Summary of Report on FY2009 CDM/JI Feasibility Study

Title of Feasibility Study

"Feasibility study on semi-aerobic disposal CDM project in Laemchabang landfill site in Chonburi Province, Thailand"

Main Implementing Entity

Tokyu Construction Co., Ltd.

Implementation Organization

Fukuoka University (Professor Matsufuji): Advice for semi-aerobic disposal of waste

Kasetsart University (Associate Professor Chart): Analysis of gas and water quality

Ch. Karnchang - Tokyu Construction Co., Ltd.: Arrangement of equipment, gas collecting assist, and surveying assist

1. Description of Project Activity

Laemchabang landfill site (approx. 6 ha) in Laemchabang City, Chonburi Province, Thailand was appointed as the project site. The site has been owned and managed by Laemchabang Cityand currently been in operation, though a part of the landfill site has been completed and cloased. Since the landfill site has conventionally applied open dumping method, it is apparently assumed that the landfill site is in an anaerobic condition and it is expected that a large amount of methane gas (CH_4) is emitted from the site. This project is to improve the anaerobic condition to a semi-aerobic condition by installing vertical and horizontal pipes for ventilation and drainage in the site. This will accelerate the degradation of waste and inhibit the emission of CH_4. By the implementation of this project, it is expected to reduce the greenhouse gas by 14,499 t - CO_2 per year on six-year average from 2011 to 2016. The project will be implemented by SPC established in the host country, and the construction work will be completed at the end of 2010.

<u>Methodology</u>

A new methodology is applied.

2. Contents of Feasibility Study

(1) Study tasks

[1] It is necessary to survey the project site to estimate the waste amount in the landfill and design vertical and horizontal pipes.

[2] It is necessary to analyze the current gas emission to predict more accurately the greenhouse gas reduction amount.

[3] It is necessary to study the monitoring items and build a system to implement them.

[4] It is necessary to discuss with TGO (Thailand Greenhouse Gas Management Organization) who is DNA in Thailand and Laemchabang City who owns and manages the project site.

[5] Since the new methodology submitted for the application has not been approved yet, it is necessary to study the applicability also including the other methodologies already approved.

(2) Contents of feasibility study

1) Task [1] Surveying of the project site

The project site was surveyed to estimate the waste amount in the landfill and design vertical and horizontal pipes.

The specifications of the target block of the project site were calculated based on the survey result.

- Site area : 58,498 m^2 (Max. width: 200.0 m, Max. length: 319.1 m)
- Crest area : 39,380 m^2 (Max. width: 150.6 m, Max. length: 270.0 m)
- Max. height: 13.45 m
- Average layer thickness: 10.54 m
- Volume of disposal site: 527,640 m^3

2) Task [2] Analysis of the current gas emission

The current gas emission was analyzed to predict more accurately the greenhouse gas reduction amount. Gas emitted from the landfill surface was collected by the chamber method, and gas near-surface ground (approx. 80 cm) was collected by the boring bar method. The gas samples were analyzed at Kasetsart University.

Based on the analysis result, it was found that CH_4:CO_2 in the emitted gas was approximately 6:4 on average. It was also found that the CH_4 emission at the spot measured this time was up to 13.16 ($ml/m^2/sec$) and 1.58 ($ml/m^2/sec$) on average.

3) Task [3] Building of a monitoring implementation system

The project will require regular monitoring. To carry out this, it is necessary to build a monitoring implementation system.

In this project study, gas was collected by the chamber method and the boring bar method while instructions were given to local workers. For the collected gas, the concentrations of methane (CH_4), carbon dioxide (CO_2) and oxygen (O_2) were measured at Kasetsart University. Leachate was also analyzed at the University, and the measurement was taken for hydrogen ion concentration (pH), electric conductivity (EC), suspended solids (SS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total amount of organic carbon (TOC), Kjeldahl nitrogen amount (TKN) and ammonia (NH_3). Based on the result, it was confirmed that monitoring necessary for the CDM project may be carried out only by local facilities.

4) Task [4] Discussion with TGO and Laemchabang City

The project was explained to TGO and Laemchabang City and following comments were obtained.

[1] TGO

- TGO is looking forward to the CDM project associated with environmental improvement.
- In Thailand, the CDM approval requires approx. 100 days on average, up to 180 days.
- TGO would like to know how much profit is expected in this project.

- Needs of measures against odor and water pollution caused by open dumping landfill sites have increased in Thailand.

[2] Laemchabang City

- Laemchabang City agrees again to carry out survey work, gas analysis, etc, in the landfill site
- Laemchabang City requires summary of the feasibility study and PDD after the feasibility study is completed.
- There are complaints from the neighborhood of the project site about odor. Some measures must be taken.
- A European company has proposed to implement CDM of power generation by methane gas. How about this request compared to your project?

Professor Matsufuji,Fukuoka University, explained that "the project of recovering methane gas brings a risk to the project and may not achieve environmental improvements (in water quality and odor) except for the recovery of greenhouse gas." Deputy Mayor agreed that our proposed CDM is preferable.

5) Task [5] Study of the applicability of methodology

There is currently no methodology approved by the United Nations and applicable to the project to improve an anaerobic condition to a semi-aerobic condition in landfill sites. Therefore, the application was filed to the UN CDM board (NM0314) for the new methodology applicable to semi-aerobic improvement. However, it was rejected (judged C) by the methodology panel (MP41) in October 2009.

The items pointed out for the semi-aerobic methodology submitted for the application will be reviewed and the application will be filed again to the UN CDM methodology panel for the new methodology for semi-aerobic improvement.

