Landfill Gas Management CDM Project
in
Kolkata , India

Final Report

February 2007

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Executive Summary

1. Purpose and significance of the project

Currently at the Dahpa waste disposal site, none of LFG is managed but left emitted into atmosphere without any treatment. A global warming potential (GWP) of methane gas is as 21 times as that of carbon dioxide, and methane gas/LFG generated from the waste disposal site regarded as the causes of global warming. In addition, LFG generated from the waste disposal site will become risk factors such as bad smell, toxic gases and fires, being a cause of deteriorating local environment.

This project aims to improve environment both at global and local scales through the capture and treatment of LFG, which gives not only significant impacts on global warming but also great negative effects on neighborhood around the waste disposal site. In addition, the project aims to contribute to sustainable development of Kolkata city as economic profits will be achieved and waste management shall be improved by assigning the project as a CDM.

2. Outline of the Study

Following tasks or activities was conducted in this Feasibility Study..

- Task 1: Qualify and quantify the CDM potential of Dhapa landfill site
- Task 2: Identify various technological options of tapping CDM potential of
- Dhapa landfill site
- Task 3: Identify various revenue model options available to KMC in regard
- Task 4: Identify available resources in international market and their ratings
- Task 5: Identify time frame for the implementation of the project

3. Methane generation at the project site

Based on the field survey result of the Dhapa waste disposal site, the amount of methane generated at the landfill was estimated, using First Order Decay Model (FOD Model) Spreadsheet, presented in the IPCC Guideline（2006 IPCC Guidelines for National Greenhouse Gas Inventories）.
Estimated methane generation for 10 years are shown in the following table.

The GHG (Green House Gas) reduction calculated based on the Methane combusted is 819,165t-CO_2e for 1st Period of Kyoto protocol and 1,425,979 t-CO_2e for 10 years.

Table 1 The estimates of the methane generated

Year	Methane generated from Dhapa site (t/yr)	Amount of methane combusted* (t/yr)	GHG (Green House Gas) Reduction (t-CO2/yr)
2009	19,607	11,764	247,049
2010	17,097	10,258	215,420
2011	15,022	9,013	189,281
2012	13,287	7,972	167,414
Total			819,165
2013	11,819	7,092	148,922
2014	10,566	6,340	133,133
2015	9,487	5,692	119,541
2016	8,552	5,131	107,753
2017	7,735	4,641	97,465
2018	7,019	4,211	88,435
Total			1,425,979

*About 60% of the Methane generation from Dhapa site

According to the estimation by First Order Decay model, it is also suggested that methane generated from the Dahpa disposal site tends to rapidly decrease after the site closure.

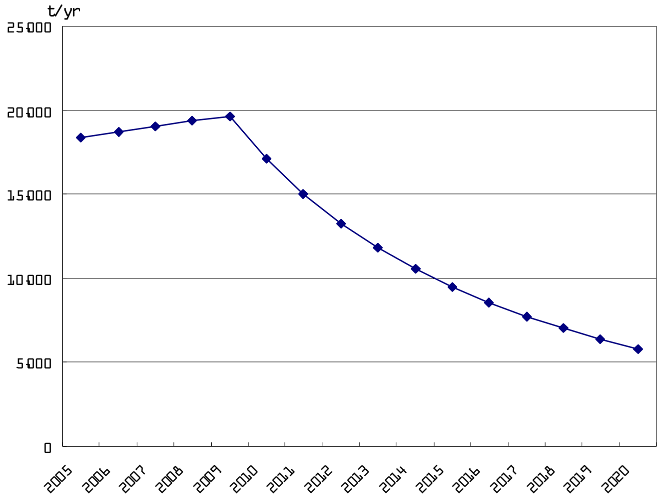


Figure 1 The methane generation from the Dhapa waste disposal site

4. Methane gas treatment technology

Two technical options were compared in this Feasibility Study.
Those are:

Case-1：Capturing LFG, generating power by gas-engine generator

Case-2：Capturing LFG and treating it in a flare.

For each case, conceptual design of the equipments was conducted and the cost for each case was estimated based on it.
Costs for installing facilities for LFG capture and power generation or flaring LFG are shown as

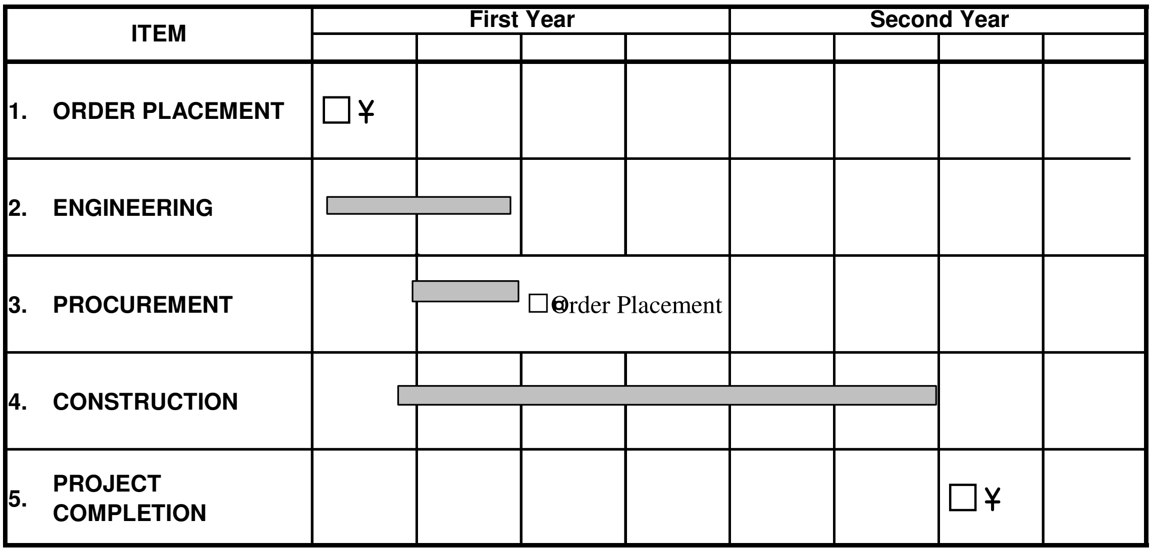
below:

□Approximate costs □US$=INR 43.9□
Installing a generation facility□US$ 8,400,000 (INR 368,760,000)
Installing a flare only□US$ 3,400,000 (INR 149,260,000)

In the case of power generation by gas engine, as methane will rapidly decrease it is not appropriate to install a generator with large capacity, hence, installed capacity will be limited to 2MW. In addition, as initial costs for generation facility will be large compared to the amount of electricity generated, economic efficiency will fall.
Therefore, as a CDM project, methane combustion by a flare system is considered appropriate.

For the construction of the facilities, it is estimated to take about one and half year.
As the capacity of the area managed by KMC in the west of the landfill is estimated to be full after about 6 months, the project can start its construction activities at the beginning of 2008.

Figure 2 Construction Schedule



5. Profitability of the Project

For the two cases when only LFG capturing and inflammation are carried out and when power is generated using the captured gas at the site, the profitabilities of the cases with/without incomes from CER are compared. A length of the project crediting period is set as 10 years.

