Feasibility Study on CDM/JI

LFG to Electricity Project in Nontaburi, Thailand

Summary Edition

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I Background, Purpose and Outline of Study

1. Purpose of the study

The purpose of the study is to further evaluate the issues revealed in the study conducted FY2002, Electric Power Generation Facility Using Methane Gas from Waste Disposal Sites in Thailand. Those issues are 1) the Landfill Gas generation rate and 2) the compositions of landfill gas (hereafter referred as "LFG"), which have significant impacts on the feasibility of a LFG to Electricity project.

To evaluate those issues, the compositions of solid wastes for the estimation of the volume of LFG are investigated. Also, LFG extraction test wells in an open dumping site close to the site proposed for the project are installed, and LFG is recovered to collect information and data necessary to design a LFG recovery and power generation system.

Based on these evaluation results, a CDM project is planned, and its project feasibility is assessed. A proposed site for the project is the same as that of the year FY2002 study, which is located in the Solid Waste Disposal Center in Nontaburi Province, in the northwest suburb of Bangkok. The study is conducted in cooperation with Hitachi Zosen Corporation. And also, Kasetsart University is retained as our consultant in Thailand.

II Study of Landfill Gas

1. Outline of the landfill site proposed for the project

The Solid Waste Disposal Center, owned and operated by Provincial Administration Organization of Nontaburi: PAON, is a waste disposal site to accept wastes generated in Nontaburi province. While the wastes are currently open dumped in this center, a reforming plan for sanitary landfill disposal is now underway. There are now three landfills (A, B and C) for the plan. The construction work of the Landfill-B and the wastewater treatment facility has already been completed. Initially, the Landfill-B was scheduled to start accepting wastes from June in 2003, however, wastes are now disposed in an open dumping site in the Solid Waste Disposal Center.

In the FY2002 study, the plan for Landfill-A was not taken into consideration, because the site for Landfill-A was at that time planned for recycling and composting facilities. However, during the study in FY2003, it is revealed that there are two alternative plans for this site, one is "recycling and composting facilities" and the other is "a sanitary landfill". In the study, the site is assumed to be used for a sanitary landfill judging from the needs for sanitary landfills in this region. The capacity of landfills and the estimated landfill work schedule are shown in Table II-1. The volume of wastes to be accepted per day is based on 800 tons/day, the amount obtained from the study by PAON, with consideration of the population growth in the future.

2. Waste composition study

Sampling and composition analyses are conducted for the actual wastes brought into the proposed project site. Based on the results of the analyses and data obtained from the waste composition study conducted by Pollution Control Department (PCD) of Ministry of Natural Resource and Environment (MONRE), the waste composition to estimate the volume of LFG to be generated are estimated as shown in Table II-2.

Table II-1: Landfill capacity and estimated landfill work schedule

	1st Phase	2nd Phase	3rd Phase
Landfill Site	Landfill - B	Landfill - C	Landfill - A
Landfill Capacity(m^3)*1	644,000	457,000	1,200,000
Net Landfill Capacity (m^3) *2、3	589,260	418,155	1,098,000
Estimated Landfill work schedule	2004.7 - 2006.1	2006.1 - 2007.2	2007.3 - 2010.5

∗1 Soil volume for Daily Cover、Intermediate Cover、Top(Final) Cover are included
∗2 Soil volume for Daily Cover、Intermediate Cover、Top(Final) Cover are excluded
∗3 Assumed waste density = 850kg/m^3

Table II-2 Waste Composition for estimation of the volume of LFG to be generated

Components	Paper	Food	Cloth	Plant	Plastic	Rubber	Skin	Iron	Misc. Metal	Glass	Stone / Ceramic	Others	Total
Wet Weight %	7.03	64.35	1.72	1.57	17.24	0.35	0.03	0.73	0.78	2.23	0	3.97	100

3. Field LFG extraction tests

To collect the basic data for designing a LFG recovery and power generation system, field tests are conducted for a period of approximately two months from December 2003. In the field tests, the open dumping site (90 m x 60 m) is covered with polyethylene sheet as substitute for soil cover to simulate the conditions of sanitary landfill. And extraction wells and blowers are installed to extract LFG from the test area. The results obtained form the tests are shown in Table II-3 and the system flow of the field test is shown in Figure II-1.