3. Findings for Implementation of CDM Project

(1) Setting of baseline scenario and project boundary

1) Setting of the baseline scenario

The study is carried out according to the procedure of the new methodology for which the application will be filed again.

Step 1: Identification of alternatives of the project

- Identify possible scenarios.
- Check the situation of applicable laws and regulations, etc.

Step 2: Study of the conditions to be excluded from the application and investment analysis

- Identify the conditions that make it impossible to implement alternatives.
- Identify the alternatives to be excluded based on the above conditions.
- Investment analysis

Step 3: Selection in the case where more than one applicable scenario is left

Select the applicable baseline scenario with the smallest baseline emission amount.

The baseline scenario for this project is studied according to the above procedure.

The following (a) to (d) are indicated by the methodology as options of "possible scenarios."

Step 1 : Identification of alternatives of the project

(a) Implement the improvement project without applying CDM.

(b) Do not recover or burn greenhouse gas, or partly recover or burn it.

(c) Recover and burn greenhouse gas for energy generation, or recover and burn greenhouse gas without energy generation.

(d) Excavate the disposal site to retreat waste.

There are no laws and regulations for limit, use, etc. on the gas generated from landfill sites. Therefore, all alternatives satisfy the laws and regulations in Thailand.

Step 2: Study of the conditions to be excluded from the application and investment analysis

In the case of (a) where the project for improvement is implemented without applying CDM, all the costs for improvement will result in irrecoverable debts. In the case of (c) where gas is recovered or burned for energy generation or gas is recovered or burned without energy generation, because of few local demands for energy use and no facilities of gas distribution, etc., the capital investment for the implementation of the project is large and a profit from the supply cannot be expected too much. Furthermore, in the case where gas is only recovered and burned without energy generation, the capital investment will not be paid back at all. In the case of (d) where a disposal site is excavated to retreat waste, a huge cost for excavation and a cost for a new disposal will be necessary.

Therefore, the applications of (a), (c) and (d) are difficult in the actual situation.

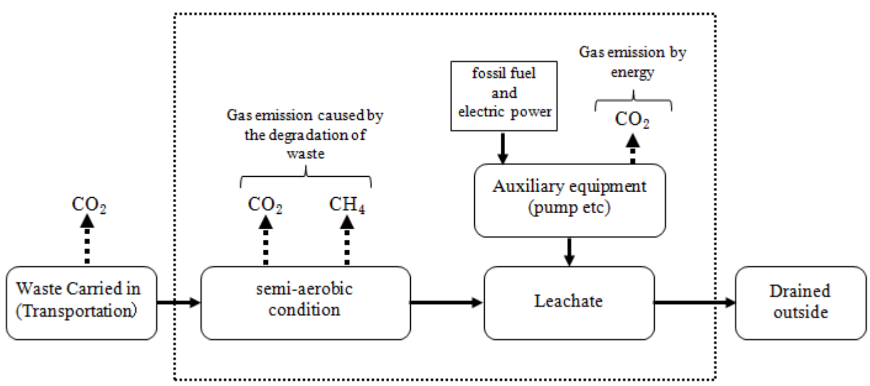
Based on the above, the case (b) where greenhouse gas is not recovered or burned (i.e. status quo) may be identified as the baseline scenario that indicates reasonably the greenhouse gas emission amount without the proposed project.

Step 3: Selection in the case where more than one applicable scenario is left

This item is not necessary because only one baseline scenario is applicable.

2) Setting of project boundary

When semi-aerobic improvement is made for a local waste disposal site as a project, the local condition is not changed from the current status. Therefore, the target will be the processes carried out inside the local waste disposal site. The boundary is as shown below.



Project Boundary

The process for seeping water may be excluded because it does not use permanent facilities of air release process, etc. and only sprinkles water in the site without consuming much energy.

3) Applicable methodology

After revising the following items pointed out for the semi-aerobic methodology already submitted for the application, the new methodology will be submitted again.

(a) Main items pointed out for the new methodology for semi-aerobic improvement submitted for the application (NM0314)

There is currently no methodology approved by the United Nations and applicable to the project to improve an anaerobic condition to a semi-aerobic condition in a landfill site. Therefore, the application was filed to the UN CDM board (NM0314) for the new methodology applicable to semi-aerobic improvement. However, it was rejected (judged C) by the methodology panel (MP41) in October 2009.

[1] The baseline emission amount is estimated too high.

The baseline emission amount is estimated by multiplying the gas emission amount to be measured every year after the implementation of the project by the methane gas ratio measured before the implementation of the project. However, since the outside air is introduced through horizontal and vertical vent pipes by the implementation of the project, the total gas emission amount becomes larger, and the baseline emission amount is calculated larger by multiplying the larger gas emission amount by the methane gas ratio. Therefore it was judged unreasonable for the calculation of the CDM credits. In this respect, we proposed to take the measurement with the horizontal pipes capped to prevent the outside air inlet, and to target only the amounts of methane and carbon dioxide among emitted gases. However, the proposal was not accepted.

[2] A reasonable improvement effect will not be achieved unless the installation distance between vertical vent pipes is within 20 m.

In this respect, since there were no national standards specifying a proper installation distance of vertical vent pipes, we proposed to apply the technical manual of United States Army and install one vertical vent pipe per 7,600m^3. This proposal was not accepted. However, the distance of 20 m suggested by the methodology panel also had no certain basis.