Case-1□Capturing LFG, generating power by gas-engined generator and selling electricity.
Expecting no incomes from CER.
Case-2□Capturing LFG, generating power by gas-engined generator and selling electricity.
Considering incomes from CER.
Case-3□Capturing LFG and treating it in a flare.
Expecting no incomes from CER.
Case-4□Capturing LFG and treating it in a flare.
Considering incomes from CER.

From the cash-flow analyses, the results at each case are evaluated as below:

Case-1□LFG power generation □without CER incomes□
Since IRR becomes □7.6□ while the investment recovery length is over 10 years, the project in the set conditions is not feasible.

Case-2□LFG power generation □with CER incomes□
As IRR becomes 9.1□ (before taxed: 15.8□) and the investment recovery length turns out to be 6.1 years (before taxed: 4.8 years), a profitability is improved by implementing the project as CDM but it lacks a project appeal.

Case-3□LFG flaring□without CER incomes□
Since there is no revenue, the cash-flow turns out to proceed in deficit throughout the project period, thus, the project is impossible to implement.

Case-4□LFG flaring □with CER incomes□
As IRR becomes 11.0□ (before taxed: 20.3□), the investment recovery length turns out to be 5.2 years (before taxed: 3.9 years), there expected to be a good profitability by implementing the project as CDM.

Economic profits by Carbon Credits is estimated as $5,734,155 (INR 251,729,404) for 1st commitment period of Kyoto Protocol and $9,981,853 (INR 438,203,346 :for project crediting period of 10 years.

Expected total profit of KMC for the project crediting period (10years) is summarized in Table 3

Table 3 Summary of KMC Profit

Unit: a thousand INR

Project Income	Total CER (t-CO2e)	1,644,815
	Market Price (INR/t-CO2)	307
	Total Income	474,258
Project Expenditure	EPC Cost	158,040
	O&M Cost	87,232
	Total Expenditure	245,272
Project Profit	Profit Before Tax	228,986
	TAX (41.82%)	-95,762
	Profit After Tax	133,224
KMC Income	Project Profit * 50%	66,612

Prerequisite□KMC□
□CER Market Price — US$7.00 /t-CO2e
1US$= INR43.9 — INR 307 /t-CO2e
□Investment Ratio — 50%
□Investments — 79,020 thousand INR
□O&M cost will be covered by CER incomes

Unit: a thousand INR

Summary of KMC Investments and Profit	
Capital Investments	79,020
Profit(After Tax)	66,612

6. Available international financial resources

There are systems and funds for the purchase of carbon credits facilitated, for instances, in World

Bank, EU member nations and Japan.
In World Bank and EU states credits are acquitted by tendering systems, whereas, in Japan, they are acquitted through individual negotiations and contracts.
In the case of Kyoto Mechanisms Credit Acquisition Program (KMCAP) by New Energy and Industrial Technology Development Organization (NEDO)of Japan, it holds a purchase progamme in which contracts on credit purchase with other project participants and else are awarded, expenses which are necessary to issue credits, such as costs for validation, registration in the CDM executive board, and emission certificates, and a part of credit purchase price can be paid in advance,while depending on conditions.

7. Conclusion

The feasibility study concluded that, as the field survey indicates sufficient amounts of methane generated to carry out the project and economic efficiency when the project is implemented is expected by the profitability assessment, hence, a LFG recovery CDM project at the Dahpa waste disposal site can be feasible.

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1. Introduction

1.1 Background

According to the estimates from the GHG emission inventory in India in 1998(ALGAS India - ADB, GEF, UNDP, October 1998), landfill gas (LFG) generated at waste disposal site in India accounts for about 7 % of the GHG emission, being estimated to be 69,048Gg-CO2e. Following energy and agriculture, it is the third biggest emission source. In addition, with population expansion and economic development, LFG emission is expected to significantly increase in future.
However, in India, there are few cases where LFG is collected and treated because such projects require additional costs and have not been technically spread within the country.

This project aims to prevent global warming effects by methane, by effectively capturing and flaring methane gas contained in LFG.

The project site is the Dhapa waste disposal landfill, located in the east-south suburb of Kolkata city, State of West Bengal, North East India.

The waste disposal site is managed by Kolkata Municipal Corporation (KMC), and receives large quantities of urban waste generated from Kolkata city and Kolkata Metropolitan Area (KMA) – approximately between 2,600 and 2,700 tones daily.
As KMA has developed rapidly in these years, burden on waste disposal facilities has increased and environmental and hygienic problems are growing. The existing Dhapa waste disposal site has the area of 21.5 ha, but its capacity is nearly reaching the limit. In addition, the management of the existing disposal site is poor that environmental problems such as illegal intruders like waste pickers, leachate and bad smell are emerging.

Kolkata city plans to close the existing disposal site within 2 years and construct a new controlled landfill type landfill site in the adjacent area as well as considers the enhancement of environmental management with the site closure.

By implementing the project as CDM, KMC will achieve carbon credits, certified emission reduction (CER), associated with methane treatment, and could allocate the revenue from the sale of CER to environmental management. In addition, it will contribute to mitigate global warming by treating methane, which is a greenhouse effect gas.

Based on the background above, the possible application of LFG collection for CDM was investigated in this study.

1.2 Purpose and significance of the project

This project shall contribute to mitigate global warming by capturing and burning methane gas in LFG that is generated from the Dahpa waste disposal site of Kolkata city, West Bengal State, India.

Currently at the Dahpa waste disposal site, none of LFG is managed but left emitted into atmosphere without any treatment. A global warming potential (GWP) of methane gas is as 21 times as that of carbon dioxide, and methane gas/LFG generated from the waste disposal site regarded as the causes of global warming. In addition, LFG generated from the waste disposal site will become risk factors such as bad smell, toxic gases and fires, being a cause of deteriorating local environment.

This project attempts to improve environment both at global and local scales through the capture and treatment of LFG, which gives not only significant impacts on global warming but also great negative effects on neighborhood around the waste disposal site. In addition, the project aims to contribute to sustainable development of Kolkata city as economic profits will be achieved and waste management shall be improved by assigning the project as a CDM.

2. Site description

2.1 Basic information

The Dhapa waste disposal site is located to about 10 km south-east to Kolkata city, and receives around from 2,600 to 2,700 tonnes of waste daily.
The disposal site is shaped long and thin from west to east, with the size of approximately 150m by 2,000m and the area of 21.4 ha, and divided into two areas by a compost plant of about 12.1 ha, which is centrally located at the site. In the west area, the area is landfilled by KMC with the area of about 8.1 ha, while in the east area landfilled by private sector with the area of about 13.3 ha.
The compost plans is designed to treat about 350 tonnes of waste daily and owned by KMC. Though KMC made a contract with a private company, Eastern Organic Fertilizer, due to the fact that profits from compost production were not secured, the present operational contract has been cancelled (expire date: 31 December 2003) and the plant is being out of operation.

