CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1. Title of the project activity:

>>
Reduction of Methane Gas Emissions and Early Environmental Improvement at Laemchabang Landfill Site in Thailand
Version 01
Date: 1/03/2010

A.2. Description of the project activity:

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Purpose

The purpose of this project is to reduce greenhouse gas emitted from Laemchabang landfill site in Thailand and improve the environment of the landfill site at an early stage by installing an additional ventilation facility at the site.

Laemchabang landfill site, where the project will be implemented, is a closed landfill site. The landfill operation at the site began in August 2004, and will be completed at the end of 2010. The covered area encompasses about 60,000 square metres, with average height of 10.5 metres. Annual waste landfilled is estimated to be 119,000 tonnes (ie. 326tpd). Amount of waste landfilled is recorded but there is no record of the type of waste landiflled: it is expected that the waste contain both municipal solid wastes and industrial wastes, though it is mostly the former.

The project activity intends to convert the currently anaerobic landfill to a semi-aerobic condition by a passive aeration system, thereby reducing the emission of methane. The passive aeration system, which has been adopted in many sites in Japan, is an effective system for early stabilization of landfill sites and improvement of their environments. Laemchabang landfill site is keeping in an anaerobic condition and slowing stabilization of the landfill site. In addition, the result of gas monitoring indicates that emission of methane gas is observed at a high rate even now.

Reduction of GHG Emission

The methane gas at the landfill site can be reduced by changing the condition of landfill from anaerobic condition to semi-aerobic condition.[1),2),] In this project, vent pipes will be additionally installed using the Steel Pipe Casing Method, inserting plastic (PVC) pipes as venting pipe. This will be expected to recover the function of the semi-aerobic landfill system and promote stabilization of the site, thus suppressing emission of the methane gas.

Contribution to Sustainable Development

There are three factors concerning indicators of sustainable development defined by the Thailand government, which are environment, economy and sociality. It is expected that implementing this project will provide the following benefits to these factors.

- Generations of gases such as CH_4 and H_2S from the landfill site will be reduced and the burden on the environment will be lightened.
- Risks of explosion and toxic gas generation at the landfill site will be eliminated.

- Since the drainage of leachate will be improved, the aerobic area will be expanded, degradation of wastes will be promoted and the impact of the leachate on the surrounding environment will be lessened.
- Safe closure of the landfill site can be achieved at an early stage.
- The post-closure landfill site can be utilized for forests, park development, etc. at an early stage.

In addition, the project does not assume operation of any business such as power generation. Therefore, even if the plant or equipment is left inoperative after the project's commerciality is no longer expected, it will not deteriorate the environment. Thus, sustainable development in the true sense can be achieved.

A.3. Project participants:

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Table A.3-1 List of project participants

Parties (including host country)	Project participants such as private and/or public entities	Investment by parties
Thailand(host)	Public entity: Laemchabang City	No
Japan	Private entity: Tokyu Construction	No

For implementation of the actual project, a special purpose company (SPC) will be established. The participants in the SPC are: Tokyu Construction and Deluxe Corporation.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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Thailand

A.4.1.2. Region/State/Province etc.:

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Chonburi State

A.4.1.3. City/Town/Community etc.:

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Laemchabang

A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):

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Laemchabang landfill site, which is the site where this project will be implemented, is located approximately 90 km to southeast from the Bangkok, at latitude 13° 04' 01" N and longitude 101° 01' 16" E.

The following figures show the location of the project site.

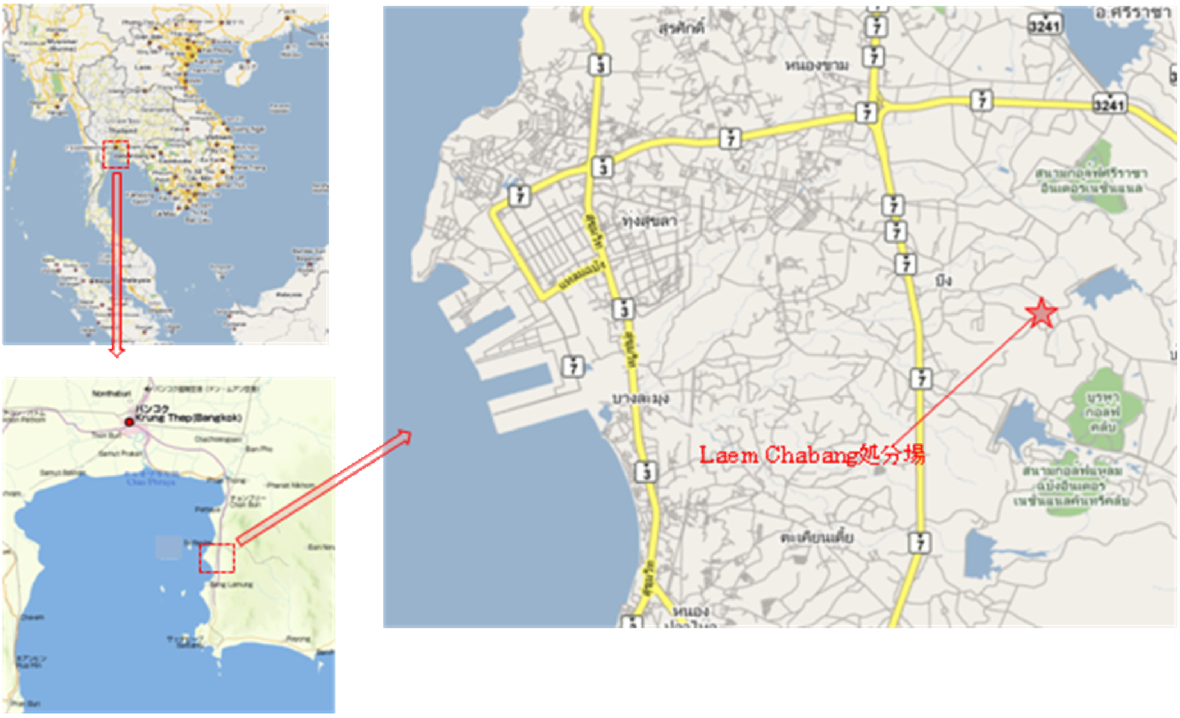

Figure A.4.1-1 Location of the project site

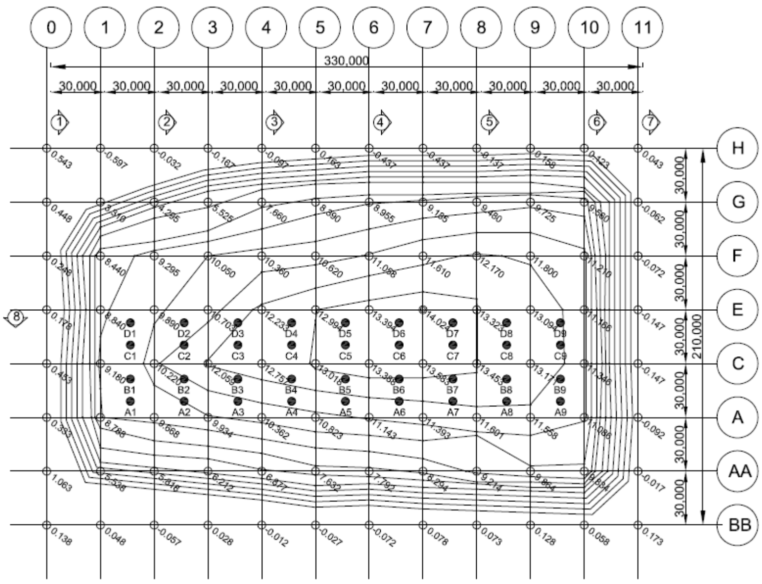

Figure A.4.1-2 description of the project site

A.4.2. Category(ies) of project activity:

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Sectoral scope 13: “Waste handling and disposal”

Reduce methane gas emission from landfill site.

A.4.3. Technology to be employed by the project activity:

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The technology that will be adopted for this project has been used at a large number of landfill sites in Japan as a method for installing vent facilities in post-closure landfill sites and therefore its effectiveness has been demonstrated.

The conventional way to facilitate improvement of a landfill site in an anaerobic condition to an aerobic condition is installing ventilation pipes by drilling the waste layer through boring. However, this method has the following problems.

- When the drilling is performed, contaminated waste is discharged, which may give rise to safety, sanitary and environmental problems.
- Boring is time-consuming and increases the construction cost.

The project activity

In the project activity, a passive aeration system will be introduced in the landfill. Perforated vent pipes will be inserted approx.27 metres apart, in a lattice (grid) format. This will require about 54 vent pipes, forming 50 to80 squares whose area is 729 square metres each. The pipes will be inserted for the entire depth of landfill (in the case of this project activity, this would be average 10.5 metres deep). At the bottom, near-horizontal pipe will be inserted to drain out the leachate. Drained leachate will be initially pumped back to the landfill (it is expected that there will be a brief period, over within a couple of weeks, where there is a flush of leachates after which leachate effluent will decrease). For the duration of the project activity, the amount of leachate is expected to be no different from that in the baseline. To ensure aerobic conditions, a sloped lagoon will be constructed in order to catch the leachate.