[3] If drained water is sprinkled by circulation inside the landfill site, the organic components contained in drained water are decomposed and emitted as gas, and the original gas amount at the setting of baseline is measured larger.

(b) Summary of new methodology

The new methodology is established by revising the above items as follows. The flow of the new methodology is prepared in reference to AM0083 which has already been approved by the United Nations.

a) Calculation of baseline emission amount

[1] Inspect the waste in the local landfill site by sampling, and calculate the methane gas amount Qc using the FOD model.

[2] Measure the gas amount in the local landfill site to estimate the actual gas emission amount Qm.

[3] Calculate the ratio R (Qm/Qc) based on the results of [1] and [2]. (Carry out the actual measurement

compensation for the calculation result of [1].)

[4] The value of Qc calculated in [1] multiplied by R obtained in [3] is the baseline emission amount.

Following the above procedure, all baseline estimations are estimated before the project is implemented and the issue of the baseline emission amount calculated larger pointed out previously by the CDM panel will be cleared.

This is the same method as AM0083 already approved by the United Nations.

For the above [1], the BMP test is carried out. For this, taking the same way as AM0083, four borings per ha in the site are carried out once before the implementation of the project. The test is carried out for the waste by sampling to estimate the waste amount that can be decomposed simultaneously.

b) Bolting pitch for vertical vent pipes

Using the manual of United States Army as the standard, one vent pipe is installed per 7,646m^3. The application of this methodology is limited to the waste layer thickness of 10 m or more (The maximum pitch is 28 m in this case).

By restricting applicable range, the issue pointed out for the case of thin waste layer thickness, etc., will be settled.

Furthermore, quoting an official standard, it will be specified that the bolting pitch shall be within 40 m at the maximum (based on the [2] and [3] mentioned below).

c) Process of seeping water by installing horizontal pipes

If the procedure for estimating the baseline emission amount is changed as described in a) above, the situation after the implementation of the project will have no relation with the estimation of the baseline emission amount, therefore this issue will be settled. Finally the process of seeping water that occurs after the implementation of the project will be sprinkled in the site as in the methodology previously submitted.

4) Calculation method for baseline emission amount (BE_y)

To calculate the baseline emission amount, the result calculated using the FOD model is compared with the result of the site measurement to obtain the gas reduction rate. It is then calculated multiplying the calculation result based on the FOD model by the gas reduction rate to calculate the future emission amount in each year.

$$BE_y = (MB_y - MD_{reg,y}) \quad \textbf{(1)}$$

where,

BE_y	=	Annual baseline emission amount (t CO_2/yr)
MB_y	=	Annual methane gas emission amount without the project (t CO_2/yr)
$MD_{reg,y}$	=	Methane gas amount to be destroyed without the project (t CO_2/yr)

In this time project, $MD_{reg,y}$ is assumed to be 0.

(a) Baseline emission amount before the implementation of the project ($MB_{y,ad} = MB_y$)

$$MB_{y,ad} = \varphi \times (1-f) \times GWP_{CH4} \times (1-OX) \times MCF_{adj} \times \sum_i A_{lf,i} \times L_{0,i} \times e^{-k_{CH4}(y-x)} \times (1-e^{-k_{CH4}}) \quad \textbf{(2)}$$

$$A_{lf,i} = f_{dg,i} \times A_{T,i} \quad \textbf{(3)}$$

where,

φ	=	Collection reduction coefficient for the model application (=0.9)
f	=	Methane capturing or burning rate (=0)
GWP_{CH4}	=	Methane warming coefficient (=21) (t CO_2/t CH_4)
OX	=	Oxidation coefficient (=0)
MCF_{adj}	=	Methane correction coefficient (1.0 in anaerobic condition, 0.5 in semi-aerobic condition)
$L_{o,i}$	=	Biochemical methane potential capacity of waste by BMP test (Mg CH_4/Mg Waste)
k_{CH4}	=	Organic waste degradation rate
x	=	Aeration period (yr)
i	=	Block i of disposal site
$A_{lf,i}$	=	Total amount of degradable waste buried in block i of disposal site (t)
$f_{dg,i}$	=	Rate of degradable waste in block i of disposal site
$A_{T,i}$	=	Total amount of waste in block i of disposal site (t)

(b) Estimation of the emission amount before the implementation of the project ($MB_{y,ea} = MB_y$) : At the preparation of the initial PDD

$$MB_{y,ea} = \varphi \times (1 - f) \times GWP \times (1 - OX) \times \frac{16}{12} \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} \sum_{j} Wj,x \times DOCj \times e^{-kj(y-x)} \times (1 - e^{-kj}) \quad (4)$$

where,

φ	: Collection reduction coefficient for the model application (=0.9)
f	: Methane capturing or burning rate (=0)
GWP	: Methane warming coefficient (=21)
OX	: Oxidation coefficient (=0)
F	: Rate of methane in the waste disposal site (=0.5)
DOC_f	: Rate of degradable organic carbon
MCF	: Methane correction coefficient (1.0 in anaerobic condition, 0.5 in semi-aerobic condition)
$W_{j,x}$	: Amount of organic waste type *j* disposed in the site in a certain year
DOC_j	: Rate of degradable organic carbon in organic waste type *j*
k_j	: Degradation rate of organic waste type *j*
j	: Waste type
x	: Crediting period
y	: Year when the methane emission amount is calculated

(2) Project emission amount

1) Project emission amount (PE_y)

(a) When the project is implemented

a) Estimation of emission amount

Estimate the emission amount according to the following formula.