The base of the landfill site is a clay layer with low water permeability of 10^{-6} ; thus, the probability of underground leakage is low. Ditches for leachate are placed around the landfill site but they are not treated, outflowing to the surrounding wetland with rainwater run-off.
The covering of the landfill is carried out irregularly, with the cover thickness as thin as between 200mm and 400mm.
At present, the layers of waste disposed reach as thick as around 17m, and the capacity of the landfill site will be reached within the next two years; hence, the construction of a new controlled landfill type landfill site is being planned. In addition, a plan on the closure of the existing site is being investigated.

2.2 Climatic conditions

Kolkata city, where the Dhapa waste disposal site is located, belongs to a climate zone of tropical savanna type, and seasons are categorized into 3 – summer, monsoon and winter. Summer season is from April to June, with high temperature and high humidity. Monsoon season is between June and September, while winter season between December and March.

An annual average temperature is26.9°C, and the maximum temperature exceeds 40 °C, while the minimum temperature goes down no less than 10□.
It frequently rains between July and September, with an annual precipitation of 1,813mm.

Table 2.1 Temperature and precipitation in Kolkata city

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	D
Mean temperature (□)	20.0	23.1	27.7	30.2	30.7	30.2	29.3	29.1	29.1	28.1	24.9	20
Precipitation (mm)	11.4	31.3	35	57.8	141.3	290.7	394.2	349.2	309.4	147.7	31.8	14

2.3 Natural environment

The Dhapa waste disposal site is situated adjacent to the East Kolkata Wetland, which is registered in Ramsar Convention November 2002. Most of the East Kolkata Wetland is man-made, covering the area of over 12,500 ha and consisting of intertidal wetlands such as saltings and salt meadows. Domestic effluents from Kolkata city enter to the East Kolkata Wetland, and utilizing nutrients, paddy field farming and aquaculture are engaged.

2.4 Social environment

The surroundings of the waste disposal site are mainly used for agriculture and aquaculture. In addition, the following four villages exist in the neighbourhood of the site. There estimated to be 509 households and the population of 2,614 in the four villages.

- Uchhapada village: north-east of the Dhapa waste disposal site
- Makaltala village: the northern of the Dhapa
- Anantamahal village: south west, divided by the Dhapa road
- Durgapore village: east of Anantamahal village, divided by the Dhapa road

The residents of these villages enter into the site and are engaged in collecting and selling valuable materials from the waste and rag picking. However, they are not making a living by rag picking but as a side income, apart from agriculture and aquaculture.

2.5 Waste intake

It is thought that waste has been disposed at the Dhapa landfill site since more than 100 years before. Between 600 and 800 trucks transport waste daily to the Dhapa. There are around 62 workers at the site, operating in two shifts (the one from 7 to 12, and the other from 12 and 17), 364 days a year. Covering is not carried out regularly. According to the records on weight measurements in 2002, waste of an average of 2,237 tonnes a day, overall 816,520 tonnes a year, was deposited at the Dhapa waste disposal site.

3. Work Plan and Methodology

3.1 Outline of the Study

The key tasks or activities to achieve the study can be categorized as follows.

- Task 1: Qualify and quantify the CDM potential of Dhapa landfill site
- Task 2: Identify various technological options of tapping CDM potential of
- Dhapa landfill site
- Task 3: Identify various revenue model options available to KMC in regard
- Task 4: Identify available resources in international market and their ratings
- Task 5: Identify time frame for the implementation of the project

3.2 Scope of the tasks

Scope of each task is summarized as follows.

Task 1: Qualify and quantify the CDM potential of Dhapa landfill site
In order to evaluate the CDM potential, it is important to know 1) Actual LFG generation status from the Dhapa landfill and 2) Waste quality and quantity. Major items to be surveyed and analyzed for each 1) and 2) is shown below.

1) Actual LFG generation status from the Dhapa landfill
- Drilling works: make monitoring well and qualify and quantify the well gas by direct measurement by handy meter. Gas well will be installed at 5 sites in total, 2 wells in west (KMC) damping site and 3 wells in east (private) damping site, respectively.
- Surface flux monitoring: set a small chamber temporally on the surface of the landfill and directly measure methane flux by handy meter. Surface flux monitoring will be carried out at 20 sites in total, 5 site west (KMC) damping site and 15 sites in east (private) damping site, respectively.

2) Waste quality and quantity
- Waste composition analysis: waste is separated into 11 categories, namely, food waste, garden & park waste, paper & cardboard, wood, textile, nappies, rubber & leather, plastics, metal, glass and others. Then weighed and chemically analyzed.
- Waste quantity estimation: estimate waste input to Dhapa landfill based on existing data and information. Observation at Dhapa site will also be conducted.

Task 2: Identify various technological options of tapping CDM potential of Dhapa landfill site
The most suitable LFG collection/utilization technology for the KMC project site will be considered based on the results of Task 1. The study will include following items;
- Conceptual/Basic design of gas collection facility
- Conceptual/Basic design of gas combustion facility (flare system)
- Consideration on specification of gas utilization facilities
- Consideration of facility construction layout

Task 3: Identify various revenue model options available to KMC in regard
Revenue model options available to KMC will be studied in the Feasibility Study. In the study, CER generated both from LFG collection and from displacing grid electricity will be considered. Necessary cost for construction and Operation/Maintenance of the project also will be estimated based on the results of Task 2.
The study will be conducted for following two cases;
- Financial Status without CDM
- Financial Status with CDM

Task 4: Identify available resources in international market and their ratings

Available international financial resources and their rating that could be applied for the project will be studied.

- Major carbon markets
- Government Purchase Program that can be available for the project
- Financial support system that could be adapted to the project

Task 5: Identify time frame for the implementation of the project

Project implementation plan and expected their time frame will be studied and recommended to KMC. The plan will be finalized in consulting with KMC. Time schedule will include the following items;

1) For CDM Procedure

- Approval of the governments
- CDM project validation
- CDM project verification
- CDM registration

2) For project construction;

- Acceptation for the Necessary permits
- Detailed design for facilities and civil works
- Shipping order and procurement
- Constructions
- Completion test

3.3 Work Schedule

Schedule of the feasibility study are shown in Table 3.1

Table 3.1 Schedule for the Feasibility Study on CDM/Landfill Gas Project at Dhapa

Item	2006	2007	
	Dec	Jan	Feb
Task 1: Qualify and quantify the CDM potential of Dhapa landfill site			
Site survey (gas measurement, waste sampling, etc.) & chemical analysis	1st visit		
Analysis of collected data			
Evaluation of CDM potential			
Discussion with KMC & report submission		2nd visit	
Task 2: Identify various technological options of tapping CDM potential of Dhapa landfill site			
Task 3: Identify various revenue model options available to KMC in regard			
Data collection and analysis			
Reporting & discussion with KMC		2nd visit	
Task 4: Identify available resoreces in international market and their ratings			
Task 5: Identify time frame for the implementation of the project			
Data collection and analysis			
Reporting & discussion with KMC		2rd visit	
Preparation of the final report			
Submission of the final report to KMC			★

4. The estimation of the amount of LFG generated

The amount of methane generated/methane available for capturing at the project site was examined, on the basis of the amount of waste generated and the results from the investigations on waste composition / methane measurement.