It is expected that vent pipes will be made from heat-resistant PVC, and have a diameter of 100mm to 200mm, wall thickness of 8mm. Perforation (hole) will have a diameter of 10mm, located at 45 angles (ie. 8 perforation around the pipe), and at 100mm lengthwise.

This will be expected to recover the function of the semi-aerobic landfill system and promote stabilization of the site, thus reducing emission of the methane gas.

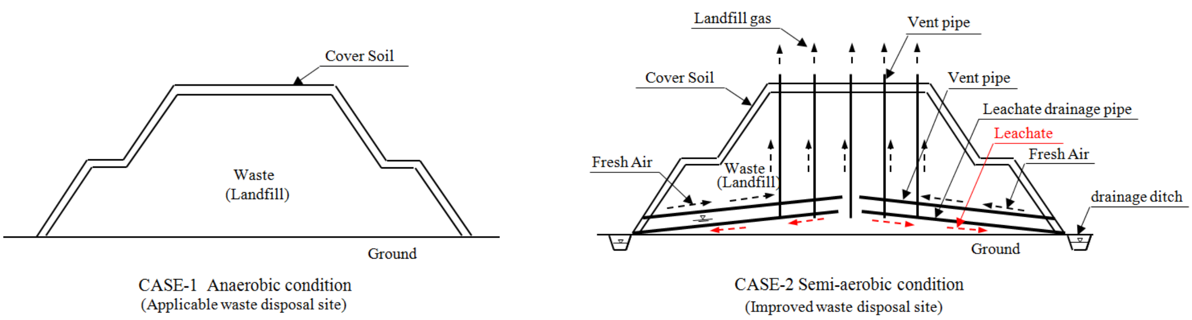

Fig. A4.3-1. Schematic diagramme of passive aeration system (semi-aerobic)

Construction: Steel Pipe Casing Method

This technology has been developed by Tokyu Construction in cooperation with another private company as a method for installing a ventilation pipe in a desired place by rotationally driving a steel casing attached with a lance-shaped piece at the end into the waste layer with no soil discharge or water supply while installing a ventilation pipe (normally made of plastics such as PVC) inside the casing, and then collecting only the casing after driving it.

This method is capable of installing a ventilation facility 30 to 40 m deep at lower cost and less time than the conventional (boring) method. Additionally, since this method does not discharge waste, it is better from a safety point of view.

The following photos show an electric facility being erected with this method, and its completion state.

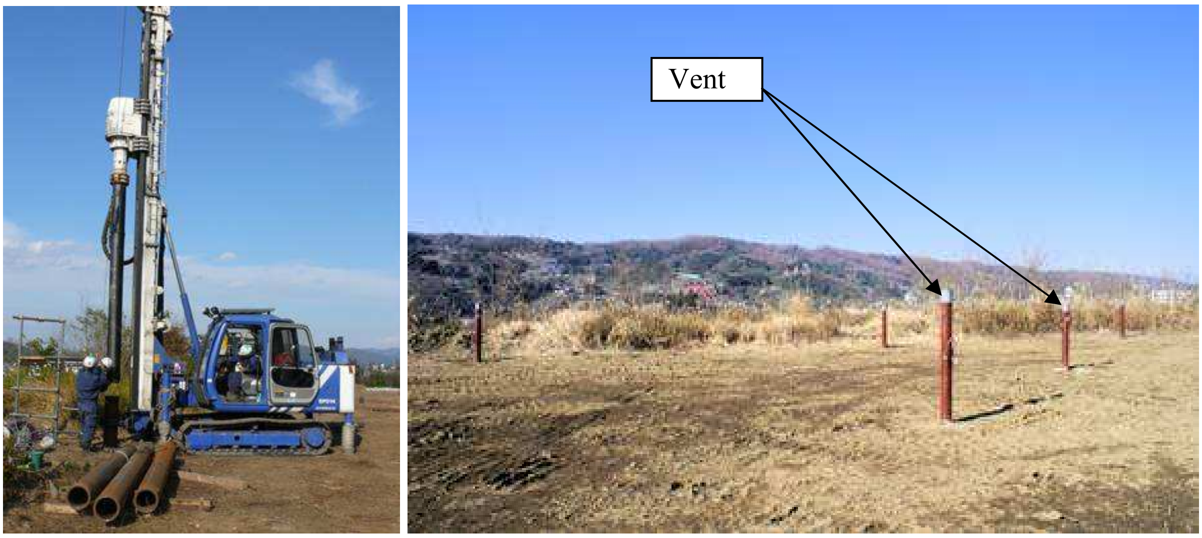

Photo A.4.3-1 Steel pipe casing method as implemented

Thus, use of this method enables safe installation of a ventilation facility with less environmental burden at a landfill site in an anaerobic condition with a high rate of methane gas emission, and improvement of the landfill site into a semi-aerobic condition.

An additional ventilation facility was installed using this technology at landfill site on a trial basis, while modifying the construction machine procured in Thailand and providing technical instructions in order to effectively use the local resource. The result demonstrated that it was possible to reliably install a ventilation facility at this landfill site and achieve technical transfer to the country through this project.

A.4.4. Estimated amount of emission reductions over the chosen crediting period:

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An ex ante calculation of emission reduction is conducted according to the first order decay function as specified in the (proposed) methodology, based on the assumption that methane fraction of landfill gas is reduced from 50% in the baseline to 20%,This is supported by the academic works of Matsufuji and others [1),2)] . The result is as follows.

Table A.4.4-1 Estimated annual emissions

Year	Annual estimation of emission reductions (t-CO_2 e/yr)
2011	29,023
2012	20,393
2013	14,545
2014	10,567
2015	7,370
2016	5,095
2017	3,446
2018	2,225
2019	1,299
2020	577
Total emission reduction (ton-CO_2e) (2011 to 2016)	86,993
Total emission reduction (ton-CO_2e)	94,541
Crediting period (years)(2011 to 2016)	6
Average emission reduction during crediting period (ton-CO_2e)	14,499

A.4.5. Public funding of the project activity:

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This project is not granted with any public funding.
(This project has not been planned as an ODA project, and its financial resource is not diverted from ODA.)

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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A new methodology entitled "Avoidance of landfill gas emissions by passive aeration of landfills" is proposed for application to this project activity.

This methodology also refers to the latest approved versions of the following tools.

- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion;
- Tool to calculate project emissions from electricity consumption;
- Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site;
- Combined tool to identify the baseline scenario and demonstrate additionality;
- Tool to determine the mass flow of a greenhouse gas in a gaseous stream[1]

B.2. Justification of the choice of the methodology and why it is applicable to the project activity:

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The methodology is applicable under the following conditions:

1. "The project activity involves alternative treatment for landfilled waste on closed landfills or closed landfill cells aiming at the reduction of landfill gas emissions in cases where the baseline scenario is the partial or total atmospheric release of landfill gas".

The project at hand comprises in-situ aeration and stabilization by converting an existing, closed landfill into a semi-aerobic system. This is an alternative treatment to simple landfilling. Thereby, the project activity will refer to the complete landfill. The landfill is currently being left unmanaged and uncontrolled. As we will show later, this represents the most plausible baseline scenario (see section B.4.). There are no regulatory requirements to capture and treat methane emissions from closed landfills. Leaving closed landfills unmanaged and uncontrolled is common practice in the host country. Thus, this project is an alternative treatment for a closed landfill that in the absence of the project activity would have been left unmanaged.

2. Furthermore, the new methodology requires that special attention has to be drawn on the differences between fresh and existing waste for the baseline scenario determination. It is required to realize a statistically significant sampling and analysis of the landfilled waste.

As required by the new methodology, the landfilled waste will be sampled directly before the project activity starts. Thereby, methane generation potential and methane generation rate of the waste disposed at Laemchabang landfill will be determined. With these values, adjusted baseline emissions

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[1] Approved at the 47th Executive Board (May, 2009)

can by calculated using an adjusted version of the first order decay model as described in the new methodology. The sampling will be as per the provision in the monitoring methodology (section III of the new methodology). With this procedure, the difference between the landfilled waste and fresh waste is suitably addressed.

3. The methodology requires identifying clearly potential after-uses of the landfill site after the project activity and corresponding land values.

Possibility of resale of landfills is examined, taking into account relevant regulations and the specific site conditions such as topography and stability.
It was found that a) Laemchabang is owned by a public entity (Laemchabang City), and b) to date, there are no examples of landfills later sold for commercial purpose in Thailand. It can be concluded that resale of landfill is unlikely.