$$PE_y = PE_{EC,y} + PE_{FC,j,y} + PE_{a,y} \quad \textbf{(5)}$$

where,

PE_y	=	Annual emission amount when the project is implemented (t CO_2/y)
$PE_{EC,y}$	=	Emission amount caused by electric power to be consumed annually when the project is implemented (t CO_2/y)
$PE_{FC,j,y}$	=	Fossil fuel to be consumed annually when the project is implemented (t CO_2/y)
$PE_{a,y}$	=	Annual emission amount from the waste disposal site by semi-aerobic improvement (t CO_2/y)

Because electric power and fossil fuel are not used for semi-aerobic improvement, there will be no $PE_{EC,y}$ and $PE_{FC,j,y}$.

b) Gas emission amount from the waste disposal site by semi-aerobic improvement $PE_{a,y}$

After the project is implemented, methane gas will be emitted through vertical vent pipes and the earth surface. Measure and calculate the project emission amount for each case according to the following formula. In the formula, the first term in the right side represents the amount of gas emitted from vertical vent pipes, and the second term in the right side represents the amount of gas emitted from the earth surface.

$$PE_{a,y} = \sum_k \sum_q (GWP_{CH4} \times MC_{CH4,v,k,q} \times SG_{v,k,q}) + \sum_i \sum_q (GWP_{CH4} \times MC_{CH4.s,i,q} \times SG_{s,i,q} \times CF) \quad \textbf{(6)}$$

$$SG_{v,k,q} = s \times N_{v,k,q} \times A_{v,k} \quad \textbf{(7)}$$

where,

GWP_{CH4}	=	Methane warming coefficient (=21) (t CO_2/t CH_4)
$MC_{CH4,v,k,q}$	=	Concentration of methane emitted from the vent pipe k in the season q (t CH_4/m^3)
$SG_{v,k,q}$	=	Emission amount from the vent pipe k in the season q (m^3/q)
$MC_{CH4,s,i,q}$	=	Concentration of methane emitted from the earth surface of block i in the season q (t CH_4/m^3)
$SG_{s,i,,q}$	=	Emission amount from the earth surface of block i in the season q (m^3)

k	=	Number of vent pipes
i	=	Quantity of surface blocks
CF	=	Correction coefficient for the emission amount from the surface (=1.37)
s	=	Time during the period of season q (seconds)
$N_{v,k,q}$	=	Flow rate of gas from the vent pipe k in the season q ($m^3/m^2.s$)
$A_{v,k}$	=	Section area of vent pipe k (m^2)

c) Estimation of gas emission amount from vent pipes

Take the measurement for all vertical vent pipes, and apply the measurement result.

d) Estimation of gas emission amount from the earth surface

[1] Number of monitoring

To calculate the number of monitoring for the measurement of the emission amount from the earth surface, consider the area of the target waste disposal site and apply the following formula specified by the UK Environment Agency.

$$n_c = 6 + 0.15\sqrt{A}$$

where,

n_c: Number of samples (Number of monitoring)

A: Area of the disposal site (m^2)

[2] Rate of methane gas from the earth surface $MC_{CH4.s,i,q}$

Carry out the statistical processing for the measured methane gas rate from the earth surface according to the following formula, and apply the value of the plus side of the 95% confidence interval.

[3] Emission amount from the surface $SG_{s,i,q}$

Carry out the statistical processing for the measured gas flux from the earth surface according to the following formula, and apply the value of the plus side of the 95% confidence interval. Multiply the value by the target area and the target period to calculate the gas emission amount during the target period.

$$SG_{s,i,q} = FL_{s,l,q} \cdot s \cdot A_i \qquad \textbf{(8)}$$

where,

$SG_{s,i,q}$	=	Total emission amount from the earth surface in block i (m^3)
s	=	Time during the period of season q (seconds)
A_i	=	Area of block i (m^2)
$FL_{s,l,q}$	=	Flux from the earth surface of block i ($m^3/s\ m^2$)

$$\mu_{FLs,l,q} - t \cdot \frac{\sigma_{FLs,i,q}}{\sqrt{n_c}} \leq FL_{s,l,q} \leq \mu_{FLs,l,q} + t \cdot \frac{\sigma_{FLs,i,q}}{\sqrt{n_c}}$$

$\mu_{FLs,i,q}$ = Average value of the actual gas emission amount from the earth surface measured in block i ($m^3/s\ m^2$)

$$\mu_{FLs,i,q} = \frac{\sum_{c=1}^{n_c} FL_{s,i,c,q}}{n_c}$$

$FL_{s,i,c,q}$ = Actual gas emission amount from the earth surface measured in block i ($m^3/s\ m^2$)

n_c = Number of monitoring

q = Measurement season (Wet season and dry season)

$\sigma_{FLs,i,q}$ = Standard deviation of the actual gas flux from the earth surface measured in block i ($m^3/s\ m^2$)

$$\sigma_{FL,s,i,q} = \sqrt{\frac{\sum_{c=1}^{n_c} (FL_{s,i,c,q} - \mu_{FLs,i,q})^2}{n_C - 1}}$$

(b) Prediction of emission amount before the project is implemented

Estimate the emission amount predicted in the case where the project is implemented based on the baseline emission amount in (1)- 4).

The methane rate applied by the calculation based on the FOD model is expressed with F x MCF in the formula and i 0.5 is taken in an anaerobic condition. Since the methane rate is reduced in a semi-aerobic condition, multiply the value of the baseline emission amount by the assumed reduction value to estimate the methane gas emission amount predicted in the case where the project is implemented.