4.1 Estimation of waste intake

According to records on waste received at the Dahpa landfill, between 2,600 and 2,700 tonnes of waste are daily deposited and disposed. With the population of Kolkata city as approximately 4.6 million, the calculation of an annual amount of waste generation per head from the above figure gives averages ranged from 206 kg/cap/yr to 214 kg/cap/yr, which represents a good coherence to the basic unit default of the amount of waste generated per head per annual, as described in IPCC Guideline Asia South Central.

For an appropriate estimation of the amount of LFG (methane) generated from the landfill, it is necessary to get a good grasp of the amounts of waste deposition going back to from 5 to 10 years before, but the data on these past amounts of waste deposition have not been obtained. Therefore, the past amounts of waste generated were estimated, based on the population of Kolkata city and the basic unit of the amount of waste generation.

According to the Census of India 2001, the data revealed that the population of Kolkata city in 1999 and 2001 was 4,399,819 and 4,580,544, respectively. Based on these, a population between 1987, the year of the commence of the Dahpa landfill, and 2000 was set as approximately 4.4 million, while a population between 2001 and 2008, the year of planned site closure, as approximately 4.6 million. In addition, assuming a basic unit of the annual amount of waste generated per head was 210kg/cap/yr, the amount of waste generated was calculated.

The amount of waste generated will be reviewed in terms of its validity by gathering more accurate data on the past amounts of waste generated throughout the investigation period.

4.2 Waste composition

Following the categories on the IPCC Guideline（2006 IPCC Guidelines for National Greenhouse Gas Inventories）, the composition of waste was categorized into 11 types: Food waste; Garden and park waste; Paper and carboard; Wood; Textile; Nappies; Rubber and leather; Plastics; Metal; Glass (and pottery and china); Other (e.g. ash, dirt, dust soil, electronic waste), and weighted.

Based on the site measurements, general waste composition was established, as shown in Table 4.1.

Table 4.1 Measurements on waste composition

No.	Waste Category	Waste samples (g)					Total	Average fraction of each waste category
		MW3-SF	MW1-SF	MW2-SF	MW4-SF	MW5-SF		
1	Food waste	47	31	23	150	300	551	5%
2	Garden and park waste	930	250	430	340	300	2,250	20%
3	Paper and carboard	200	180	180	190	310	1,060	9%
4	Wood	33	39	-	29	26	127	1%
5	Textile	200	100	120	110	29	559	5%
6	Nappies (disposable diapers)	-	26	-	-	-	26	0%
7	Rubber and leather	110	100	33	60	16	319	3%
8	Plastics	210	300	130	200	250	1,090	9%
9	Metal	13	18	-		26	57	0%
10	Glass (and pottery and china)	400	500	110	120	210	1,340	12%
11	Other (e.g. ash, dirt, dust soil, electronic waste)	650	1,650	400	500	920	4,120	36%
							11,499	100%

4.3 Methane generation at the project site

The amount of methane generated at the landfill was estimated, using First Order Decay Model (FOD Model) Spreadsheet, presented in the IPCC Guideline□2006 IPCC Guidelines for National Greenhouse Gas Inventories□. The estimation formula of FOD Model will be described in the below.

FOD Model calculates the amount of methane generated with assumption that the rate of generation is proportional to the amount of reactant remaining, in this case the mass of degradable organic carbon decomposable under anaerobic conditions (DDOCm).

In FOD Model, in the end of the year T at the landfill, the mass of organic carbon remaining DDOC$m\ rem_T$ and the mass of degradable organic carbon DDOC$m\ dec_T$ will be revealed by the following equation□

DDOCm REMAINING AT END OF YEAR OF DISPOSAL

$$DDOCm\ rem_T = DDOCmd_T \bullet e^{-k \bullet (13-M)/12}$$

DDOCm DECOMPOSED DURING YEAR OF DISPOSAL

$$DDOCmdec_T = DDOCmd_T \bullet [1-e^{-k \bullet (13-M/12)}]$$

Where:
DDOCm remT = DDOCm disposed in year T which still remains at the end of year T (Gg)
DDOCmdT = DDOCm disposed in year T (Gg)
DDOCm decT = DDOCm disposed in year T which has decomposed by the end of year T (Gg)
T = year T

M = month when reaction is set to start, equal to the average delay time + 7 (month)
k = rate of reaction constant (y-1)

In addition, the amounts of accumulation and decomposition of DDOCm each year will be calculated by the following equations:

DDOCm ACCUMULATED AT THE END OF YEAR T

$$DDOCma_T = DDOCmrem_T + (DDOCma_{T-1} \bullet e^{-k})$$

(Column H in the CH_4 calculating sheets in spreadsheet model)

DDOCm DECOMPOSED IN YEAR T

$$DDOCmdecomp_T = DDOCmdec_T + DDOCma_{T-1} \bullet (1 - e^{-k})$$

(Column I in the CH_4 calculating sheets in the spreadsheet model)

Where:
DDOCmaT = DDOCm accumulated in the SWDS at the end of year *T*, Gg
DDOCmaT-1 = DDOCm accumulated in the SWDS at the end of year (*T*□ 1), Gg
DDOCm decompT = DDOCm decomposed in year *T*, Gg

Based on the above equations, the decomposable DOCm (DDOCm) entering the SWDS will be calculated as below, in accordance to each category of waste (e.g. food waste, paper/carboard, park and garden waste and wood):

CALCULATION OF DECOMPOSABLE DOCm FROM WASTE DISPOSAL DATA

$$DDOCmd_T = W_T \bullet DOC \bullet DOC_f \bullet MCF$$

Where:
DDOCmdT = DDOCm disposed in year *T*, Gg
WT = mass of waste disposed in year *T*, Gg
DOC = Degradable organic carbon in disposal year (fraction), Gg C/Gg waste
DOCf = fraction of DOC that can decompose in the anaerobic conditions in the SWDS (fraction)
MCF = CH4 correction factor for year of disposal (fraction)

The amount of CH_4 generated from the decomposable DDOCm will be calculated by the following equation:

CH_4 GENERATED FROM DECOMPOSED DDOCm

$$CH_4\ generated_T = DDOCm\ decomp_T \bullet F \bullet 16/12$$

Where:
CH4 generatedT = amount of CH4 generated from the DDOCm which decomposes
DDOCm decompT = DDOCm decomposed in year *T*, Gg
F = fraction of CH4, by volume, in generated landfill gas
16/12 = molecular weight ratio CH4/C (ratio)

The CH4 generated by each category of waste disposed is added to get total CH4 generated in each year. Finally, emissions of CH4 are calculated by subtracting first the CH4 gas recovered from the disposal site, and then CH4 oxidized to carbon dioxide in the cover layer.