The landfill has been poorly managed throughout its operational phase. That way, the landfilled wastes have not been properly compacted and the slopes are steep. Thus, the landfill body has low stability which is unsuitable for building or other purposes. The proposed project activity will on the one hand substantially reduce the methane emission potential. But on the other hand, it will not lead to a substantially increased stability of the landfill. The compaction will only increase to a small degree (due to settlements as a consequence of the degradation of organic matter). Thus, building or other commercial or productive after-uses will remain unviable.

The application of the procedure to identify the baseline scenario results in that No or partial collection and combustion of LFG from the landfill is the most plausible baseline scenario.

Current situation is defined as the baseline scenario according to the analysis using the "*Combined tool to identify the baseline scenario and demonstrate additionality*". Please refer to the analysis result in section B4.

B.3. Description of the sources and gases included in the project boundary:

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The project boundary is the Laemchabang Landfill site where aeration system is installed, including leachate collection and treatment systems. Since passive aeration system is installed, no energy-consuming devices (e.g. pumps) are included in the project boundary, except for pumps to pump back initial drainage water.

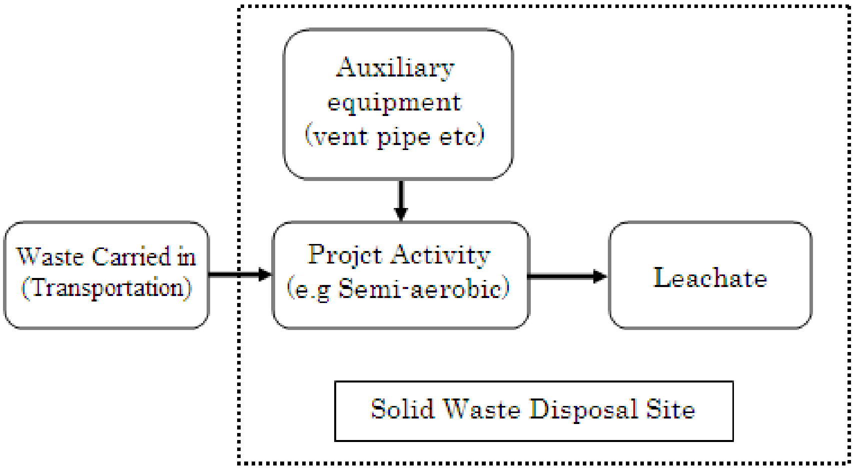

Fig. B.3-1 (a) Project boundary

The greenhouse gases included in or excluded from the project boundary are shown in Table B.3-1.

Table B.3-1:Emissions sources included in or excluded from the project boundary

Source		Gas	Included?	Justification / Explanation
Baseline	Emissions from decomposition of waste at the landfill site	CO_2	No	Not considered
		CH_4	Yes	Major source of emissions
		N_2O	No	Emission is negligible
Project activity	Emissions from decomposition of waste at the landfill site	CO_2	No	Not considered
		CH_4	Yes	Major source of emissions
		N_2O	No	Emission is negligible
	Emissions from on-site fossil fuel consumption due to the project activity	CO_2	Yes	May be an important emission source.
		CH_4	No	Emission is negligible
		N_2O	No	Emission is negligible
	Emissions from on-site electricity consumption due to the project activity	CO_2	Yes	May be an important emission source.
		CH_4	No	Emission is negligible
		N_2O	No	Emission is negligible

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

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Project participants shall apply the following steps to identify the baseline scenario:

>Step 1 Identification of alternative scenarios

Project participants should use Step 1 of the latest version of the “Tool for the demonstration and assessment of additionality”, to identify all realistic and credible baseline alternatives. In doing so, relevant policies and regulations related to the management of landfill sites should be taken into account. Such policies or regulations may include mandatory landfill gas capture or destruction requirements because of safety issues or local environmental regulations.[2] Other policies could

[2] Relevant clarifications on the treatment of national and/or sectoral policies and regulations in determining a baseline scenario should be taken into account as per Annex 3 to the 22nd meeting of the Executive Board and any other forthcoming guidance from the Board on this subject.

include local policies promoting productive use of landfill gas such as those for the production of renewable energy or policies on proper after-care of abandoned landfills. In addition, the assessment of alternative scenarios should take into account local economic and technological circumstances.

National and/or sectoral policies and circumstances must be taken into account in the following ways:

- In Sub-step 1b of the "Tool for the demonstration and assessment of additionality", the project developer must show that the project activity is not the only alternative that is in compliance with all regulations (e.g., because it is required by law);
- Via the adjustment factor AF in the baseline emissions, project participants must take into account that some of the methane generated in the baseline must be captured and destroyed to comply with regulations or contractual requirements;
- The project developer must monitor all relevant policies and circumstances at the beginning of each crediting period and adjust the baseline accordingly.

Alternatives for the treatment of existing waste in the absence of the project activity (in-situ aeration of landfills), i.e., the scenario relevant for estimating baseline methane emissions, to be analyzed should include, *inter alia*:

- LFG1: The project activity (passive aeration of landfills) or any other form of aeration not implemented as a CDM project;
- LFG2: No or partial collection and combustion of LFG from the landfill;
- LFG3: LFG collection and combustion system, with or without energy generation;
- LFG4: Landfill mining: The landfill is opened and all existent waste is recycled and/or composted.

None of the alternative scenarios above have conflict with existing mandatory applicable laws and regulations in Thailand. In addition, Thailand law does not demand landfill gas (LFG) capture and combustion (either usage or flare) at closed landfills at present. Hence, no alternative scenario is rejected by step 1

Step 2: exclusion of alternatives that face barriers

Step 2 and/or Step 3 of the latest approved version of the "Tool for the demonstration and assessment of additionality" shall be used to assess which of these alternatives should be excluded from further consideration (e.g., alternatives facing prohibitive barriers or those clearly economically unattractive).

If the project implements LFG1 option, the cost of improvement for the landfill site will be uncollectible. Because no revenues can be expected except for CER by the project conducted as CDM. There is no facility of gas and electricity supply system and no demand of these energies in Laemchabang district. Then installing these facilities need a lot of expenses and cannot expect the revenues from supplying them. LFG4 also need a lot of cost to excavate and retreat the waste of landfill site. Therefore option LFG1, LFG 3 and LFG4 cannot be adopted.
Thus, LFG2 is the most plausible baseline scenario.

Step 3: selection of baseline scenario

Where more than one credible and plausible alternative remains, project participants shall, as a conservative assumption, use the alternative baseline scenario that results in the lowest baseline emissions as the most likely baseline scenario. In assessing these scenarios, any regulatory or contractual requirements should be taken into consideration.

The plausible baseline scenario is left only one, LFG2. To check under the step3 is needless.

Alternative (LFG2) can be identified as the most plausible baseline scenario.

The methodology is only applicable if the most plausible baseline scenario is identified as business-as-usual, i.e., no or partial collection and combustion of LFG from the landfill (LFG2)

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

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Additionality of the project activity is demonstrated as per the previous section, drawing upon the "*Combined tool to identify the baseline scenario and demonstrate additionality*". The project activity only incurs cost (6.7million Japanese yen) and no significant revenue except for what can be expected in return of certified emission reductions. This means that, assuming 10 Euros (approx. 1,200JPY) per t-CO_2, about 55,000 t-CO_2 of CER is needed to recover the cost of investment (not taking into account operational expenses). Given further that landfill gas is highly variable, it can be said that the project is additional).

The latest version of "*Combined tool to identify the baseline scenario and demonstrate additionality*" is used to identify the baseline scenario and confirm the additionality of the project.

Step 1: **Identification of alternatives to the project activity consistent with current laws and regulations**

According to the explanations in chapter B.4, alternatives may include:

- LFG1: The project activity (passive aeration of landfills) or any other form of aeration not implemented as a CDM project;
- LFG2: No or partial collection and combustion of LFG from the landfill;
- LFG3: LFG collection and combustion system, with or without energy generation;
- LFG4: Landfill mining: The landfill is opened and all existent waste is recycled and/or composted.

As already mentioned in paragraph B.4, none of the alternative scenarios above have conflict with existing mandatory applicable laws and regulations in Thailand. In addition, Thailand law does not demand landfill gas (LFG) capture and combustion (either usage or flare) at closed landfills at present. Hence, no alternative scenario is rejected by step 1.

Step 2: Barrier analysis

Sub-step 2a: Identify barriers that would prevent the implementation of alternative scenarios

Laemchabang Landfill site is located in suburban of the city, and there is no residential area adjacent to this landfill site. There is no on-site and off-site demand of heat since Thailand, being a tropical country, has no significant demand of heat other than for industrial use, and the nearest heat demand is far. As for electricity, building of transmission capacity is an insurmountable barrier, as well as the general unwillingness of the Thailand grid to purchase unreliable power such as landfill gas generation.

Sub-step 2b: Eliminate alternative scenarios which are prevented by the identified barriers
Following sub-step 2a, LFG3 is excluded from the alternative scenario.

Step 3: Investment analysis

Prior to conducting an investment analysis, possibility of resale of landfills is examined, taking into account relevant regulations and the specific site conditions such as topography and stability.