Table II-3: Results of field tests (abstract)

Items	Data obtained
(1) LFG flow rate (Ave.)	144.82 m^3/h
(2) LFG temp. (Ave.)	51.2 ℃
(3) Composition of LFG(Ave.)	CH_4 = 55 %, CO_2 = 30.1 %, O_2 = 0.3 %

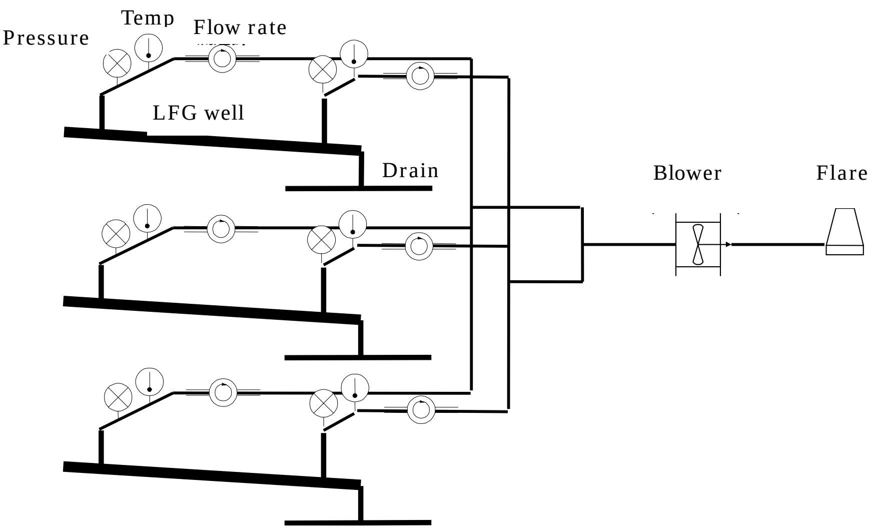

Figure II-1: Field test System Flow

4. Estimation of volume of LFG generated and recovery volume

Volume of LFG is estimated by First Order Decay (FOD) method in the same way as the study in FY2002. Parameters, k value and L_0, for FOD method are established at a conservative side, because the conservative estimation of the Volume of LFG gives a conservative result in the feasibility study as well. The parameters for the estimation are shown in Table II-4, and the result of the estimation is shown in Table II-5.

Table II-4: Parameters for estimation of volume of LFG

Parameters	Data		
	Landfill - B	Landfill - C	Landfill - A
Start Filling	2004	2006	2007
Finish Filling	2006	2007	2010
Net Landfill Capacity (ton)	500,871	355,432	933,300
k Value (1/y)	0.15		
L_0 (m^3/ton)	49.1		
Methane content(%)	50		

Table II-5: Estimated Volume of LFG

year	Methan emission rate(FOD Caluculation)			LFG emission rate			LFG emission rate		LFG Collection Rate		Remarks
							Case-1	Case-2	Case-1	Case-2	
	Landfill B	Landfill C	Landfill A	Landfill B	Landfill C	Landfill A	Landfill B+C	Landfill B+C+A	B+C	A+B+C	
	k=0.15 L_0=49.1			CH4=50.0%					Tolerance= 25% Collection rate=49%		
	(m^3/yr)			(m^3/yr)			$\times 10^6$ m^3		$\times 10^6$ m^3		
2004											
2005	1.61E+06			3.23E+06							
2006	3.46E+06	8.39E+04		6.93E+06	1.68E+05		6.93	6.93	2.55	2.55	Landfill-B start
2007	2.98E+06	2.24E+06		5.96E+06	4.48E+06		10.44	10.44	3.84	3.84	Landfill-C start
2008	2.57E+06	1.93E+06	1.81E+06	5.13E+06	3.86E+06	3.63E+06	8.99	9.36	3.30	3.44	
2009	2.21E+06	1.66E+06	3.75E+06	4.42E+06	3.32E+06	7.50E+06	7.74	11.56	2.84	4.25	Landfill-A start
2010	1.90E+06	1.43E+06	5.42E+06	3.80E+06	2.86E+06	1.08E+07	6.66	17.19	2.45	6.32	
2011	1.64E+06	1.23E+06	4.67E+06	3.27E+06	2.46E+06	9.34E+06	5.73	15.07	2.11	5.54	
2012	1.41E+06	1.06E+06	4.02E+06	2.82E+06	2.12E+06	8.04E+06	4.93	12.97	1.81	4.77	
2013	1.21E+06	9.11E+05	3.46E+06	2.42E+06	1.82E+06	6.92E+06	4.25	11.16	1.56	4.10	
2014	1.04E+06	7.84E+05	2.98E+06	2.09E+06	1.57E+06	5.95E+06	3.65	9.61	1.34	3.53	
2015	8.98E+05	6.75E+05	2.56E+06	1.80E+06	1.35E+06	5.12E+06	3.15	8.27	1.16	3.04	
2016	7.73E+05	5.81E+05	2.21E+06	1.55E+06	1.16E+06	4.41E+06	2.71	7.12	1.00	2.62	
2017	6.65E+05	5.00E+05	1.90E+06	1.33E+06	1.00E+06	3.80E+06	2.33	6.13	0.86	2.25	
2018	5.73E+05	4.30E+05	1.63E+06	1.15E+06	8.61E+05	3.27E+06	2.01	5.27	0.74	1.94	
2019	4.93E+05	3.71E+05	1.41E+06	9.86E+05	7.41E+05	2.81E+06	1.73	4.54	0.63	1.67	
2020	4.24E+05	3.19E+05	1.21E+06	8.48E+05	6.38E+05	2.42E+06	1.49	3.91	0.55	1.44	
2021	3.65E+05	2.75E+05	1.04E+06	7.30E+05	5.49E+05	2.08E+06	1.28	3.36	0.47	1.24	
2022	3.14E+05	2.36E+05	8.97E+05	6.28E+05	4.72E+05	1.79E+06	1.10	2.89	0.40	1.06	