CH_4 EMITTED FROM SWDS

$$CH_4\ emitted_T = \left(\Sigma x\ CH_4\ generated_{x,T} - R_T\right) \bullet (1 - OX_T)$$

Where:
CH_4 emittedT = CH_4 emitted in year *T*, Gg
x = waste type/material or waste category
RT = CH_4 recovered in year *T*, Gg
OXT = Oxidation factor in year *T*, (fraction)

Only part of the DOCm in waste disposed in SWDS will decay into both CH_4 and CO_2. The DOCm available for anaerobic decay will not decompose completely either. The part of DOCm that will not decompose will be stored long-term in the SWDS, which will then be:

CALCULATION OF LONG-TERM STORED DOCm FROM WASTE DISPOSAL DATA

$$DOCm\ long\text{-}term\ stored_T = W_T \bullet DOC \bullet (1 - DOC_f) \bullet MCF$$

For the estimation of the amount of methane generated using the above estimation formula, the following parameters will be referred:

For the parameters of the above formula, since the mean annual temperature was above 20°C and mean annual precipitation above 1000mm in Kolkata city, the parameters that are affected by local climate were set as the ones applicable to Moist and Wet Tropical climate presented in the IPCC Guidelines.

Table 4.2 shows the parameters used for the estimation of the amount of methane generated.

Table 4.2 Setting the parameters in FOD Model

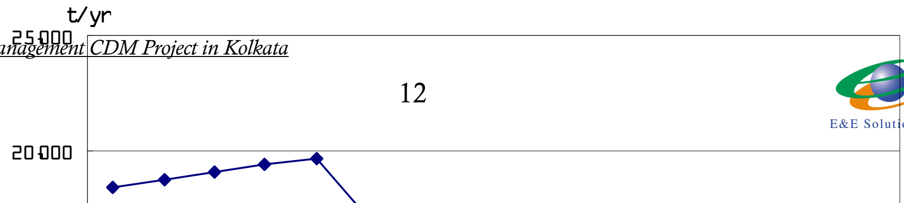
DOC (Degradable organic carbon) :weight fraction, wet basis	
Food waste	0.15
Garden	0.2
Paper	0.4
Wood and straw	0.43
Textiles	0.24
Disposable nappies	0.24
Sewage sludge	0.05
DOCf (fraction of DOC dissimilated)	0.5
Methane generation rate constant (k): For moist and wet tropical (years-1)	
Food waste	0.4
Garden	0.17
Paper	0.07
Wood and straw	0.035
Textiles	0.07
Disposable nappies	0.17
Sewage sludge	0.4
Delay time (months)	6
Fraction of methane (F) in developed gas	0.5
Conversion factor, C to CH_4	1.33
Oxidation factor (OX)	0

Table 4.3 shows the estimates of the amounts of methane generated. The landfill started its operation in 1987 and was assumed to close in 2009. In addition, since the proportion of methane that is possible for capture by installing a gas capture system at the waste disposal site is generally more than 60%, estimation in this project adopts 60% from a conservative perspective.

Table 4.3 The estimates of the amount of methane generated

Year	Population (millions)	Amount of waste generated per head (kg/cap/yr□	Amount of waste generated □kt/yr□	Amount of methane generated □t/yr□	Corresponding value to GHG □t-CO2/yr□	Amount of methane captured □t/yr□	Corresponding value to GHG □t-CO2/yr□
1986	0	0	0	0	0	0	0
1987	4.4	210	924	0	0	0	0
1988	4.4	210	924	5,333	0	0	0
1989	4.4	210	924	9,179	0	0	0
1990	4.4	210	924	12,014	0	0	0
1991	4.4	210	924	11,454	0	0	0
1992	4.4	210	924	11,463	0	0	0
1993	4.4	210	924	11,807	0	0	0
1994	4.4	210	924	12,335	0	0	0
1995	4.4	210	924	12,952	0	0	0
1996	4.4	210	924	13,598	0	0	0
1997	4.4	210	924	14,236	0	0	0
1998	4.4	210	924	14,848	0	0	0
1999	4.4	210	924	15,422	0	0	0
2000	4.4	210	924	15,952	0	0	0
2001	4.6	210	966	16,439	0	0	0
2002	4.6	210	966	17,002	0	0	0
2003	4.6	210	966	17,505	0	0	0
2004	4.6	210	966	17,955	0	0	0
2005	4.6	210	966	18,358	0	0	0
2006	4.6	210	966	18,721	0	0	0
2007	4.6	210	966	19,047	0	0	0
2008	4.6	210	966	19,341	0	0	0
2009	0	0	0	□□□□□ □	411,748	11,764	247,049
2010	0	0	0	17,097	359,034	10,258	215,420
2011	0	0	0	15,022	315,469	9,013	189,281
2012	0	0	0	13,287	279,024	7,972	167,414
2013	0	0	0	11,819	248,203	7,092	148,922
2014	0	0	0	10,566	221,889	6,340	133,133
2015	0	0	0	9,487	199,235	5,692	119,541
2016	0	0	0	8,552	179,589	5,131	107,753
2017	0	0	0	7,735	162,442	4,641	97,465
2018	0	0	0	7,019	147,392	4,211	88,435
2019	0	0	0	6,386	134,115	3,832	80,469
2020	0	0	0	5,826	122,351	3,496	73,411

According to the estimates, an annual average of approximately 10,000 tonnes of methane will be generated. However, the amount of generation will quickly decline after the peak in 2009, the year of site closure.



5. Methane gas treatment technology

5.1 Elemental Technology

This project intends to effectively capture LFG, which contains much of methane, which has a high global warming potential, and combust it in a flare system or use the energy that is generated when the gas is combusted for power generation and sell the electricity to a power company through a power grid.

A system flow of gas capturing and its effective use in this project is drawn as below. The technologies that are required here are: □ LFG capture wells and plumbing system, □ LFG treatment system, □ LFG inflammation-generation system.

□ A LFG capture wells and plumbing system for capturing LFG
LFG generated within the landfill is captured by suctioning by a blower in a well set vertically into the site, and stored in a gas holder through a plumbing system. It is assumed that a width of setting gas capture wells is 30m.

□ A LFG pre-treatment system (purification)
Considering any corrosions of the following blowers and generation facilities, impurities such as moisture, particulate and hydrogen sulfide are removed beforehand in order to generate power effectively from the captured LFG.

□ A LFG generation/inflammation system
For a gas-engine generator using LFG as its fuel, a system with durability against to hydrogen sulfide contained in LFG is adapted.

Up to this date, considering changed in the amount of LFG, a capacity for power generation is assumed to be 2MW (1MW×2 generators).

Any LFG that is not used for power generation will be combusted in a flare. (If power generation is not carried out, LFG will be combusted only by flare.

With assumption of monitoring the rate of gas inflammation that is required in a CDM monitoring methodology, an enclosed flare is adopted.

5.2 Technological Options and Conceptual Design

Two technical options were compared in this Feasibility Study.
Those are:

Case-1□Capturing LFG, generating power by gas-engine generator

Case-2□Capturing LFG and treating it in a flare.

An overview of the main facility specification is shown in Table 5.1 Also, Figure 5.1 (1) shows the system flow when power generation is carried out, while Figure 5.1(2) draws the system flow when power generation is NOT carried out (if only flare is installed).

Figure 5.2 represents an image of the plane configuration of methane capture plumbing.