It was found that a) Laemchabang is owned by a public entity (Laemchabang City), and b) to date, there are no examples of landfills later sold for commercial purpose inThailand. Therefore, it can be concluded that resale of landfill is unlikely and investment analysis for remaining options can be performed without taking into account possible future revenue due to sale of the land. To this end, simple cost analysis will be applied.

All options except for LFG2 require a significant amount of investment; for example the cost for option LFG1 is considered to be 6.7 million Japanese yen (approx. 550 thousand Euros), not taking into account operational expenses. No revenues can be expected except for CER by the project conducted as CDM. Thus, LFG2 (continuation of current situation) is the most plausible baseline scenario.

Step 4: Common practice analysis
As mentioned, there are examples of semi-aerobic aeration conducted in Thailand. However, all are implemented with the extensive financial and technical assistance by Japan International Cooperation Agency (JICA). Furthermore, an overwhelming majority of landfills are not equipped with aeration devices. Therefore, it can be ascertained that LFG2 is the baseline.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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For this project activity, the methodology "Avoidance of landfill gas emissions by passive aeration of landfills" is selected.

Emission reduction

Emission reductions are calculated as follows:

$$ER_y = (R \times BE_y) - PE_y \quad (1)$$

Where:

ER_y	Emission reductions in year *y* (t CO_2e/yr)
BE_y	Baseline emissions in year *y* (t CO_2e/yr)
R	Ratio between the actual methane measured and the methane estimated using the FOD model
PE_y	Project emissions in year *y* (t CO_2/yr)

If PE_y is smaller than 1% of BE_y, the project participants may assume a fixed percentage of 1% for PE_y combined for the remaining years of the crediting period

1)Ratio between FOD model and measurement

$$R = \frac{ME_{CH4,bl\_campaign}}{MB_{bl\_campaign,ad}} \quad (2)$$

Where:

R	Ratio between the actual methane measured and the methane estimated using the FOD model. If *R* is greater than 1, a value of 1 shall be used
$ME_{CH4,bl\_campaign}$	Methane produced in the landfill in the baseline campaign measured and calculated as per equation (8)below. (t CO_2/bl_campaign)
$MB_{bl\_campaign,ad}$	Methane produced in the landfill in the baseline campaign estimated as per equation (9) below. (t CO_2/bl_campaign)

$$ME_{CH4,bl\_campaign} = \sum_k (GWP_{CH4} \times MC_{CH4,v,k,bl\_campaign} \times SG_{v,k,bl\_campaign}) + \sum_i (GWP_{CH4} \times MC_{CH4.s,i,bl\_campaign} \times SG_{s,i,bl\_campaign}) \quad (3)$$

Where:

GWP_{CH4}	= Global Warming Potential (GWP) of methane, valid for the relevant commitment period (t CO_2/t CH_4)
$MC_{CH4,v,k,bl\_campaign}$	= Monitored methane content in venting well *k* during the baseline campaign (t CH_4/m^3).
$SG_{v,k,bl\_campaign}$	= Volume of emissions in venting well *k* in the baseline campaign (m^3/bl_campaign)
$MC_{CH4,s,i,bl\_campaign}$	= Monitored methane content from surface emissions in zone *i* during the baseline campaign (t CH_4/m^3)
$SG_{s,i,bl\ campaign}$	= Volume of surface emissions in zone *i* in the baseline campaign (m^3/yr)
k	= Number of venting wells (monitoring of vented emissions might require measuring at different sampling points)

i = Number of surface zones (see monitoring procedures below)

$$MB_{bl\_campaign,ad} = \varphi \times (1-f) \times GWP_{CH4} \times (1-OX) \times MCF_{adj} \times \sum_i A_{lf,i} \times L_{0,i} \times e^{-kCH4(m-x)} \times (1-e^{-kCH4}) \quad \textbf{(4)}$$

Where:

φ	=	Default model correction factor to account for model uncertainties (0.9)
f	=	Fraction of methane captured and flared
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period (t CO_2/t CH_4)
OX	=	Oxidation factor (reflecting the amount of methane from the landfill that is oxidized in the soil or other material covering the waste)
MCF_{adj}	=	Adjusted methane correction factor. MCF values according to the latest version of the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" have to be applied
$A_{lf,i}$	=	Amount of landfilled waste in landfill zone *i* (t). Estimated as per equation (8)below.
$L_{o,i}$	=	Potential methane generation capacity of the waste in landfill zone *i* as determined by sampling and lab analysis (Mg CH_4/Mg Waste) once before start of the project activity as per the monitoring methodology described below
k_{CH4}	=	Monthly methane generation rate. k_{CH4} value as per table in the data and parameters not monitored section below is used after adjusting to monthly values (by dividing the values in the table by 12)
x	=	Month of start of baseline campaign (months)
m	=	Month for estimating methane emission during baseline campaign (months)
i	=	Landfill zone category (index). Depending on the characteristics and tipping history of the landfill, the landfill is subdivided into different zones with different characteristics and methane generation potential and landfilled waste quantities determined separately for each zone

Monthly campaigns for measuring surface emissions during the baseline campaign are required. Guidance given in the monitoring methodology for conducting surface measurement campaigns should be followed replacing *q* (season) with *m* (month).

Baseline emissions

Baseline emissions are calculated as follows:

$$BE_y = (MB_y - MD_{reg,y}) \quad \textbf{(5)}$$

Where:

BE_y	Baseline emissions in year *y* (t CO_2/yr)
MB_y	Methane that would be produced in the landfill in the absence of the project

	activity in year *y* (t CO_2/yr)
$MD_{reg,y}$	Methane that would be destroyed in the absence of the project activity in year *y* (t CO_2/yr)

1) $MD_{reg,y}$

In cases where regulatory or contractual requirements do not specify $MD_{reg,y}$, an Adjustment Factor (*AF*) shall be used and justified, taking into account the project context. In doing so, the project participant should take into account that some of the methane generated by the landfill may be captured and destroyed to comply with other relevant regulations or contractual requirements, or to address safety and odour concerns.

$$MD_{reg,y} = MB_y \times AF \qquad \textbf{(6)}$$

Where:

AF	Adjustment Factor for MB_y (%)

For the proposed project activity, AF can be set to 0, as there is no regulatory requirement to treat methane from closed landfills

2) Methane generation from the landfill in the absence of the in-situ project activity

Methane emissions that would have been released in the absence of the project activity will be determined based on a first order decay model computed with current analysis data from the landfilled waste:

$$MB_{y,ad} = \varphi \times (1-f) \times GWP_{CH4} \times (1-OX) \times MCF_{adj} \times \sum_i A_{lf,i} \times L_{0,i} \times e^{-k_{CH4}(y-x)} \times (1-e^{-k_{CH4}}) \qquad \textbf{(7)}$$

$$A_{lf,i} = f_{dg,i} \times A_{T,i} \qquad \textbf{(8)}$$

Where:

φ	=	Default model correction factor to account for model uncertainties (0.9)
f	=	Fraction of methane captured and flared(=0)
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period (t CO_2/t CH_4)(=21)
OX	=	Oxidation factor (reflecting the amount of methane from the landfill that is oxidized in the soil or other material covering the waste)
MCF_{adj}	=	Adjusted methane correction factor. MCF values according to the latest version of the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site” have to be applied
$L_{o,i}$	=	Potential methane generation capacity of the waste in landfill zone *i* as determined by sampling and lab analysis (Mg CH_4/Mg Waste) once before start of the project activity as per the monitoring methodology described below
k_{CH4}	=	Methane generation rate. k_{CH4} value as per table in the data and parameters not monitored section below is used

x	=	The year of start of aeration. (yr)
i	=	Landfill zone category (index). Depending on the characteristics and tipping history of the landfill, the landfill is subdivided into different zones with different characteristics and methane generation potential and landfilled waste quantities determined separately for each zone
$A_{lf,i}$	=	Amount of landfilled waste in landfill zone i (t)
$f_{dg,i}$	=	Fraction of degradable waste in landfill zone i
$A_{T,i}$	=	Total waste quantities in landfill zone i (t)

Project emissions

1)Project emissions are calculated as follows

$$PE_y = PE_{EC,y} + PE_{FC,j,y} + PE_{a,y} \quad \textbf{(9)}$$

Where:

PE_y	=	Project emissions in year y (t CO_2/yr)
$PE_{EC,y}$	=	Project emissions from electricity consumption in year y (t CO_2/yr)
$PE_{FC,j,y}$	=	Project emissions from fossil fuel combustion in year y (t CO_2/yr)
$PE_{a,y}$	=	Project emissions from in-situ aeration of the landfill in year y (t CO_2/yr)

Electricity and fossil fuel will not use under semi-aerobic treatment. Then there are no electricity consumption and fossil fuel combustion. Consequently $PE_{EC,y}$ and $PE_{FC,j,y}$ emissions will be zero.