LFG emission rate=Methan emission rate(FOD Caluculation)×CH4 density
LFG Collection Rate =LFG emission rate ×Collection rate/100×(100-tolerance)/100

III. CDM Project

1. Outline of the project

The project planed in FY2003 is a project that recovers LFG from the sanitary landfill in Nontaburi Solid Waste Disposal Center, and uses it for power generation. GHG emission is reduced by capturing and combusting methane generated as LFG from the landfill, in the power generation system and the flare system. The project is also expected to reduce GHG by replacing the electricity generated by other resources.

The project is evaluated on two cases, Case-1 and Case-2; Case-1 for the Landfills B and C only, which is the same as the case for FY2002, and Case-2 for the Landfills A, B and C. A block flow of the project is shown in Figure III-1, the project outline in Table III-1 and the overall site plan in Figure III-2.

Gas engines are assumed as the power generation system for both cases 1 and 2. And also, re-built gas-engine generators are assumed for the purpose of improving the economic efficiency of the project.

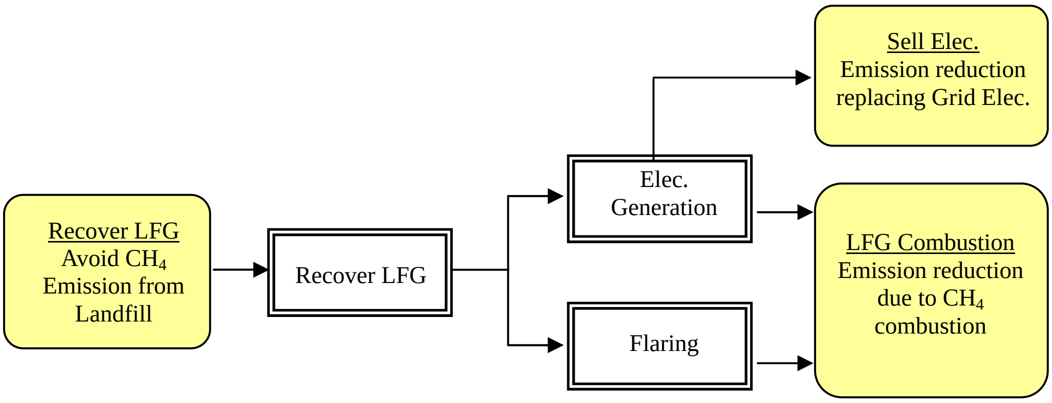

Figure III-1: Project block flow

Table III-1: Outline of the Project

Case	Case 1	Case 2
Location of the Project	Nontaburi Province, Thailand	
Landfill sites	Landfill - B, C	Landfill - B, C, A
Elec. Generator Capacity	300 kW (300kW x 1set)	600kW (300kW x 2set)
Duration of Project Activity	10 years (2007 - 2016)	