It is reported that CO_2:CH_4 represents approx. 4:6 generally in an anaerobic condition and improved to approx. 8:2 in a semi-aerobic condition. Therefore, assuming that the rate of methane in an anaerobic condition is 0.5 of the estimated value based on the FOD model and the rate of methane by semi-aerobic improvement is 0.2, the methane gas amount in a semi-aerobic condition is 40% (0.2 after the improvement is 40% in relation to the initial 0.5) compared to that in an anaerobic condition. Therefore, the emission amount in semi-aerobic improvement is obtained multiplying the calculated baseline value by 0.4.

2) Leakage amount

There will be no leakage by the implementation of the project.

(3) Monitoring plan

For the monitoring method, apply the new methodology newly submitted.

Measure the gas emission amount from vertical vent pipes and the earth surface. Measure the quality of seeping water from the landfill site and odor in the neighborhood to check the neighboring environmental conditions.

1) Emission amount from vent pipes: Measurement of flow rate and concentration

Take the measurement from all vent pipes (54 pipes in total). Calculate the emission amount from vent pipes using the gas flow rate inside the vent pipes and the sectional area of vent pipes.

2) Measurement of emission amount from the earth surface: Chamber method

Take the measurement by determining the number of sampling based on the standard specified by UK Environment Agency, and apply the chamber method.

3) Gas measurement interval

The gas generation is affected by the outside air condition, and it is essential to take the measurement in each local characteristic season. The local climate is tropical and classified roughly in wet season and dry season. Therefore, take the measurement in each of these seasons.

The list of monitoring items is shown below.

Monitoring items and frequency

Target	Parameter	Unit	Contents	Data source	Measuring method	Measurement interval	Quality assurance
Gas	$MC_{CH4,v,k,q}$	ml / m^2 • sec	Monitored methane content in venting well k in season q	Site measurement	Calculation based on the result of the measurement by the chamber method	When the baseline campaign is implemented	-
	Ai	m^2	Area of zone i	Site measurement	Site measurement	Once before the project is started	Use measuring equipment calibrated according to the internationally-recognized standard.
	L_0	Mg (methane) / Mg(waste)	Biochemical methane potential of waste	Laboratory analysis	Analysis of the value of L_0 by the BMP (Biochemical Methane Potential) test	When the project is started	ake the measurement according to the documents concerning BMP including the following <http://www.scsengineers.com/Papers/Kelly_WM-Analytical_Tools_LF_Waste_Stability.pdf>.
	$f_{dg,i}$	-	Fraction of degradable waste in landfill zone i	Site measurement	Classification of degradable gases and undegradable gases using samples collected at the BMP test	Once when the project is started	–
	$A_{T,i}$	ton	Total waste quantities in landfill zone i	Site measurement	Measurement of the volume and the weight before the project is started		Compare with the past waste landfill records. Use measuring equipment calibrated according to the internationally-recognized standard.
	$FL_{s,i,c,q}$	m^3/ s m^2	Flux of surface emissions in zone i in location c in season q	Site measurement	Chamber method	When the baseline campaign is implemented, and in the middle of each of every wet seasons and dry seasons	Use measuring equipment calibrated according to the internationally-recognized standard.
	$MC_{CH4,s,i,c,q}$	tCH_4 / m^3	Monitored methane content from surface emissions during aeration in zone i in location c in season q	Site measurement			–
	$N_{v,k,q}$	m^3/ s m^2	Total landfill gas flux of sampled venting well k in season q	Site measurement	Measurement by flame ionization detector, infrared sensors		Use measuring equipment calibrated according to the internationally-recognized standard.
	$MC_{CH4,v,k,q}$	tCH_4 / m^3	Monitored methane content from venting well k in season q	Site measurement			Ditto
	T_s	℃	Temperature at the emission from the earth surface	Site measurement	Simultaneous measurement of the temperature and the pressure using a flowmeter		Ditto
	P_s	Pa	Pressure at the emission from the earth surface	Site measurement			Ditto
	AF	%	Adjustment Factor (Demand for	National and local	Survey by a yearly progress report	Once a year	–
	$RATE^{Compliance}_{y}$	Numerical value	State-level compliance rate with the regulation in that year y.	Municipality	Yearly progress report issued by the municipality	Once a year	–
Water quality	BOD, COD, TKN	mg/l	Water quality index	Laboratory analysis of seeping water collected from the disposal site	Method compliant with the measuring method according to the effluent standard in Thailand	Once before the implementation of the project, and every three months until it becomes lower than the value specified by the water quality standard, and once a year after that during the implementation of the project	Use measuring equipment calibrated according to the internationally-recognized standard.
	pH	-	Water quality index				
	SS	mg/l	Turbidity				
Odor	Odor	Odor index	Odor in the neighborhood of the waste disposal site	Ditto	Measurement by the triangle odor bag method or it simplified method	Once before the implementation of the project, and every six months until the odor index becomes 10 or less, and once a year after that during the implementation of the project	–

(4) Greenhouse gas reduction amount (or absorption amount)

The greenhouse gas to be reduced by the project is only the methane gas generated from the waste disposal site.