2) Methane emissions from in-situ aeration of landfills

CH_4 emissions from aeration of the landfill in year y are calculated as follows

$$PE_{a,y} = \sum_k \sum_q (GWP_{CH4} \times MC_{CH4,v,k,q} \times SG_{v,k,q}) + \sum_i \sum_q (GWP_{CH4} \times MC_{CH4.s,i,q} \times SG_{s,i,q} \times CF) \quad \textbf{(10)}$$

$$SG_{v,k,q} = s \times N_{v,k,q} \times A_{v,k} \quad \textbf{(11)}$$

$$\mathrm{S}G_{\mathrm{s,i,q}} = FL_{\mathrm{s,i,q}} \times s \times A_l \quad \textbf{(12)}$$

Where

GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period (t CO_2/t CH_4)
$MC_{CH4,v,k,q}$	=	Monitored methane content in venting well k in season q (t CH_4/m^3)
$SG_{v,k,q}$	=	Total volume of captured emissions in venting well k in season q (m^3/q)

$MC_{CH4,s,i,q}$	=	Monitored methane content from surface emissions in zone *i* in the season *q* (t CH_4/m^3)
$SG_{s,i,,q}$	=	Total volume of surface emissions in zone *i* in season *q* (m^3/q)
k	=	Number of venting wells
i	=	Number of surface zones (see monitoring procedures below)
CF	=	Conservativeness factor. Due to the high degree of uncertainty of surface measurements, a factor of 1.37 is applied
s	=	Total duration of season *q* (seconds)
$N_{v,k,q}$	=	Monitored flux from venting well *k* in season *q* ($m^3/m^2.s$)
$A_{v,k}$	=	Cross-sectional area of venting well *k* (m^2)
A_i	=	Area of zone *i* (m^2)
$FL_{s,i,q}$	=	Flux rate surface emissions in zone *i* in season *q* ($m^3/s\ m^2$)

The landfill gas from vent wells will be monitored by using Option2 and Sub-Option2-1 in proposed methodology. All vent wells will be monitored.

Determination of the monitored methane content from surface emissions during aeration in zone i in season q ($MC_{CH4,s,i,q}$)

(1) Calculate sample mean (μ) for each zone *i* and season *q*.

$$\mu_{MCCH4,s,i,q} = \frac{\sum_{c=1}^{n_c} MC_{CH4,s,i,c,q}}{n_c} \quad \textbf{(13)}$$

Where:

$\mu_{MCCH4,s,i,q}$	=	Mean of monitored methane content from surface emissions in zone *i* in season *q* (t CH_4/m^3)
$MC_{CH4,s,i,c,q}$	=	Monitored methane content from surface emissions during in zone *i* in location *c* in season *q* (t CH_4/m^3)
n_c	=	Number of monitoring locations per zone as per guidance from the UK environment agency (function of the zone size)
q	=	Seasons. Project proponents should realize seasonal measurement campaigns per year, i.e. at least 4 measurements in temperate and boreal climate and at least two measurements in tropical regions.If more measurements are made then this will be the number of campaigns during the year

(2) Calculate the sample standard deviation (σ).

$$\sigma_{MCCH4,s,i,q} = \sqrt{\frac{\sum_{c=1}^{n_c} (MC_{CH4,s,i,c,q} - \mu_{MCCH4,s,i,q})^2}{n_C - 1}} \quad \textbf{(14)}$$

Where:

$\sigma_{MCCH4,s,i,q}$ = Standard deviation of monitored methane content from surface emissions during aeration in zone *i* in season *q* (t CH_4/m^3)

(3) Calculate the 95% confidence interval.

$$\mu_{MCCH4,s,i,q} - t \cdot \frac{\sigma_{MCCH4,s,i,q}}{\sqrt{n_c}} \leq MC_{CH4,s,i,q} \leq \mu_{MCCH4,s,i,q} + t \cdot \frac{\sigma_{MCCH4,s,i,q}}{\sqrt{n_c}} \quad \textbf{(15)}$$

Where:

t = *t* statistic from the student *t* distribution table for a confidence level of 95% with degrees of freedom n-1

(4) Use the upper bound of the 95% confidence interval obtained from the above to ensure conservativeness.

Determination of total volume of surface emissions in zone i in season q ($SG_{s,i,q}$)

(1) Calculate sample mean (μ) for each zone *i* and ***season q***.

$$\mu_{FLs,i,q} = \frac{\sum_{c=1}^{n_c} FL_{s,i,c,q}}{n_c} \quad \textbf{(16)}$$

Where:

$\mu_{FLs,i,q}$ = Mean of flux of surface emissions in zone *i* in season *q* (m^3/s m^2)

$FL_{s,i,c,q}$ = Flux of surface emissions in zone *i* in location *c* in season *q* (m^3/s m^2)

n_c = Number of monitoring locations as per guidance from the UK environment agency (function of the zone size)

q = Seasons. Project proponents should realize measurement campaigns corresponding to the number of season as stipulated in paragraph 46.

(2) Calculate the sample standard deviation (σ).

$$\sigma_{FLs,i,q} = \sqrt{\frac{\sum_{c=1}^{n_c} (FL_{s,i,c,q} - \mu_{FLs,i,q})^2}{n_C - 1}} \quad \textbf{(17)}$$

Where:

$\sigma_{FLs,i,q}$ = Standard deviation of flux of surface emissions in zone *i* in season *q* (m^3/s m^2)

(3) Calculate the 95% confidence interval.

$$\mu_{\mathrm{FLs,i,q}} - t \cdot \frac{\sigma_{\mathrm{FLs,i,q}}}{\sqrt{n_c}} \leq FL_{\mathrm{s,i,q}} \leq \mu_{\mathrm{FLs,i,q}} + t \cdot \frac{\sigma_{\mathrm{FLs,i,q}}}{\sqrt{n_c}} \qquad \textbf{(18)}$$

Where:

t	=	t statistic from the student t distribution table for a confidence level of 95% with degrees of freedom n-1
$FL_{s,i,q}$	=	Flux rate surface emissions in zone i in season q (m^3/s m^2)

(4) Use the upper bound of the 95% confidence interval obtained above to ensure conservativeness.

Leakage

Corresponding with the new methodology, no leakage will be considered.

B.6.2. Data and parameters that are available at validation:

(Copy this table for each data and parameter)

Data / Parameter:	AF
Data unit:	%
Description:	Methane destroyed due to regulatory or other requirements
Source of data:	Local and/or national authorities
Measurement procedures (if any):	-
Monitoring frequency:	At renewal of crediting period
QA/QC procedures:	Data are derived from or based upon local or national guidelines, so QA/QC-procedures for these data are not applicable
Any comment:	Changes in regulatory requirements, relating to the baseline landfill(s) need to be monitored in order to update the adjustment factor (AF) or directly $MD_{reg.}$. This is done at the beginning of each crediting period

Data / Parameter:	$RATE^{Compliance}_{y}$
Data unit:	Number
Description:	Rate of compliance with landfill regulation
Source of data:	Municipal bodies
Measurement procedures (if any):	The compliance rate is based on the annual reporting of the municipal bodies issuing these reports. The state-level aggregation involves all landfill sites in the country. If the rate exceeds 50%, no CERs can be claimed
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Data / Parameter:	L_o
Data unit:	Mg methane/Mg waste
Description:	Potential methane generation capacity; depending on type and composition of the waste placed in the landfill
Source of data:	Laboratory analysis
Measurement procedures (if any):	L_o should be analyzed as Biochemical Methane Potential (BMP) according to the methods described by Kelly et al. (2006)[3], Owens & Chenowyth (1993)[4], Hansen et al. (2004)[5] or alternative appropriate standards
Monitoring frequency:	At project start
QA/QC procedures:	See procedures description above
Any comment:	More frequent sampling is encouraged

Data / Parameter:	$f_{dg,i}$
Data unit:	-
Description:	Fraction of degradable waste in landfill zone *i*
Source of data:	Project
Measurement procedures (if any):	The same samples taken to determine L_o shall be classified into degradable and non degradable materials (by mass) to determine this parameter
Monitoring frequency:	Once at the start of the project activity and optionally after stopping aeration of the landfill
QA/QC procedures:	To be compared to data for waste classification per type of waste, if available
Any comment:	-

Data / Parameter:	$A_{T,i}$
Data unit:	Tons

[3] Ryan J. Kelly, Bradley D. Shearer, Jongmin Kim, C. Douglas Goldsmith, Gary R. Hater, John T. Novak (2006): Relationships between analytical methods utilized as tools in the evaluation of landfill waste stability, Waste Management, 26, p.1349–1356, download at <http://www.scsengineers.com/Papers/Kelly_WM-Analytical_Tools_LF_Waste_Stability.pdf>.

[4] J.M. Owens, J.M., D.P. Chynoweth, (1993): Biochemical methane potential of municipal solid waste (MSW) components. Water Science and Technology 27 (2), p. 1–14.