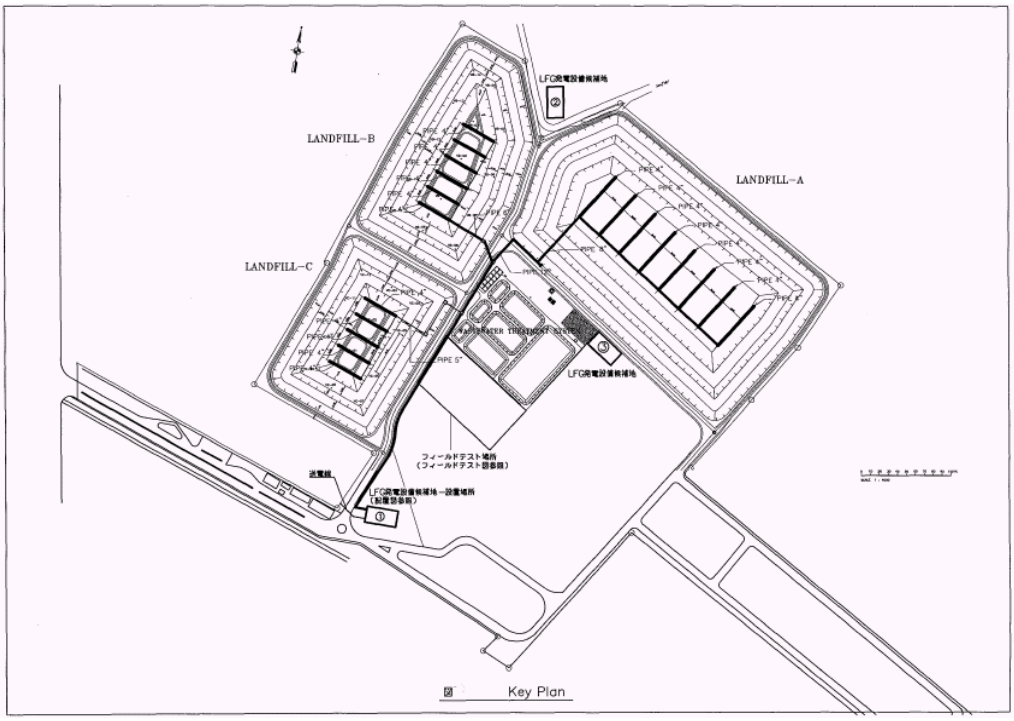

Figure III-2: Overall site plan

2. Baseline scenario and monitoring plan

AM 0003 (NM0005) “Simplified Financial Analysis for Landfill Gas Capture Projects” is selected as the baseline and monitoring methodology for this project after reviewing the applicability condition of the methodology and the project circumstances. As the baseline scenario, business as usual scenario, “Methane generated from the landfills will be released into the atmosphere”, is assumed.

3. Estimation of GHG emission reduction

The amount of GHG emission reduction by this project is estimated based on the calculation of the volume of LFG to be captured, the baseline methodology applied for this project and the conditions shown in Table III-2. The results show that the amounts of GHG emission reduction in Case-1 and Case-2 are approximately 140,000 tons and 280,000 tons of CO_2, respectively.

Table III-2: Conditions used for estimation of GHG emission reduction

No.	Conditions	Set Value	Unit
1	LFG CH_4 content	50	%
2	LFG recovery rate	49	%
3	System Operating hours	8,664	Hour / year
4	System Failure rate	5	% /total yearly operating hours
5	CH_4 density	0.0006446	ton / m^3

4. Project feasibility assessment

The economic feasibilities of Case-1 and Case-2 are assessed, assuming the expenses and incomes during the project period. In Case-1, Internal Rate of Return (IRR) is not realized and the accumulated losses are not paid off. On the other hand, Case-2 shows some improvements in both IRR and the accumulated losses. However, the accumulated losses are still not paid off and IRR is as low as -4.6%. The prerequisites used for the economic efficiency assessment are shown in Table III-3 and the costs excluded from the assessment are shown in Table III-4.