Unit (t-CO_2/y)

Year		Year of waste landfill							Total
		2004	2005	2006	2007	2008	2009	2010	
2011	1	1,221	1,649	2,275	3,196	4,556	6,569	9,556	29,023
2012	2	926	1,221	1,649	2,275	3,196	4,556	6,569	20,393
2013	3	721	926	1,221	1,649	2,275	3,196	4,556	14,545
2014	4	577	721	926	1,221	1,649	2,275	3,196	10,567
2015	5		577	721	926	1,221	1,649	2,275	7,370
2016	6			577	721	926	1,221	1,649	5,095
2017	7				577	721	926	1,221	3,446
2018	8					577	721	926	2,225
2019	9						577	721	1,299
2020	10							577	577
During the implementation of the project (2011 - 2016)		3,446	5,095	7,370	9,989	13,824	19,467	27,802	86,993
Grand total		3,446	5,095	7,370	10,567	15,123	21,692	31,248	94,541

The column for the period during the implementation of the project in the table indicates the total amount of emission in six years from 2011 to 2016. The grand total indicates the total amount of emission in the decade from 2011 to 2020.

(5) Duration of project activity/crediting period

1) Duration of project activity/crediting period

The duration of the project activity is between the start of the installation of the facilities for the project for semi-aerobic improvement in the local landfill site and the end of credit earning.

The credit is earned every year by the implementation of the project. However, if the credit amount becomes smaller, the expense required for monitoring, etc. exceeds the credit earning. This case or seven years, whichever is shorter, is established as the crediting period. The crediting period is six years in this project.

The project is started in October 2010 when the installation of the facilities for the project for semi-aerobic improvement in the local landfill site is started, and the credit earning is started in January 2011 when the construction work has been completed. For the start date, around October 2010 may be reasonable considering that the period required from the application as CDM to the approval is about six months.

2) Situation of preparation for CDM

For the feasibility study on CDM, the local situation studied in this report and the gas emission amount measurement result by site measurement may be used. However, the contents of this time study are insufficient in the study of biochemical methane potential of waste (BMP test: Biochemical methane potential test) in the local landfill site. Therefore, additional study on this point will be necessary before the implementation of the project.

(6) Environmental impact and other indirect impacts

This project is only to install horizontal and vertical vent pipes in the landfill site that has been completed. Therefore, new procedure for environmental impact assessment is not necessary. In the implementation of the project, there may be effluent gas and noise caused by the installation of the vertical and horizontal pipes, or effluent gas and noise caused by construction vehicles for carrying in materials. However, the environmental impact of them will be very limited according to the Thai laws in the construction work.

Furthermore, since the project reduces methane gas, makes improvements for leachate and odor from the landfill site, and stabilizes the waste landfill, it will be able to improve the neighboring environment.

Based on the above, it is thought that this project will give no environmental impact.

For other indirect impacts, the economic and social impacts were studied, and it is thought that this project will give no adverse impact on both aspects.

(7) Comments from the interested parties

In the field study, we visited TGO (Thailand Greenhouse Gas Management Organization), Ministry of Natural Resources and Environment, Laemchabang City, and Kasetsart University, and obtained the following comments.

1) TGO (Thailand Greenhouse Gas Management Organization)
- TGO is looking forward to the CDM project associated with environmental improvement.
- In Thailand, the CDM approval requires approx. 100 days on average, up to 180 days.
- Early submission is recommended because the documents are checked in 20 days.
- TGO would like to know how much profit is expected in this project.
- In Thailand, there have been more and more needs for measures against odor and water pollution caused by the open dumping landfill sites.

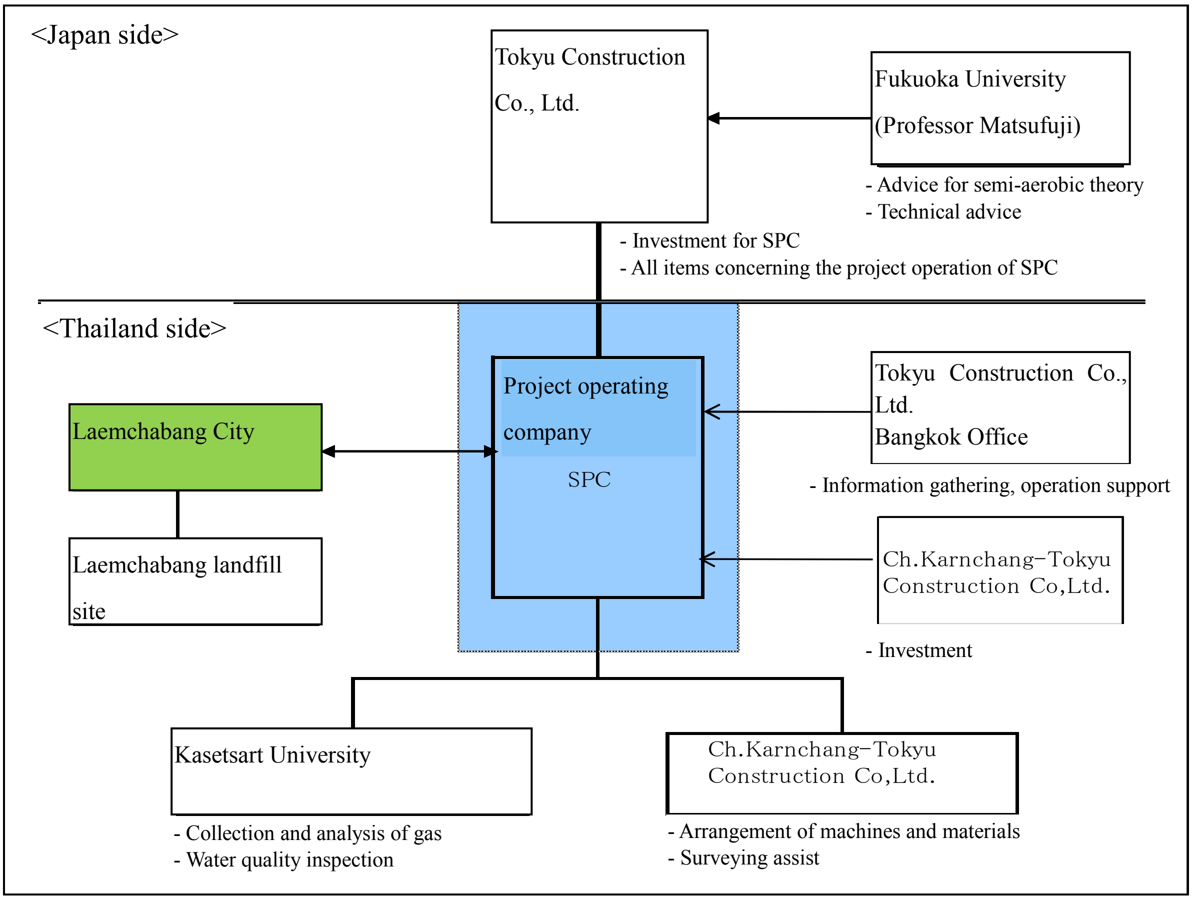
2) Ministry of Natural Resources and Environment
- NRE welcomes the co-benefit CDM to be win-win.
- In Thailand, there are many small-scale landfill sites by open dumping method without soil covering and complaints from the neighborhood have been increasing.
- In Thailand, there are many landfill sites that do not consider water pollution. The environmental improvement using the CDM method is desired.