[5] Train L. Hansen, Jens Ejbye Schmidt, Irini Angelidaki, Emilia Marca, Jes la Cour Jansen, Hans Mosbaek, Tomas H. Christensen (2004): Method for determination of methane potential of solid organic waste, Waste Management, 24, p. 393-400.

Description:	Total waste quantities in landfill zone *i*
Source of data:	Project
Measurement procedures (if any):	Volume and density shall be measured before the project start (by geodetic surveys and test excavation)
Monitoring frequency:	Once at the start of the project activity
QA/QC procedures:	To be checked against data for historical waste quantities
Any comment:	The value is assumed to be constant; this is conservative. The value has to be available at validation

Data / Parameter:	A
Data unit:	m^2
Description:	Total area of landfill
Source of data:	Project
Measurement procedures (if any):	By geodetic surveys
Monitoring frequency:	Once at the start of the project activity
QA/QC procedures:	To be checked against data from existing maps
Any comment:	-

Data / Parameter:	A_i
Data unit:	m^2
Description:	Area of zone *i*
Source of data:	Project
Measurement procedures (if any):	By geodetic surveys
Monitoring frequency:	Once at the start of the project activity
QA/QC procedures:	To be checked against data from existing maps
Any comment:	-

Data / Parameter:	$SG_{s,i,bl\ campaign}$
Data unit:	m^3
Description:	Volume of surface emissions in zone *i* in the baseline campaign at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the surface emissions will be carried out according to VDI guideline 3790[6] or the UK guidance mentioned above
Monitoring frequency:	Monthly during the baseline campaign
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

Data / Parameter:	$MC_{CH4,s,i,bl\ campaign}$
Data unit:	tCH_4/m^3
Description:	Monitored methane content from surface emissions during the baseline campaign
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the methane content will be carried out according to internationally recognized standards, using flame ionization detector, infrared sensors or similar
Monitoring frequency:	Monthly during the baseline campaign
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

[6] VDI guideline VDI 3790 “Emissions of gases, odours and dusts from diffuse sources”, January 2005, <www.vdi.de>.

Data / Parameter:	T_s
Data unit:	°C
Description:	Temperature of the surface emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Periodic (in the middle of each season.
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged

Data / Parameter:	P_s
Data unit:	Pa
Description:	Pressure of surface emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Periodic (in the middle of each season.
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged

Data / Parameter:	$SG_{v,k,bl\ campaign}$
Data unit:	m^3
Description:	Volume of emissions in venting well *k* in the baseline campaign at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the emissions will be carried out according to internationally recognized standards. The monitoring system should either comply with the VDI Guideline 3860 (Blatt 1 and 2)[7] or to any other national or international guidelines comparable. It is recommended that measurement be made by an appropriate flow meter, at a depth more than three metres deep from the surface of landfill in order to avoid the effect of air turbulence.
Monitoring frequency:	Continuous
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

Data / Parameter:	$MC_{CH4,v,k,bl\ campaign}$
Data unit:	tCH_4/m^3
Description:	Monitored methane content in venting well *k* during the baseline campaign
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the methane content will be carried out according to internationally recognized standards, using flame ionization detector, infrared sensors or similar
Monitoring frequency:	Continuous
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

[7] VDI Guideline 3860: Measurement of landfill gas - Measurements in the gas collection system (Blatt 1 and 2); February 2008; <www.vdi.de>.

Data / Parameter:	T_v
Data unit:	°C
Description:	Temperature of the vented exhaust emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

Data / Parameter:	P_v
Data unit:	Pa
Description:	Pressure of the vented exhaust emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of pressure is necessary when using flow meters thatautomatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

B.6.3. Ex-ante calculation of emission reductions:

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(1) General remark

As per the (proposed) methodology, an *ex ante* estimation of baseline emissions should be conducted by using the first order decay (FOD) model which is the latest version of "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*".

For the GHG reduction, the effect of the project can be identified by calculating the emission in the baseline condition and the emission in an improved semi-aerobic condition after the implementation of the project, and then subtracting the latter from the former.

(2) Ex ante calculation of baseline emissions($MB_{y,ea}$)

The *ex ante* estimation of the methane generation from the landfill in the absence of the project activity (aeration of landfills) may be done with the latest version of the approved "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". In this case, the following additional equation shall be used:

$$MB_{y,ea} = BE_{CH4,SWDS,y} \quad \textbf{(19)}$$

Where:

$BE_{CH4,SWDS,y}$ Methane generation from the landfill in the absence of the project activity at year *y*, calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". The tool estimates methane generation adjusted for, using adjustment factor (f), any landfill gas in the baseline that would have been captured and destroyed to comply with relevant regulations or contractual requirements, or to address safety and odor concerns. The variable $w_{j,x}$ in the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" is to be replaced by a variable $A_{lf,exante,j,x}$, which is the amount of organic waste disposed in the landfill in the year *x* (tonnes/year)

The estimate of $A_{lf,exante,j,,x}$, should take (c), that is ;

Using a default value for the share of biodegradable waste, calculated as the sum of the categories "Food waste", Paper/Cardboard", "Wood" and "Textiles", applicable for the region where the project is located, in Table 2.3 of the IPCC national greenhouse gas inventories (2006), volume 5, chapter 2. In case data for different types of waste is not available, the value of k_j for the share of biodegradable waste is the one specified for "bulk waste" in Table 3.3 of the IPCC national greenhouse gas inventories (2006), volume 5, chapter 3 may be used.

(3) Ex ante calculation of project emissions ($PE_{a,y}$)

Ex ante estimation of $PE_{a,y}$ may be done with the latest version of the approved "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". The same guidance given in the *Ex ante calculation of baseline emissions* above may be used for waste classification and waste quantities. It is assumed that MCF for semi-aerobic landfill is 0.5[8] may be used for ex ante estimation. For the parameter MCF*F (fraction of methane is SWDS), a value of 0.2 shall be used, according to previous results[9]

Table B.6.3-1 shows the baseline emission and the project activity emission, as well as the overall emission reductions, of GHG generated from waste disposed of in a year at the landfill site.

See Data – 3 of Annex 3.

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[8] Table 3.1, Volume 5, Chapter 3 (Solid Waste Disposal) of IPCC 2006 Guidelines.

[9] As shown in reference 1) and 2) in APPENDIX1

Table B.6.3-1 Emissions and emission reductions

t-CO_2e/y

Year		Baseline Emissions	Project Emissions	Emission Reductions
2011	1	48,372	19,349	29,023
2012	2	33,989	13,595	20,393
2013	3	24,242	9,697	14,545
2014	4	17,611	7,044	10,567
2015	5	12,284	4,913	7,370
2016	6	8,492	3,397	5,095
2017	7	5,743	2,297	3,446
2018	8	3,708	1,483	2,225
2019	9	2,165	866	1,299
2020	10	962	385	577
Project periods (2011～2016)		144,989	57,996	86,993
Total		157,568	63,027	94,541

Waste disposal at the landfill site started from 2004 to 2010. Table B.6.3-2 below shows the annual GHG emission in 2011 onward after the project is implemented.

Table B.6.3-2 Baseline emissions

t-CO_2e/y

Year		Year(year of disposed waste)							Total
		2004	2005	2006	2007	2008	2009	2010	
2011	1	2,035	2,748	3,792	5,327	7,593	10,949	15,927	48,372
2012	2	1,544	2,035	2,748	3,792	5,327	7,593	10,949	33,989
2013	3	1,202	1,544	2,035	2,748	3,792	5,327	7,593	24,242
2014	4	962	1,202	1,544	2,035	2,748	3,792	5,327	17,611
2015	5		962	1,202	1,544	2,035	2,748	3,792	12,284
2016	6			962	1,202	1,544	2,035	2,748	8,492
2017	7				962	1,202	1,544	2,035	5,743
2018	8					962	1,202	1,544	3,708
2019	9						962	1,202	2,165
2020	10							962	962
Total		5,743	8,492	12,284	17,611	25,204	36,153	52,081	157,568

Table B.6.3-3 Project emissions

t-CO_2e/y

Year		Year(year of disposed waste)							Total
		2004	2005	2006	2007	2008	2009	2010	
2011	1	814	1,099	1,517	2,131	3,037	4,380	6,371	19,349
2012	2	617	814	1,099	1,517	2,131	3,037	4,380	13,595
2013	3	481	617	814	1,099	1,517	2,131	3,037	9,697
2014	4	385	481	617	814	1,099	1,517	2,131	7,044
2015	5		385	481	617	814	1,099	1,517	4,913
2016	6			385	481	617	814	1,099	3,397
2017	7				385	481	617	814	2,297
2018	8					385	481	617	1,483
2019	9						385	481	866
2020	10							385	385
Total		2,297	3,397	4,913	7,044	10,082	14,461	20,832	63,027

Table B.6.3-4 Emission reduction

t-CO2e/y

Year		Year(year of disposed waste)							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
Project periods (2011〜2016)		3,446	5,095	7,370	9,989	13,824	19,467	27,802	86,993
Total		3,446	5,095	7,370	10,567	15,123	21,692	31,248	94,541

B.6.4 Summary of the ex-ante estimation of emission reductions:

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Table B.6.4 shows a list of the emission reduction results.