Table III-3: Prerequisites used for the economic efficiency assessment

No.	Items	Conditions	
		Case - 1	Case - 2
1	Investment Cost	81,500,000 JPY	117,100,000 JPY
2	O&M Cost	3,930,000 JPY/Year	7,490,000 JPY/Year
3	Labor Cost	638,000 JPY/Year	
4	Elec. Unit Price to sell	5.3 JPY/kWh (1.9 Baht/kWh)	
5	Unit Price of Carbon Credit	336 JPY/t-CO_2 ($ 3/t-CO_2)	
6	Expenses for PDD, Validation	15,000,000 JPY	
7	Expenses for Verification	3,000,000 JPY/Year	
8	Corporate tax	30 %	
9	Misc. Project Expenses for Start –up	25,200,000 JPY (9,000,000 Baht)	
10	Administration Overhead	20 %	
11	Exchange Rate	1Baht＝ 2.8 JPY、	1 US$= 112 JPY

Table III-4: Subjects excluded from the assessment

No.	Subjects	Remarks
1	LFG Unit Price	Appropriate compensation for the project shall be determined
2	Land Lease Fee	ditto

5. Summary

5.1 Comparison with the study in FY2002.

5.1.1 Volumes of LFG to be generated and Characteristics of LFG generation

The estimation conditions and results of both the volume of LFG to be generated and recovered are compared between the studies in FY2002 and FY2003. The results are shown in Table III-5, and the result of the LFG recovery volume is shown in Figure III-3.

Table III-5: Comparison of volumes of LFG to be generated and Characteristics of LFG generation

No.	Items	FY 2003		FY 2002		FY2003 / FY2002
1	Amount of Wastes (Landfill – B + C)	0.86	(M-ton)	1.2	(M-ton)	71 %
2	CH_4 Generation Potential (L_0)	49.1	(m^3/t)	155.93	(m^3/t)	31 %
3	k value	0.15	(1/y)	0.03	(1/y)	
4	LFG Collection rate	49	(%)	80	(%)	61 %
5	LFG Collection Variation (Tolerance)	-25	(%)	0	(%)	
6	Volume of LFG to be generated ・Duration: 10 years ・Landfill – B + C	5.83E+07 (Incl. Collection Variation)	(m^3/y)	9.42E+07	(m^3/y)	62 %
7	Volume of LFG to be collected ・Duration: 10 years ・Landfill – B + C	2.14E+07	(m^3/y)	7.53E+07	(m^3/y)	28 %

(1) Volume of LFG to be generated and recovery volume

The results of the study in FY2003 show that the volume of LFG assumed to be generated during the term of the project (for 10 years) is 62% of the volume of FY2002, and the recovery volume assumed is 28% of the level of FY2002. Major reasons for such low volume are summarized as below:

1) Decrease in the amount of wastes

In the study in FY2002, the capacity of landfills (Landfills B + C) was assumed as 1.2 million tons as indicated in the plan of PAON. In FY2003, however, to be more accurate, the landfill capacity is estimated, taking the actual density of the wastes and the soil cover placed in the landfill layers into account. Consequently, the amount of the wastes in the landfills decreases by 29% comparing to the study in FY2002, which results in a decrease in the volume of LFG to be generated.

2) Methane generation potential (L_0)

In the study in FY2003, the methane generation potential L_0 = 49.1(m^3 CH_4/Mg Waste) is assumed, while L_0 = 155.93 (m^3 CH_4/Mg Waste) was assumed in FY2002. The lower methane generation potential assumed results in a decrease in the volume of LFG to one third (1/3). The reason for the low L_0 of FY2003 is that the actual conditions of waste composition and actual climate are reflected in the parameters in the L_0 calculation formula.

3) LFG recovery efficiency and recovery volume tolerance

In the study in FY2003, the recovery efficiency of 49% is assumed, while 80% was assumed in FY2002. The low recovery efficiency come from the fact that a low level landfill management is anticipated in the region, compared with the international standard level of landfill management.

In addition, the LFG recovery volume is reduced by 25%, taking account of such factors as LFG seasonal fluctuations, soil cover conditions, effect of leachate and so forth. As a result, these factors lower the recoverable volume of LFG to a substantial extent.

