site, it is expected that the land acquisition issue would not be very difficult.

Concerning EIA, EIA procedures should be finished before the bidding stage. Da Nang City which is the project owner should accurately explain to the public that this project would not create negative environmental impact but rather create economic, social, and environmental benefits to the area through intermediate treatment of wastes and power generation.

6.1.2 Risks in relation land acquisition and business approval

The project site is scheduled to be inside the Khanh Son disposal site which is currently owned by URENCO which is planned to participate in the project consortium. As it is planned that URENCO would provide this land free of charge to the SPC, sufficient consultations should be made in advance with URENCO to avoid risks concerning land acquisition.

In relation to business approval, there is the possibility that unforeseen time and costs may be taken in obtaining approval for investment and construction. As the SPC cannot be created without such an approval, sufficient discussions and negotiations should be made with Da Nang City and URENCO which is the candidate Vietnamese investor to avoid such risks.

Furthermore, it is unlikely that the business approval would be stopped if URENCO becomes one of the investors.

The largest risk at the project preparation stage is the risk in relation to PPP bidding. Currently, under the Vietnamese Law on BOT and Law on PPP, PPP projects that are proposed and approved by Da Nang City or Vietnamese government would become open to biding. Therefore, the proposer of the project must compete with other bidders based on technical specifications and the cost. Under the current laws, the project proposer can go into the contract negotiations without any bidding only if there is no other bidder.

Therefore, it is important to specify high standards or specify in detail the technical specifications regarding the facility design, treatment quality, operation & maintenance, and capacity of staffs (years of experience and technical expertise in operating & maintenance) so that entities that do not fulfill a certain technical standards would not participate in the bidding.

In addition, this project is expected to be profitable only if it is financed by JCM subsidy and JICA Private Sector Investment Finance. Therefore, it should be clearly explained to the Vietnamese side that an entity from another company would not be able to receive the same financial assistance.

Vietnam is currently reviewing its regulations regarding PPP bidding. For instance, there is the possibility that the proposer of a project would be given incentives to participate in in the bidding process. Therefore, a close watch should be kept on the future developments.

6.1.3 Risks in relation to financing

In relation to financing, there is the risk regarding investment by the SPC members and the risk regarding obtaining finance. Currently, it is expected that the capital of the project would be about 30% of the initial investment. How the Japanese consortium and the Vietnamese side would share the burden must be thoroughly discussed and agreed on before establishing the SPC, and the agreement should be included in the memorandum of understanding regarding establishment of SPC. Under the Vietnamese Law on Investment, there are no regulations regarding the ratio of capital between foreign and domestic companies. Issues such as the financial capacity of the Vietnamese partner should be clarified in the discussions among SPC members. In addition, whether the investment would be made in local currency or foreign currency (USD or JPY) should also be clarified taking into account exchange risk. With regard to JICA Private Sector Investment Finance, in order to avoid exchange risk, loan in VND would be necessary.

6.1.4 Risks in relation to contracting (waste treatment service contract, power purchase agreement)

As explained in the previous sections, signing long-term contracts regarding waste treatment service and power purchase would assure the stability of the project revenue. Unless stable revenue is assured by the central government guarantee, entities with sufficient capabilities may not be able to participate in the bidding or more over there may be no winner in the bid.

Da Nang City would consider about the project based on this report and then ask for the approval of its implementation to the central government. Then, the central government would consider the project in detail. Further, as FIT for power from waste-to-energy facilities has been made public by the Vietnamese government and thus formalities regarding power purchase from the facilities in this Project are expected to be the next steps. However, as there has been no similar case in Vietnam, signing the power purchase agreement may take considerable time which may drastically delay the project, or bidding may be conducted with unfixed conditions.

6.1.5 Risks in relation to competition with the other investors

Currently, there is a small-scale composting and plastic-based oil recovery facilities in operation near Khanh Son Landfill. It partially uses the waste received in Khanh Son Landfill for its treatment and oil production.

Although the proposed facility in this Study may compete with the above facilities in the future, Da Nang City mentioned that the above facilities were still in testing operation and there was no concrete contract on solid waste management service. It also said that Da Nang City would consider and decide what types of intermediate treatment facilities should be developed after the proposal in this study.

The Study Team will continuously follow up the activities of the above facilities and Da Nang City to avoid the risk of competition.

6.2 Risks at the facility construction stage

6.2.1 Risks in relation to completing construction works

At the construction stage, as the works would take place in a developing country, there is the risk that the machineries, equipment, and facilities do not complete at the planned time, with the planned cost, or with the planned quality.

In this project, it is planned that JFE Engineering which is the member of the SPC would sign the EPC contract with the SPC. Thus, this risk could be minimized if JFE Engineering conducts sufficient preparation and planning regarding material and equipment procurement in Japan and in Vietnam.

However, with regard to materials and equipment that would be procured in Japan and the exported to Vietnam, it is important to reach an agreement with the Vietnamese government in advance so that tax exemption and reduction would be applied according to the current Law on Investment and taxation system.