Table B.6.4 List of the emission reductions

Year	Baseline emission (ton- CO_2e)	Project emission (ton- CO_2e)	Leakage emission (ton-CO_2e)	Emission reduction (ton-CO_2e)
2011	48,372	19,349	0	29,023
2012	33,989	13,595	0	20,393
2013	24,242	9,697	0	14,545
2014	17,611	7,044	0	10,567
2015	12,284	4,913	0	7,370
2016	8,492	3,397	0	5,095
2017	5,743	2,297	0	3,446
2018	3,708	1,483	0	2,225
2019	2,165	866	0	1,299
2020	962	385	0	577
Total	157,568	63,027	0	94,541

B.7. Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

(Copy this table for each data and parameter)

Data / Parameter:	$FL_{s,i,c,q}$
Data unit:	$m^3/ m^2.s$
Description:	Flux of surface emissions in zone *i* in location *c* in season *q* at Normal Temperature and Pressure
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the surface emissions will be carried out according to VDI guideline 3790[10] or the UK guidance mentioned above
Monitoring frequency:	Periodic (in the middle of each season)
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged.

Data / Parameter:	$MC_{CH4,s,i,c,q}$
Data unit:	tCH_4/m^3
Description:	Monitored methane content from surface emissions during aeration in zone *i* in location *c* in season *q*
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the methane content will be carried out according to internationally recognized standards, using flame ionization detector, infrared sensors or similar
Monitoring frequency:	Periodic (in the middle of each season.
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged

Data / parameter:	$A_{v,k}$
Data unit:	m^2
Description:	Cross-sectional area of venting well *k*
Source of data:	Specification.
Measurement procedures (if any):	None.
Monitoring frequency:	Upon installation.
QA/QC procedures:	None.
Any comment:	-

[10] VDI guideline VDI 3790 "Emissions of gases, odours and dusts from diffuse sources", January 2005, <www.vdi.de>.

Data / Parameter:	T_s
Data unit:	°C
Description:	Temperature of the surface emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Periodic (in the middle of each season.
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged.

Data / Parameter:	P_s
Data unit:	Pa
Description:	Pressure of surface emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Periodic (in the middle of each season.
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	More frequent sampling is encouraged.

Data / Parameter:	$N_{v,k,q}$
Data unit:	$(m^3/m^2.s)$
Description:	Monitored flux from venting well *k* in season *q*
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the emissions will be carried out according to internationally recognized standards. The monitoring system should either comply with the VDI Guideline 3860 (Blatt 1 and 2)[11] or to any other national or international guidelines comparable, or to the provisions in this methodology (see option 2 in the section "*Procedure for monitoring of methane emissions*") It is recommended that measurement be made by an appropriate flow meter, at a depth more than three metres deep from the surface of landfill in order to avoid the effect of air turbulence.
Monitoring frequency:	Continuous
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	Also, guidelines other than VDI Guidelines are included to broaden applicability and ensure consistency with the text of the methodology, which like AM0083, allows to use any other comparable guidelines.

Data / Parameter:	$MC_{CH4,v,k,q}$
Data unit:	tCH_4/m^3
Description:	Monitored content of methane in venting well *k* in season *q*
Source of data:	Project participants
Measurement procedures (if any):	The measurements of the methane content will be carried out according to internationally recognized standards, using flame ionization detector, infrared sensors or similar
Monitoring frequency:	Continuous
QA/QC procedures:	Maintenance and calibration of equipment will be carried out according to internationally recognized standards. Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

[11] VDI Guideline 3860: Measurement of landfill gas - Measurements in the gas collection system (Blatt 1 and 2); February 2008; <www.vdi.de>.

Data / Parameter:	T_v
Data unit:	°C
Description:	Temperature of the vented exhaust emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

Data / Parameter:	P_v
Data unit:	Pa
Description:	Pressure of the vented exhaust emissions
Source of data:	Project participants
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4}. No separate monitoring of pressure is necessary when using flow meters thatautomatically measure temperature and pressure, expressing gaseous emissions volumes in normalized cubic meters
Monitoring frequency:	Continuous
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards Where laboratory work is outsourced, one which follows rigorous standards (ISO 9001 or local equivalent) shall be selected
Any comment:	-

Data / parameter:	*s*
Data unit:	Seconds.
Description:	Total duration of season *q*
Source of data:	-
Measurement procedures (if any):	Calendar or clock.
Monitoring frequency:	Seasonally.
QA/QC procedures:	None.
Any comment:	To be used for calculating $SG_{v,k,q}$

B.7.2. Description of the monitoring plan:

>>

The monitoring plan is as follows.

Step 1: Landfill gas emissions in the baseline through a "baseline campaign"

Since the landfill area encompasses 58,498 square metres, the number of sample plots will be 6 + 0.15 ×sqrt (58,498) = 42 points, according to the methodology. Thus, the sample size will considerably exceed 30, ensuring robust statistical analysis. To select 42 points, expected location of vent pipes are determined, and the grid surrounded by four vent pipes are numbered in an orderly manner, (e.g. 1, 2, … from a corner), and measurement points will be selected randomly. Since there will be about 54 grids (the top of landfill area is approximately 39,380 square metres), it is possible to establish a sample size which enables statistically robust calculation (see figure below).

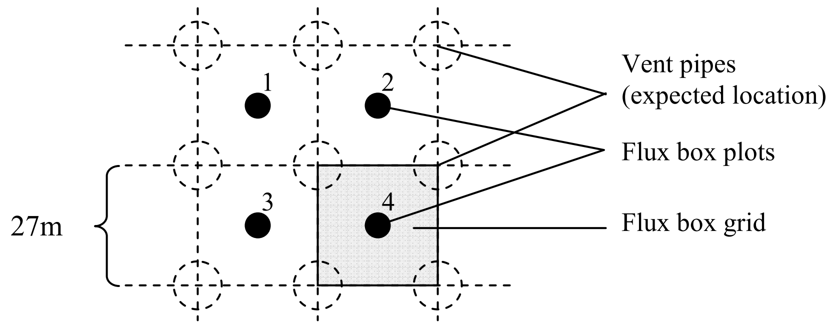

Fig 7.2-1. Schematic diagram of vent pipes and flux box plots during the baseline campaign

Step 2: Monitoring landfill gas flux during the crediting period

(1) Landfill gas from Vent well

There will be about 54 grids (the top of landfill area is approximately 39,000 square meters) in the landfill site. Then the project activity intends to install approx. 54 vent pipes. The landfill gas from vent wells will be monitored by using Option2 and Sub-Option2-1 in proposed methodology.

All vent wells will be monitored.

(2)Surface landfill gas

Surface landfill gas flux is obtained through the Flux Box method. The project activity intends to install approx. 54 vent pipes, which would probably mean that there would be about 50 – 80 grids to place flux boxes. Therefore, the landfill has enough locations to ensure that analysis of landfill gas flux is conducted.

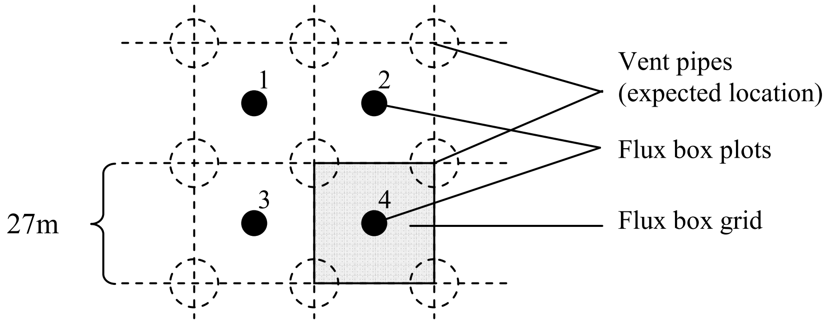

Fig 7.2-2 Schematic diagram of vent pipes and flux box plots during the crediting period

The number of grids where flux boxes are located will be decided upon detailed survey of the landfill. It is tentatively assumed that 42 plots will be sufficient to ensure robust statistical analysis. For this purpose, each grid will be numbered in an orderly manner (e.g. 1, 2, … from a corner), and grid assigned will be selected randomly.

Since the location is a tropical region where the only discernible variable is rainfall, the baseline campaign survey will select one representative day for dry season, one for rainy season. For each day, the survey should be conducted according to the specifications of the equipment during the period where wind conditions are ideal (this would be mornings).