3) Kasetsart University
- Gas and water from the landfill site may be analyzed at Kasetsart University.
- The BMP test required in the new methodology for this CDM may be carried out if equipment and materials are prepared.

4) Laemchabang City
- Laemchabang City agrees again to the local surveying, gas analysis, etc.
- Laemchabang City requires the summary of the feasibility study and PDD after the feasibility study is completed.
- The project site is about 1 km close to the residential area. There are complaints from neighborhood residents about odor. Some measures must be taken.
- A European company has proposed to implement CDM of power generation by methane gas. How about this request compared to your project?

Professor Matsufuji,Fukuoka University, explained that "the project of recovering methane gas brings a risk to the project and may not achieve environmental improvements (in water quality and odor) except for the recovery of greenhouse gas." Deputy Mayor agreed that our proposed CDM is preferable.

(8) Project implementation system



(9) Financial plan

Considering that there have been no project performances based on the new methodology waiting for its approval in this project, it seems that financing from a third party will be difficult. Therefore, in this case, the project proposer will procure a total of 90 million yen that consists of the initial investment of 68 million yen, the immediate operation fund of 12 million yen, and the capital of 10 million yen.

The following table indicates the cash flow for every financial year in the case of [3] mentioned in the estimated operation income and expenditure for each case in the analysis of economic efficiency.

(Unit: Million yen)

FY	Income	Equipment investment	Costs and interests	Corporate taxes	Balance
2010	90	▲67	▲1	0	22
2011	52	0	▲8	▲9	57
2012	37	0	▲8	▲5	81
2013	26	0	▲8	▲2	97
2014	19	0	▲7	▲0	109
2015	13	0	▲7	0	115
2016	9	0	▲7	0	117

(10) Analysis of economic efficiency

Since the profit in this project is only the CER selling profit, the economic efficiency of this project is greatly affected by the unit price of CER. For the Laemchabang landfill site, assuming that the initial investment, costs, etc., remain the same as the current situation, the unit price of CER needs to be around 1,800 yen/t - CO_2 to undertake the project.

Estimated operation income and expenditure for each case

(Unit: Million yen)

Unit price of CER	Reduction amount (ton) (CO_2 equivalent)	Income	Initial investment	Costs, interests paid	Profit before taxes	Profit after taxes	IRR (%)
[1]@1,200	86,933	104	68	44	▲9	▲15	▲11.1
[2]@1,500	86,933	130	68	44	18	5	3.7
[3]@1,800	86,933	156	68	44	42	25	15.4

(11) Demonstration of Additionality

For the verification, the latest version of the "tool for the demonstration and assessment of additionality" by the CDM Executive Board is used.

Step 1: Identification of alternatives of the project

Step 2: Investment analysis, or Step 3: Analysis of obstacles

Step 4: Analysis of common practices

In this project, if the credit earning is not expected, it cannot be expected to recover the investment costs required for semi-aerobic improvement. Therefore, the application of CDM is assumed for the study.

For the identification of alternatives of the project in Step 1, alternatives and compliance with laws and regulations are studied. The following items are possible as alternatives.

(a) Carry out the improvement project without applying CDM.

(b) Do not recover or burn greenhouse gas, or partly recover or burn it.

(c) Recover and burn greenhouse gas for energy generation, or recover and burn greenhouse gas without energy generation.

(d) Excavate the landfill site to retreat waste.

There are no laws and regulations for limit, use, etc. on the gas generated from landfill sites. Therefore, all alternatives satisfy the laws and regulations in Thailand.

For the analysis of obstacles in Step 3, study is conducted to confirm that there are obstacles that prevent the implementation of the project activity but do not prevent the implementation of at least one alternative.