(Recovery Volume in FY2002) = (volume of LFG to be generated) x (Rec. Efficiency: 80%)
= 0.80 x (Volume of LFG to be generated)

(Recovery Volume in FY2003) = (Volume of LFG to be generated) x (Rec. Efficiency: 49%)
x (1 - Recovery Volume Tolerance: 25%)
=0.37 x (Volume of LFG to be generated)

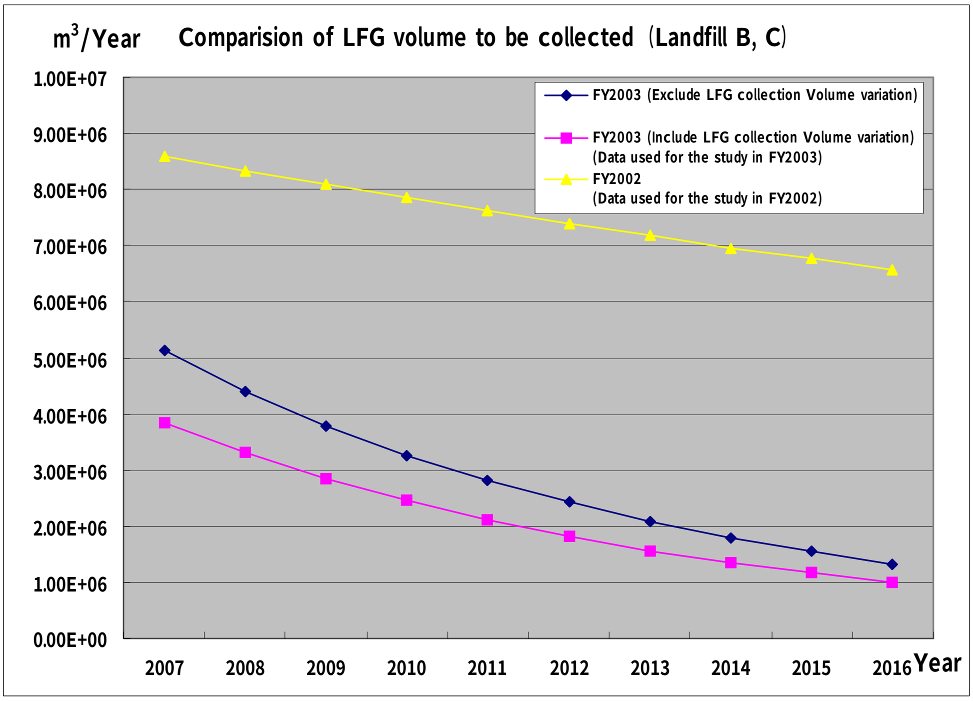

Figure III-3: LFG recovery volume comparison

(2) Changes in characteristics of LFG generation

Referring to LFG experts for their opinions, k=0.15 (k=0.03 in FY2002) is assumed. Due to the higher rate, the peak of LFG generation becomes higher and occurs earlier, and then afterwards the generation rapidly decreases. The rapid change in the LFG generation is disadvantageous for the power generation business that requires a stable gas supply to generate electricity.

5.1.2 LFG power generation system

The capacity of the power generation system (Case-1) in FY2003 is designed as 300kW x 1. This is 770kW lower than that in FY2002 due to the decrease in the gas recovery volume. And, while the operating hours of the power generation system assumed in the report for FY2002 was 8,760 hours/year, the operating hours in FY2003 is reduced to 8,280 hours/year, assuming maintenance work and so on during the project duration. On the other hand, the number of LFG recovery wells is increased, compared to those of FY2002, in order to improve the recovery efficiency.

5.1.3 Project feasibility

The economic feasibilities of the project are assessed by IRR. The feasibility assessment results are; non-calculable for Case-1 and IRR = -4.6% for Case-2. Case-1 is a comparison of the study in FY2002 in terms of the size of landfill sites. Comparing to the IRR = 29.2% in FY2002, the economic feasibility for FY2003 become drastically worse.

Major reasons for the lower economic feasibility are summarized below:

(1) Decrease in the project incomes

The LFG recovery volume of FY2003 is considerably lower than that of FY2002. Also, the characteristics of LFG generation show an undesirable pattern for power generation business. Consequently, the amount of power sale to an electricity company and the amount of CO2 credit from GHG reduction decrease, causing a drop in the project incomes.

(2) Expenses for implementation of CDM

In the study for FY2002, the expenses necessary for CDM implementation were not included. In FY2003, however, the expenses for CDM, 15 million Yen as an initial cost and annually 3 million Yen/year are included. It is found that the expenses for CDM are not negligible, but rather major expense items for the size of this project, particularly Case-1.

5.2 Issues to be solved to execute

5.2.1 Measures to improve the project feasibility

(1) Expansion of landfill sites (= an increase in the volume of wastes)

The simplest way to increase the volume of LFG is to increase the landfill capacity (the wastes volume). In Case-2 in FY2003, Landfill-A is included in addition to Landfill-B and C, which were originally assumed in the study in FY2002. The economic feasibility of Case-2 is improved substantially, however not enough to become feasible (Landfill-B and C: IRR =non-calculable → Landfill B,C and A: IRR = -4.6%).