5.3 Facilities Installation Cost

Costs for installing facilities for LFG capture and power generation or flaring LFG are shown as below:

□Approximate costs □US$=INR 43.9□

Installing a generation facility□US$ 8,400,000 (INR 368,760,000)

Installing a flare only□US$ 3,400,000 (INR 149,260,000)

At the present, an estimate of the costs is calculated based on the standard prices in Japan and the US. In addition, costs for the closure of the waste disposal site are not included in the above costs.

Table 5.2 Preliminary Cost Estimation

PRELIMINARY ESTIMATED FACILITY COST

(CASE 1 : Gas Engine Generator + Flare Stack)

ITM		Description	Quantity		Price (US$)	Price (INR)
1.	LFG Recovery Facility	1-1 LFG Extraction Well	1	lot	1,367,000	60,011,300
		1-2 LFG Recovery Piping System	1	lot	252,000	11,062,800
		1-3 First Filter Unit	1	lot	51,000	2,238,900
		1-4 LFG Blower Unit	1	lot	143,000	6,277,700
		1-5 H2S Removal Unit	1	lot	80,000	3,512,000
			Sub Total		US$1,893,000.00	INR83,102,700
2.	LFG Utilization Facility	2-1 Closed Flare Stack Unit	1	lot	311,000	13,652,900
		2-2 Secondary Filter Unit	1	lot	30,000	1,317,000
		2-3 LFG Holder Unit	1	lot	177,000	7,770,300
		2-4 LFG Compressor Unit	1	lot	276,000	12,116,400
		2-5 Gas Engine Generator Unit	1	lot	3,660,000	160,674,000
		2-6 Piping for LFG Utilization	1	lot	63,000	2,765,700
			Sub Total		US$4,517,000.00	INR198,296,300
3.	Electrical and Instrument		1	lot	777,000	34,110,300
4.	Fence and Lighting Post		1	lot	304,000	13,345,600
5.	Packing and Shipping		1	lot	472,000	20,720,800
6.	Engineering		1	lot	437,000	19,184,300
			TOTAL AMOUNT		**US$8,400,000**	**INR368,760,000**

1US$= INR43.9

PRELIMINARY ESTIMATED FACILITY COST

(CASE 2: Flare Stack)

ITM		Description	Quantity		Price (US$)	Price (INR)
1.	LFG Recovery Facility	1-1 LFG Extraction Well	1	lot	1,367,000	60,011,300
		1-2 LFG Recovery Piping System	1	lot	252,000	11,062,800
		1-3 First Filter Unit	1	lot	51,000	2,238,900
		1-4 LFG Blower Unit	1	lot	143,000	6,277,700
		1-5 H2S Removal Unit	1	lot	0	0
			Sub Total		US$1,813,000	INR79,590,700
2.	LFG Utilization Facility	2-1 Closed Flare Stack Unit	1	lot	311,000	13,652,900
		2-2 Secondary Filter Unit	0	lot	0	0
		2-3 LFG Holder Unit	0	lot	0	0
		2-4 LFG Compressor Unit	0	lot	0	0
		2-5 Gas Engine Generator Unit	0	lot	0	0
		2-6 Piping for LFG Utilization	1	lot	56,000	2,458,400
		Sub Total			US$367,000	INR16,111,300
3.	Electrical and Instrument		1	lot	478,000	20,984,200
4.	Fence and Lighting Post		1	lot	304,000	13,345,600
5.	Packing and Shipping		1	lot	83,000	3,643,700
6.	Engineering		1	lot	355,000	15,584,500
		TOTAL AMOUNT			**US$3,400,000**	**INR149,260,000**

1US$= INR43.9

5.4 Project Schedule

Figure 5.3 (1), (2) shows a expected time schedule for the construction of the project facilities. The schedule for CDM procedure is shown below.

Figure 5.4 Schedule for CDM Procedure

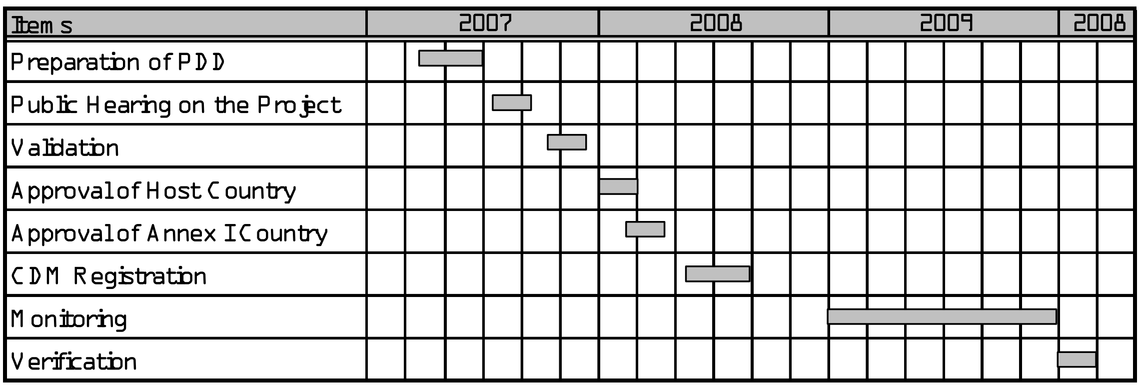


Table 5.1 An overview of the main facility specification

Equip. Name	Qty	Type	Specification			Design Press. [MPa]	Design temp. [□]	Remarks
			Capacity	Main Material	Dimension			
LFG Extraction Well	172	Vertical Extraction Well	4"	HDPE	25.0m L or 17.0m L	-1,300 mm H_2O	Amb.	
First Filter	2	Cyclone with Demister	1,200 Nm3/h LFG	Stailess Steel	900f Å1,600H	-1,300 mm H2O	Amb.	
Secondary Filter	1	Cyclone with Demister	1,400 Nm3/h LFG	Stailess Steel	900f Å1,600H	0.2 Mpa	Amb.	
H2S Removal Unit	1	Adsorption/Regeneration	2,300 Nm3/h LFG	Stailess Steel	-	0.2 Mpa	Amb.	
LFG Blower	2	Centrifugal Blower	2,300 Nm3/h x 2,400mmH2O	Stailess Steel	-	0.2 Mpa	Amb.	90kW
Flare Stack	1	Closed Frare Stack	2,300 Nm3 LFG	Carbon Steel	7.9m Height	By Manufacturer	operation 1,000	
LFG Holder	1	Water Seal	450 m3	Carbon Steel	8.0m f Å10.0m H	ATM	Amb.	20 Min. buffer
LFG Compressor	2	Centrifugal Compressor	2,300 Nm3/h x 0.56 MPa	Stailess Steel	-	0.65 Mpa	70	120 kW
Gas Engine Generator	2	Gas Engine	1,000kW	varied	20.3m x10.8m x6.75m H	By Manufacturer	By Manufacturer	

Figure 5.1(1) A system flow of LFG power generation

Figure 5.1(2) A flow of the LFG flaring system

Figure 5.2 A plane configuration of the LFG capture plumbing

Figure 5.3(1) A schedule for construction (in the case when installing a generation facility)

Figure 5.3(2) A schedule for construction (in the case when installing a flare only)

6. Profitability of the Project

6.1 Profitability tests by different system

(1) Study Case

For the two cases when only LFG capturing and inflammation are carried out and when power is generated using the captured gas at the site, the profitabilities of the cases with/without incomes from CER are compared. A length of the project crediting period is set as 10 years.