The investment obstacles and the technical obstacles in the implementation of the proposed CDM project are studied. For the investment obstacles, the project income may not be expected because the improvement by this project will be reduction of the current methane gas emission amount from the landfill site by semi-aerobic improvement and capital recovery such as electric power, etc. may not be obtained by the improvement. Therefore, the project becomes economically feasible only by selling credits. For the gas distribution by landfill gas recovery, a huge cost will be necessary for the installation, operation of recovery facilities and gas distribution facilities, and the demand for gas may not be expected in the neighborhood area. Also for the implementation of power generation, a huge cost will be necessary for the recovery, power generation and electric transmission facilities, and the demand may not be expected in the neighborhood area. Furthermore, a huge cost will be necessary to excavate the landfill site to retreat waste and the capital recovery by improvement may also not be expected. Based on the above, it is obvious that there are investment obstacles.

For the technical obstacles, it is very difficult to stably supply gas emitted from the landfill site in an amount and at a concentration suitable for "gas distribution" or "power generation." If the waste containing degradable organic carbon is supplied constantly in large amounts in a landfill site, there is a high possibility of the stable gas recovery. However, in a landfill site already closed, it is difficult to solve this problem because the waste is not newly supplied. Therefore, there are technical obstacles.

Studying the identified obstacles that do not impede the realization at least one alternative scenario, it is found based on the above result that there are obstacles in the scenarios of (1), (3), and (4) in Step 1. On the other hand, it is found that the scenario (2) assuming the status quo does not prevent the implementation.

For the analysis of common practices, studying whether the project type (technology or operation) has already been spread in the sectors and regions concerned, it is found that most landfill sites in Thailand employ the open dumping method and are in an anaerobic condition, and the method of waste landfill in a semi-aerobic condition is not actually popular. The construction of a landfill site in a semi-aerobic condition is not generally accepted because it is necessary to install horizontal and vertical vent pipes, etc. beforehand, and the cost becomes higher compared to open dumping landfill disposals. The semi-aerobic improvement of landfill sites that have been completed are also not implemented because a huge cost is necessary and there are no economic benefits.

The landfill sites will maintain the current situation of anaerobic landfill by open dumping. It is difficult to carry out the landfill in a semi-aerobic condition or semi-aerobic improvement for the existing landfill sites unless there is an income source for recovering the investment for semi-aerobic improvement.

Based on the above, any projects similar to this project will not be implemented. Since registration of the CDM project is indispensable for the implementation of this project, it may be judged that this project has additionality.

(12) Feasibility

The feasibility of the project depends on two points mentioned in the analysis of economic efficiency; [1] the bolting pitch of vent pipes in the methodology, and [2] the trend of credit prices. It is currently estimated that the project becomes feasible if the unit price of CER is around 1,800 yen/t-CO_2.

4. Findings concerning co-benefit

(1) Evaluation of the effect of antipollution measures in the host country

This project is to improve an anaerobic condition to a semi-aerobic condition in a landfill site by installing vertical and horizontal pipes that accelerate ventilation and drainage to reduce methane gas (greenhouse gas) by stimulating the aerobic digestion of organic matters. Since this method helps the stabilization of waste, the situation of the leachate quality and odor may be improved to contribute to the needs for environmental improvement in the host country.

According to the co-benefit quantitative evaluation manual, the co-benefit in this project is classified in "environmental conservation" and "environmental pollution prevention." The specific field of co-benefit to be targeted is the "waste management" and the stage of the project to be implemented is the "implementation of reasonable waste disposal."

The co-benefit evaluation index is the leachate quality and odor. For the leachate quality, the actual situation of leachate pollution was surveyed for nine items to compare with the effluent standard of Thailand. As a result, for the evaluation index of the leachate, pH, SS, BOD, COD, TKN, and water temperature were selected as the items for which the effluent standard is set in Thailand.

Therefore, the evaluation method for the co-benefit type measures against global warming in this project

is equivalent to the evaluation method level Tier 2 because actual measured data are used. The level of the evaluation index is equivalent to Level 2 because data are obtained easily by measuring equipment.
For the "baseline scenario" of the co-benefit evaluation in this project, the measured value before the implementation of the project is used.

(2) Proposal of co-benefit index

The co-benefit index, the monitoring method and the frequency to be proposed in this project are indicated in the table below.

Evaluation index	Explanation of index	How to use the index	Monitoring method	Frequency
Hydrogen ion concentration (pH)	Dominant factor of microbial activity	Evaluate the relation with the effluent standard.	Method compliant with the measuring method according to the effluent standard in Thailand	Before the implementation of the project: Once During the implementation of the project: Every three months until it becomes lower than the value specified in the effluent standard, and once a year after that
Suspended solids (SS)	Concentration of insoluble material	Evaluate the turbidity reduction effect based on the SS level reduction amount.		
Biochemical oxygen demand (BOD)	Amount of biodegradable organic matters	Evaluate the water pollution reduction effect based on the BOD level reduction amount.		
Chemical oxygen demand (COD)	Amount of chemically degradable organic matters	Evaluate the water pollution reduction effect based on the COD level reduction amount.		
Kjeldahl nitrogen (TKN)	Organic nitrogen and ammonia nitrogen	Evaluate the degree of the degradation of waste based on the TKN reduction amount.		
Water temperature	Seeping water temperature	Evaluate the degree of the degradation reaction inside the waste layer of landfill.		
Odor	Odor emitted from waste	Evaluate the odor inhibition effect based on the change of the odor index.	Triangle odor bag method or its simplified method	Before the implementation of the project: Once During the implementation of the project: Every six months until the odor index becomes 10 or less, and once a year after that

5. Findings concerning the contribution to sustainable development

None