6.2.2 Risks in relation to utilities

Not only during construction stage but also during operation, there are risks that the utility services required for the project (e.g. electricity, water supply, infrastructure for communications) would not be supplied as requested.

In order to minimize this risk, the utility services that would be necessary during construction and operation would be clarified and contracts would be signed with the Vietnamese authorities for the stable supply of such services. Furthermore, the current situation in Da Nang City regarding such services should be evaluated and if there are possibilities that certain services may not be stably supplied, the SPC should consider countermeasures.

6.3 Risks at the operation stage

6.3.1 Exchange risk

Although the project would be implemented based on the local currency VND, certain expenditures such as loan repayment or operation and maintenance cost would have to be paid in foreign currency. Thus, the change in exchange rate would have an important impact on the profitability of the project. There is also the exchange risk at the construction stage, as the cost for procurement from Japan may have to be paid by foreign currency. Thus, this risk should also be hedged.

In order to minimize this risk, it is important to manage the currency for revenue and expenditure through measures such as exchange marry (to settle loan repayment with the same currency to the extent possible) or advance purchase of the foreign currency. Especially for the revenue, it is important to define in the waste treatment service contract and power purchase agreement the conditions regarding exchange rate so that the impact of the change in exchange rate would be minimized (the risks would be minimized if all or a part of the payments can be paid in a currency such as USD or JPN which are relatively stable, but the Vietnamese side may not agree on such conditions).

6.3.2 Risks in relation to project revenue and expenditure

At the operation stage, there are risks that the profit would be lower than initially planned due to waste amount and/or power generation amount lower than planned or operation and maintenance costs higher than planned.

With regard to revenue, as explained in the previous sections, the risk can be minimized by assuring the minimum revenue in the contract.

Meanwhile, the risk regarding increase in costs can be minimized by designing the project so that it would be profitable even with 5 to 10% of the expected cost as physical and price contingency.

In addition, if there may be serious impact to the profitability of the project by other incidents (Force Majeure), it may be important to buy in advance project insurance. In this case, the additional cost that would be necessary should be financed by the insurance (i.e. for risks concerning natural disasters, environmental change).

As PPP projects have high public nature and are under great influence of the financial conditions of the local governments, it is essential that SPC obtain guarantee from the central government regarding its revenue.

6.3.3 Inflation risk

There is also the risk that inflation may occur during the project construction and operation period. In order to minimize this risk, a parameter (a deflator) that would indicate the level of inflation may be established when setting the tipping fee in the contract so that the tipping fee would change in accordance to the change in this parameter.

7 Necessity of the Project

7.1 Assumptions made for the financial feasibility analysis and result of analysis

The cash flow of the proposed project on waste intermediate treatment and electric power generation was analyzed under the conditions outlined in the tables below. In this Chapter, the feasibility of Option 3 (MRF + waste incinerator with capacity of 300 tons) was examined as the tipping fee of this option (30 USD/ton) fulfills the condition requested by Da Nang City.

Table 7-1: Conditions and Results of Cash Flow Analysis (1)

Item	Conditions
Implementing Organization	SPC composed of Japanese private consortium and Vietnamese partner
Project outline	Intermediate treatment (incineration) of municipal wastes in Da Nang City from households and businesses and electric power generation
Project period	20 years from 2017 to 2036 Excluding construction and preparation of operation period
Capital	Approximately 1.5 billion JPY (24% of initial investment)
Initial investment	Approximately 6.3 billion JPY
Method of financing	• Direct investment through Private Sector Investment Finance of JICA: Approximately 3 billion JPY • JCM Grant from MOE Japan: Approximately 2.5 billion JPY
Conditions of loan	• Private Sector Investment Finance of JICA: Redemption in 15 years; equal repayment during 15 years with interest rate of 13% (in VND) • JCM Grant from MOE Japan: Grant assistance (As to JCM grant, the Study Team has informed Da Nang City that the Team would try to apply for obtaining it next fiscal year. It also mentioned that the amount of GHGs emission reduction achieved by the project must be transferred for free to the Government of Japan in case the above grant is provided. Da Nang City accepted this offer.)
Operation and maintenance cost	Approximately 5.9 billion JPY/year
Depreciation of facilities	Facilities will depreciate completely in 20 years under the straight-line method
Corporate tax	The project will be completely exempt from taxes for 4 years as it is an environmental project, then exempt for 50% for 5 years, and then be imposed of taxes of 10%. Procurement from overseas would be exempt from customs duties
Revenue from operation	1. Electric power sales • Power selling price: 10.05 JPY/kWh • Amount of power to be sold: Approximately 33,034 MWh/year 2. Revenue from waste treatment The fee that would realize project EIRR of 18%: 2,500 JPY/t

Table 7-2: Conditions and Results of Cash Flow Analysis (2)