Case-1□Capturing LFG, generating power by gas-engined generator and selling electricity.
Expecting no incomes from CER.
Case-2□Capturing LFG, generating power by gas-engined generator and selling electricity.
Considering incomes from CER.
Case-3□Capturing LFG and treating it in a flare.
Expecting no incomes from CER.
Case-4□Capturing LFG and treating it in a flare.
Considering incomes from CER.

(2) Calculating the amount of CER

According to the CDM methodology, ACM0001, the amount of GHG emission reduced□□ the amount of CER□ will be calculated in the following formula:

ERy□□MDpoject,y□MDreg,y□×GWP_CH4□EG,y×CEFelectricity,y□ETy×CEFthermal,y

Where,
y□a project length
ERy□the amount of GHG emissions reduced□t-CO2□
MDproject,y□the amount of methane reduced if the project is carried out□t-CO2□
MDreg,y□the amount of methane reduced if the project is NOT carried out□t-CO2□
GWP_CH4□a global warming potential of methane□t-CO2/t-CH4□□21
EGy□the amount of electricity sales□MWh□
CEFelectricity,y a coefficient of reduced emissions of carbon dioxide by substituting electricity □t-CO2/MWh□
ETy□the amount of heat energy□TJ□□since heat is not utilized in the project, this is not applicable (i.e. the figure will be zero)
CEFthermal,y□a coefficient of reduced emission of carbon dioxide by substituting heat energy □t-CO2/MWh□; this is not applicable (i.e. the figure will be zero)

□ The amount of methane reduced if the project is carried out□MDproject,y□
The amount of methane reduced if the project is carried out will be the sum of the amounts of methane reduced by power generation by the gas-engined generators and by combustion by a flare. This is calculated by the amount of methane generated from waste x the rate of methane capturing, as mentioned below.
□ The amount of methane reduced if the project is NOT carried out□MDreg,y□
The amount of methane reduced if the project is not carried out will be zero.
□ A global warming potential of methane□GWP_CH4□
A global warming potential of methane approved b IPCC will be applied: GWP_CH4□21 t-CO2/t-CH4.

□ The amount of the electricity sale□EGy□

With all the electricity generated is sold, it is assumed that a capacity for power generation is 2MW (1MW x 2 generators) and annual generation hours are 8,000. Also, the figure is calculated, with the combined margin of a power grid emission in Kolkata, West Bengal as 0.9769 Kg-CO2/KWh.

The price of CER (Carbon Credit□ is set as US$ 7/t-CO_{2e}. (INR 307)

(3) The evaluation of the profitability

From the cash-flow analyses, the results at each case are evaluated as below:

Case-1□LFG power generation □without CER incomes□

Since IRR becomes □7.6□ while the investment recovery length is over 10 years, the project in the set conditions is not feasible.

Case-2□LFG power generation □with CER incomes□

As IRR becomes 9.1□ (before taxed: 15.8□) and the investment recovery length turns out to be 6.1 years (before taxed: 4.8 years), a profitability is improved by implementing the project as CDM but it lacks a project appeal.

Case-3□LFG flaring□without CER incomes□

Since there is no revenue, the cash-flow turns out to proceed in deficit throughout the project period, thus, the project is impossible to implement.

Case-4□LFG flaring □with CER incomes□

As IRR becomes 16.0□ (before taxed: 28.9□), the investment recovery length turns out to be 4.2 years (before taxed: 3.1 years), there expected to be a good profitability by implementing the project as CDM.

Cash Flow Table for each Case is attached as an attachment of this report.

6.2 Profit of KMC

The profit of KMC is evaluated in this section.

As the premise of the evaluation, it is assumed that the KMC and the Project Proponent in the investment country will establish SPC (Special Purpose Company) to implement and operate this project and KMC will receive its profit from SPC as a dividend per investment.

In this scheme, the risk of the project (such as facility construction risk, operation risk, CER market risk etc.) will be deconcentrated, because the KMC and Project Proponent of Investing Country will take the risk according to their each share.

Following assumptions are set to evaluate the profit of KMC.

- LFG flaring system will be installed in the CDM project (i.e. Case-4 of section 6.1) and initial cost for the facility installation will be set as INR 158,040,000 (EPC cost : INR 149,260,000+ CDM Set up cost: INR 8,780,000)
- The project will be implemented with own resources of each parties and no official loan will be taken
- KMC and the Project Proponent in Investing Country to set up SPC (Special Purpose Company) to implement and operate this project
- SPC to incur cost to construct facility for CDM project, and make necessary procedures for approval of the project. Management and selling of Carbon Credit (CER) will also be beard by

SPC.

- Each KMC and the Project Proponent in Investing Country will invest 50% of SPC cost.
- The profit of the SPC will be shared between KMC and the Project Proponent in Investing Country, in accordance with their investment rate(50%/50%).
- It is assumed that the average market price of CER through the project period is $7.

Expected total profit of KMC for the project crediting period (10years) is summarized in Table 6.1. The yearly breakdown of KMC profit is shown in Table 6.2

Table 6.1 Summary of KMC Profit

Unit: a thousand INR

Project Income	Total CER (t-CO_2e)	1,644,815
	Market Price (INR/t-CO_2)	307
	Total Income	474,258
Project Expenditure	EPC Cost	158,040
	O&M Cost	87,232
	Total Expenditure	245,272
Project Profit	Profit Before Tax	228,986
	TAX (41.82%)	-95,762
	Profit After Tax	133,224
KMC Income	Project Profit * 50%	66,612

Prerequisite (KMC)

- CER Market Price: US$7.00 /t-$CO_2e$; 1US$= INR43.9: INR 307 /t-CO_2e
- Investment Ratio: 50%
- Investments: 79,020 thousand INR
- O&M cost will be covered by CER incomes

Unit: a thousand INR

Summary of KMC Investments and Profit	
Capital Investments	79,020
Profit(After Tax)	66,612

Table 6.2 Yeary Breakdown of KMC Profit

□ Prerequisite

Project

Initial investment				
EPC	149,260	thousand INR		
Costs for CDM set-up	8,780	thousand INR		
Capital costs	158,040	thousand INR		
Operating and Maintenance cost				
Maintenance and management c	7,463	thousand I	:	5%Percent of the capital costs
CDM monitoroing cost	790.2	thousand INR		
Income				
CER				
Credit Market price	307	INR/t-CO2eq	($7/t-CO2e)	
Financial prerequisite				
Depreciation	10	Year	Fixed fee□ no remaining book value	
Corporate tax rate	41.82%		Tax rates in India	

KMC

Investment Ratio	50%		
Investment of KMC	79,020	thousand INR	*50%of the Project Capital Cost