(2) Incentives for carbon credit price and electricity selling price

An increase of the carbon credit price and the electricity-selling price directly improves the project feasibility.

(3) Increase in the volume of LFG to be generated

In the study in FY2003, a lower methane generation rate (L_0) is assumed to be conservative in the project feasibility assessment. While it is almost impossible to accurately estimate the volume of LFG generated, it is considered that the volume estimated in FY2003 is at the lowest level and the actual volume is expected to be more than the estimate.

(4) Application for government subsidy

Any subsidies directly improve the project feasibility. It is encouraged to check all the government subsidy available for each stage and assess the improvement in the project feasibility with those subsidies.

(5) Improvement of LFG recovery efficiency by landfill management improvement

The improvement in landfill management improves the LFG recovery efficiency. In general, the landfill operators do not have knowledge how to manage the landfill to the international level and need funds to execute the appropriate landfill management. The government support to the funds as well as the education is highly required.

(6) Decrease in the compensation for use of LFG

The compensation for use of LFG was one of the issues to be solved in the study in FY2002. However, discussions regarding the compensation for use of LFG with the provincial administration organization, were not held. Any compensation for use of LFG gives an adverse impact on the project feasibility. Understanding and cooperation by the provincial administration organization, the owner of landfill sites are indispensable.

5.2.2 Other Issues that may affect the project feasibility

(1) Time to start sanitary landfill operation

In the LFG power generation project, it is a principal condition that landfills are being filled with wastes as scheduled. Therefore, to proceed with the project, it is necessary that the landfill operation and construction be carried out as scheduled.

(2) Rights and interests in the waste disposal industry

It is generally said that there structurally lie the rights and interests in the waste disposal industry. Once these kinds of issues occur, additional costs and time might be required, which all affect the project. Such obstacles might become the most challenging problems in the implementation of the actual project.

(3) Procedures and applications for CDM project execution

To execute the CDM project, various clerical and practical procedures will be required. Although all the required procedures are not yet clear to us, it is foreseen that those procedures are time-consuming. The support from Japanese government and relevant agencies will be very instrumental to carry out these procedures smoothly.

(4) Capacity building

Through the research during this study, it has become clear that most of the officials and others related to this project have very limited knowledge about Kyoto Protocol and CDM. For execution of this project, it is indispensable that all of the parties that involve this project have a clear and positive understanding of this project. Therefore, it is strongly requested that the governments of Japan and the host country will facilitate capacity building for such party as a provincial administration. Better understanding of CDM is also expected to abate the issues related to the rights and interests in the waste disposal industry.

(5) Reliability of characteristics of LFG generation

As a comparison, the volume of LFG is estimated by the Seldon Arleta model with the cooperation by The National Institution for Environmental Studies of Japan. The two estimates show some difference in terms of the generation characteristics.

5.3 Summary

The results of the study in FY2003 are summarized as below:

1) The economic feasibility of the LFG power generation project

- With a decrease in the recoverable volume of LFG, the project income (from power generation and carbon credits) decreases to a large extent.
- The expenses of CDM are relatively high comparing to the project incomes.
- From the reasons above, the economic feasibility of the project decreases drastically.

  For Case-1 (Landfill-B and C) : IRR= non-calculatable

  For Case-2 (Landfill A, B and C) : IRR= -5%

2) Volume of LFG to be generated and recovered

- The re-examination of both the waste volume acceptable in the landfills and the methane generation potential shows that the volume of LFG to be generated decreases by 38% from the level estimated in FY2002.
- The LFG generation rate is remarkably faster than the rate assumed in 2002 (The volume of LFG generation will increase sharply in the early stage of the landfill work, reaching its peak, and it decreases sharply after that).
- Taking account of the factors above and the expected management level of landfill sites, the recoverable volume of LFG is found to decrease by 75% from the level in the study in FY2002.

3) Measures to improve the project feasibility

To make the project feasible, a variety of practical improvement measures, i.e. expansion of proposed landfill sites, higher prices of both the carbon credit and electricity selling, government subsidies, the improvement of LFG recovery efficiency by landfill management improvement, reduction in the compensation for use of LFG, etc., are proposed.