<table>
<tr><th>Item</th><th>Conditions/Result</th></tr>
<tr><td>Project IRR and Equity IRR under basic scenario</td><td>Project IRR: 18.22%
Equity IRR: 20.08%</td></tr>
<tr><td>Sensitivity analysis regarding inflation risk</td><td>Project IRR and Equity IRR was calculated under the following conditions:
3. Inflation occurs during the project period by annual average of 5% or 10%
4. O/M increases in accordance with the inflation rate
5. Revenue stays the same as the unit price stays the same
<table>
<tr><th>Average inflation rate</th><th>Project IRR</th><th>Equity IRR</th></tr>
<tr><td>5%</td><td>18.58%</td><td>20.71%</td></tr>
<tr><td>10%</td><td>16.85%</td><td>17.58%</td></tr>
</table>
If inflation occurs by 5%, as taxes will decrease, IRR will rise. Meanwhile, if inflation occurs by 10%, IRR will decrease.</td></tr>
<tr><td>Sensitivity analysis regarding exchange risk</td><td>Project IRR and Equity IRR was calculated when VND depreciates against JPY every year by 1% and 2%.
<table>
<tr><th>Annual average depreciation rate of VND against JPY</th><th>Project IRR</th><th>Equity IRR</th></tr>
<tr><td>1%</td><td>15.88%</td><td>15.46%</td></tr>
<tr><td>2%</td><td>12.11%</td><td>Unmeasurable</td></tr>
</table>
If VND depreciates against JPY by annual average of 2%, the project will not be profitable. Therefore, efforts must be made to finance the project in VND to the extent possible. If that is not an option, other measures to mitigate the exchange risk should be taken such as receiving the payments of “waste treatment service fee” and “power sales” in JPY (if the project can be financed in USD, the above fees should be received in USD).</td></tr>
</table>

7.2 N Necessity of the Project and its Impact

Based on the current remaining capacity of Khan Son Landfill (2,535,521 cubic meter) at the time of October 2012 and the result of estimation on future waste generation and treatment above, the Study estimated the remaining years of Khan Son Landfill as shown in the table below. As a result, the Khan Son Landfill is estimated to be full by 2019 if all the wastes collected are landfilled without any treatment for volume reduction.

Table 7-3: Projected Trend of Waste Disposal at Khan Son Landfill

Year	Amount of solid waste (ton/year)	Amount of sludge (ton/year)	Amount of cover soil (t/year)	Amount of waste disposal at landfill (ton/year)	Volume of waste disposal at landfill (m^3/year)	Remaining capacity of landfill (m^3)
2012	-	-	-	-	-	2,535,521
2013	268,597	2,920	16,291	287,808	287,808	2,247,713

Year	Amount of solid waste (ton/year)	Amount of sludge (ton/year)	Amount of cover soil (t/year)	Amount of waste disposal at landfill (ton/year)	Volume of waste disposal at landfill (m^3/year)	Remaining capacity of landfill (m^3)
2014	286,890	2,999	17,393	307,282	307,282	1,940,431
2015	297,475	3,078	18,033	318,586	318,586	1,621,844
2016	308,904	3,168	18,724	330,796	330,796	1,291,048
2017	318,280	3,244	19,291	340,815	340,815	950,233
2018	328,500	3,329	19,910	351,739	351,739	598,494
2019	338,355	3,416	20,506	362,277	362,277	236,217
2020	348,798	3,514	21,139	373,451	373,451	-137,234

Remark: Average specific gravity of waste is assumed at 0.8 ton/m^3 based on the result of waste amount and composition survey conducted in the Study.

However, based on the experience of constructing the current Khanh Son disposal site, it is highly difficult if not impossible to construct new disposal sites in the surrounding areas. Thus, Da Nang City should extend the lifetime of the current Khanh Son Landfill as much as possible, and in order to achieve this objective, introduction of intermediate treatment facilities could be highly effective as they would drastically reduce the volume of wastes to be landfilled.

In this Survey, it was found that although the effect would be different depending on the chosen option, introduction of the intermediate treatment facility would reduce the amount of wastes by 40 to 70% (if it is assumed that direct landfill would reduce the wastes by 0%).

7.3 Challenges and Countermeasures regarding Project Implementation

Option 3 which will introduce MRF with waste incineration and power generation facility (treatment capacity of 1,000 ton/day), the tipping fee would be from 25 to 30 USD/ton under the most favorable conditions[3] (in order to use the JCM grant, Da Nang City must handover to SPC free of charge the carbon credit that will be generated through the project).

Meanwhile, the current cost for municipal solid waste management (collection, transport, treatment, and disposal) is 233,000 VND (approximately 11 USD)/ton. Within this cost, the cost for treatment and disposal is 24,611 VND (approximately 1.1 USD)/ton.

In order to realize this project, it is essential that the conditions listed in Table 5-4 are met. As obtaining the guarantee by the central government would be especially difficult with only the efforts by the Japanese private companies, efforts will be made in collaboration with Da Nang city.

[3] Conditions such as "electric power sales price would be USD 0.1/kWh", "USD 46million would be financed by the JCM Program of the Ministry of the Environment, Japan"