Unit□ thousand INR

Project Income	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Income												
CER	0	76,252	66,745	58,880	52,290	46,708	41,931	37,810	34,226	31,089	28,328	474,258
Total income	0	76,252	66,745	58,880	52,290	46,708	41,931	37,810	34,226	31,089	28,328	474,258
Exenditure												
Operation & Maintenance costs												
Total O/M costs	0	8,303	8,297	8,292	8,287	8,284	8,281	8,278	8,275	8,273	8,272	82,841
Financial costs												
Depreciation	0	15,804	15,804	15,804	15,804	15,804	15,804	15,804	15,804	15,804	15,804	158,040
Interest expenses	0	7,902	7,112	6,322	5,531	4,741	3,951	3,161	2,371	1,580	790	43,461
Total financial costs	0	23,706	22,916	22,126	21,335	20,545	19,755	18,965	18,175	17,384	16,594	201,501
Total expenditure	0	32,009	31,212	30,417	29,623	28,829	28,036	27,243	26,450	25,658	24,866	284,341
Pretax profits	0	44,243	35,532	28,462	22,667	17,879	13,896	10,567	7,776	5,431	3,462	189,915
Corporate Tax	0	18,502	14,860	11,903	9,480	7,477	5,811	4,419	3,252	2,271	1,448	79,423
After-tax profits	0	25,741	20,673	16,559	13,188	10,402	8,085	6,148	4,524	3,160	2,014	110,493
KMC Income	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Income												
(50%of After-tax profits)		12,870	10,336	8,280	6,594	5,201	4,042	3,074	2,262	1,580	1,007	55,247

7. Available international financial resources

7.1 Emission Trading Market

The European Union (EU) has started the Emission Trading System (ETS) in January 2005, in order to achieve GHG emission reduction targets set by the Kyoto Protocol.
The ETS by EU and the Kyoto Mechanisms only define that emission quotas can be transferred between the holders of these but no provisions for smooth transaction. Thus, 'negotiation transaction', 'transaction through financial brokers' and 'transaction in e-marketplace' exist as transaction modes.
Among them, CO2 transaction markets (e-markets) include the Nordic power market (Nordpool), European Energy Exchange (EEX) in Germany the French power market (PowerNext), and Chicago Climate Exchange (CCX) in the US.
The value of emission transaction in 2006 is 28 billion US dollars, which is nearly 2.5 times by that in 2005, and transaction in the markets after gaining advisory emission permits has been enlarging.
Nevertheless, in the EU emission trading markets, at present, a trend shows that the supply of carbon credits is excess and credit prices are fallen. In contrast, in Japan, since the reduction period set by the Kyoto Protocol will have started by 2008, those companies which are imposed with emission reduction have accelerated to gain emission permits, and such permits have become subject to speculation.

7.2 International emission credit purchasing systems and funds

There are systems and funds for the purchase of carbon credits facilitated, for instances, in World Bank, EU member nations and Japan. The Table 7.1 shows the major international systems for purchasing carbon credits.
Particularly, the capital scales in World Bank, Austria, Belgium and Japan are large.
In World Bank and EU states credits are acquitted by tendering systems, whereas, in Japan, they are acquitted through individual negotiations and contracts.
In the case of Kyoto Mechanisms Credit Acquisition Program (KMCAP) by New Energy and Industrial Technology Development Organization (NEDO), NEDO is itself a participant and holds a purchase progamme in which contracts on credit purchase with other project participants and else are awarded, while depending on conditions, expenses which are necessary to issue credits, such as costs for validation, registration in the CDM executive board, and emission certificates, and a part of credit purchase price can be paid in advance.
Also, Japan Carbon Finance Inc. (JCF) allows advanced payment of a part of credit and is proactive in supporting and giving advices on projects.

Table 7.1 The major international systems for purchasing carbon credits.

Country	Institute	Foundation year	Capital	Remarks
World Bank	Prototype Carbon Fund (PCF)	1999	144 m EURO ($180 m)	CDM by tendering/contract award to JI project client
	Community Development Carbon Fund (CDCF)	2003	103 m EURO ($128.6 m)	For small scale projects in unprivileged villages and alike
	Bio Carbon Fund (BioCF)	2004	36 m EURO ($45 m)	For afforestation projects
EBRD	Multilateral Carbon Credit Fund (MCCF)	2005	50-150 m EURO	□ l
Austria	Austria CDM/JI Program	2003	288 m EURO	CDM/Credit purchase from JI The second invitation starts in November 2004
Belgium	Belgium CDM/JI Tender	2004	10 m EURO	Credit tendering system
	Flemish Government JI/CDM Tender	2004	70 m EURO	Funds in Flandre
Denmark	Danish Carbon Fund	2002	27 m EURO	□ l
Holland	Emission Reduction Unit Procurement Tender (ERUPT)	2001	287 m EURO	For JI
	Certified Emission Reduction Unit Procurement Tender (CERUPT)	2003	78 m EURO	For CDM : contract award to tendered CDM project clients
Finland	Finland CDM/JI Pilot Program	1999	10 m EURO	Started as a pilot programme
Sweden	Swedish International Climate Investment Program (SICLIP-CDM)	2002	15 m EURO	□ l
Germany	KfW Carbon Fund	2004	50 m EURO	Funds in which KfW Bank purchases credits from the german government and CDM/JI
Japan	Japan Greenhouse-Gas Reduction Fund (JGRF)	2004	113 m EURO ($141.5 m)	Invested by JBIC, power companies and alike
	Kyoto Mechanisms Credit Acquisition Program	2006	101 m EURO	Programms such as up-front-payment and CDM registration support are available

8. Conclusions and Recommendation

The feasibility study concluded that, as the field survey indicates sufficient amounts of methane generated to carry out the project and economic efficiency when the project is implemented is expected by the profitability assessment, hence, a LFG recovery CDM project at the Dahpa waste disposal site is feasible.

According to the estimation by First Order Decay model, it is proved that methane collected from the Dahpa disposal site tends to rapidly decrease after the site closure. This attributes to that degradable organic materials accumulated within the site will be rapidly decomposed and converted to methane due to high temperature and humidity in India, hence, carbon storage at the site will decrease.

In the case of power generation by gas engine, as methane will rapidly decrease it is not appropriate to install a generator with large capacity, hence, installed capacity will be limited to 2MW. In addition, as initial costs for generation facility will be large compared to the amount of electricity generated, economic efficiency will fall.

Therefore, as a CDM project, methane combustion by a flare system is considered appropriate.
In the case of CDM with a flare system, with approximately $7 as CER sale price, investment recovery period after taxed is calculated as about 5 years.

The present brief design and specification of a LFG capturing facility are based on the designs of general waste disposal sites. In order to achieve a more accurate pitch of collection well, the permeability of gas in the soil of the waste disposal site (waste layer) should be measured.

In addition, at present, a plan on the Dahpa disposal site is being prepared and land readjustment for increasing the slop stability planned.
In the phase of detailed design, following a detailed engineering work in the closure plan, the positioning and the installation of facility should be reviewed.

The capacity of the area managed by KMC in the west of the landfill is estimated to be full after about 6 months. By closing the area ahead and carrying out a CDM programme along, it is possible to implement an efficient project.

Attachment

Cash Flow Table of the Project Case Study