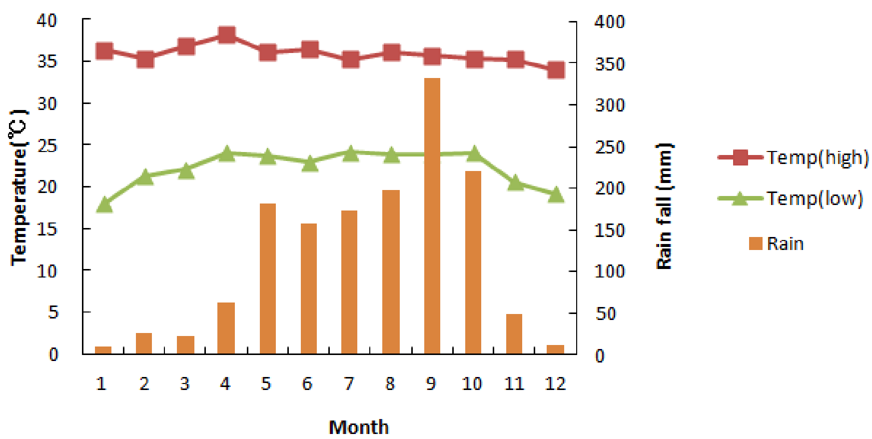

Fig.7.2-3 weather characteristics in Bangkok Thailand

B.8. Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies):

>>

Date of completion: Feb 24, 2010

Responsible persons and entities are the following:

Project developed by: Shuichi Ueno, Tokyu Construction Co., Ltd. (Project participant: for contact details, see Annex 1)

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

>>
Oct 1, 2010
The date of starting installation of the vent pipes shall be regarded as the date of starting the project activity.

C.1.2. Expected operational lifetime of the project activity:

>>
6 years.

C.2. Choice of the crediting period and related information:

For this project, a fixed, 10-year credit period is selected.

C.2.1. Renewable crediting period:

C.2.1.1. Starting date of the first crediting period:

>>
Not applicable

C.2.1.2. Length of the first crediting period:

>>
Not applicable

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
The starting date will be Jan1, 2011, or the date of project registration.

C.2.2.2. Length:

>>
6 years

SECTION D. Environmental impacts

>>

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>

(1) Present state of the site

This project is a plan to be implemented at Laemchabang landfill site, where the landfill operation is currently in progress. The operation of the landfill site is performed by filling the plain land, and the overall height of the landfill consisting of sub stages each measuring approximately 5m in height, reaches approximately 10m in total. Since the cover soil is added after each stage is filled, respective cover layers make an impermeable layer, and leakage of leachate from each sub stage is observed. In addition, since the landfill embankment is in an anaerobic condition inside, discharge of methane gas from the surface and generation of odour are observed.

(2) Environmental impact of the implementation of the project

1) Environmental impact of installation of the ventilation facility

The ventilation facility will be installed with the steel casing method as described earlier. In installing the ventilation facility, there may be environmental impacts such as the following. These factors are considered to be the same as the environmental impacts estimated when Laemchabang landfill site was constructed and started operation.

- Noise and vibration from the construction machinery, and noise and vibration from the construction vehicles
- Generation of dust during the installation work
- Impact of exhausts from the construction machinery and construction vehicles on the atmosphere
- Control of hazardous materials and wastes at the installation site

2) Estimated impact on the atmosphere after the installation of the ventilation facility

Since the landfill layer will be in an anaerobic condition inside immediately after the ventilation facility is installed, discharge of large amount of methane gas from the ventilation facility will occur. The level of this methane gas generation will be within the range of methane gas generated from an ordinary landfill, and the area transitioning from the anaerobic to semi-aerobic condition inside the landfill layer will expand as the time after the installation of the ventilation facility. Therefore, generation of methane gas and hydrogen sulphide will be suppressed.

3) Estimated impact on the water quality after the installation of the ventilation facility

There will be no adverse impact on the leachate discharged from the landfill layer through installation of the ventilation facility. Instead, the semi-aerobic area inside the landfill layer will expand and aerobic microorganisms will become more active to facilitate degradation of wastes. Therefore, the water quality of the leachate will be improved.

4) Estimated noise and vibrations after the installation of the ventilation facility

The ventilation facility will produce no noise or vibrations.

5) Other environmental impacts

Other factors of environmental impacts in addition to the above may include impacts on soil, landscape and ecosystem. However, since this project involves installation of only a ventilation facility on the existing landfill site, its impact on the landscape and the ecosystem will be minimum. In addition, since the ventilation facility will facilitate stabilization of the landfill site, it will enable the landfill site to be utilized early, thus even making a contribution to environmental improvement.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

As a result of inquiring Thailand Greenhouse Gas Management Organization (TGO) and the Ministry of Natural Resources and Environment of Thailand, it has been recognised that the project activity will improve the environment. Additionally, the project does not fall under projects for which environmental impact assessment defined by the nation should be performed.

SECTION E. Stakeholders' comments

>>

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

Comments were received through explanatory meetings for the stakeholders involved in the project. The explanatory meetings were conducted between October 2009 and January 2010 for the relevant parties.

(1) Thailand Greenhouse Gas Management Organization: TGO is accredited DNA in Thailand.
(2) Laemchabang Municipal Council: The city possesses Laemchabang landfill site
(3) Kasetsart University : It may be in charge of gas monitoring and analysing

E.2. Summary of the comments received:

>>

Oct 12, 2009 Thailand Greenhouse Gas Management Organization (TGO)
SirithanPairoj-Boriboon/E.Director

- TGO expects that the project will be beneficial in Thailand.
- Since there are many landfill sites in Thailand, we hope semi-aerobic systems will be widely deployed.

Oct 12, 2009 Kasetsart University
Dr.Chart Chiemchaisri/Associate Professor

- Confirming the possibility of analysis of landfill gas in the university. Analysing the gas will be completed in a week.

Oct 14, 2009 Laemchabang Municipal Council(LMC)
Apichet/Director of Environmental div. in Laemchabang Municipal
Sunparee/Manager of Environmental div. in Laemchabang Municipal

- LMC accepted to measure the Feasibility study in Laemchabang site.
- After FS is finished filing the PDD and summary of FS to LCM.
- For this site, certain company in EU proposed the electric generation by methane gas under the CDM. Want to compare both plans.

Oct 15, 2009 Ministry of Natural Resources and Environment(MNRE)
Patcharaporn / person in charge of Planing Div.

- This method of CDM will be welcome. There are many landfill site without covered by soil, many complaints are increasing recently.
- MNRE would like the project participant to improve the environment of surrounding by using the same method.

Jan 12, 2010 Laemchabang Municipal Council(LMC)
Jinda Thanomrod/Vice mayor

- LMC recognized that the CDM method will be suitable to improve the environment in this area.

Jan 13, 2010 Ministry of Natural Resources and Environment(MNRE)
Chanin / Dupty director of Planing Div.

- MNRE would like the project participant to apply the CDM method in order to improve the environment of landfill site because there are many waste landfill site without considering the water pollution.
- MNRE want to know the guideline of waste landfill in Japan for making the criteria of solid waste landfill in Thailand.

Jan 14, 2010 Kasetsart University
Dr.Chart Chiemchaisri/Associate Professor

- Confirming the possibility of BMP (biochemical methane potential test) in the university. It will be able to do the test after preparing the equipment.

E.3. Report on how due account was taken of any comments received:

>>

At the explanatory meetings for relevant parties of this project, we received no negative opinion about this project and it was favourably received. The Vice mayor of Laemchabang Municipal Council, where the project will be implemented, seems to put expectations on the project in order to improve the environmental problem.

On October 14, 2009, and January 12, 2010, we visited Laemchabang Municipal Council to provide explanations of the method, etc.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

This project is not granted with any public funding.

(This project has not been planned as an ODA project, and its financial resource is not diverted from ODA.)

Annex 3

BASELINE INFORMATION

[Data - 1] Issues related to laws and regulations

In Thailand, specified businesses (subject businesses) are required to perform environmental impact assessment (EIA) under the environmental order on environmental impact evaluation enforced in 1979. Even for businesses on which the obligatory EIA requirement cannot be imposed, various regulations in accordance with the Environmental Quality Act BE, 1992 may be imposed.

The Environmental Quality Act BE enforced in 1992 represents the law concerning pollution prevention, mitigation and restrictions as well as environmental improvement in Thailand. This act restricts discharge of wastes into the environment that violate the permission conditions, as indicated in Table D.1-1.

Table D.1-1 Industrial Effluent Standards

Parameters	Standard Values	Method for Examination
1. pH value	5.5-9.0	pH Meter
2. Total Dissolved Solids (TDS)	・ not more than 3,000 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 5,000 mg/l ・ not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea	Dry Evaporation 103-105 °C, 1 hour
3. Suspended solids (SS)	not more than 50 mg/l depending on receiving water or type of industry or wastewater treatment system under consideration of PCC but not exceed 150 mg/l	Glass Fiber Filter Disc
4. Temperature	not more than 40°C	Termometer during the sampling
5. Color and Odor	not objectionable	Not specified
6. Sulphide as H_2S	not more than 1.0 mg/l	Titrate
7. Cyanide as HCN	not more than 0.2 mg/l	Distillation and Pyridine Barbituric Acid Method
8. Fat, Oil & Grease (FOG)	not more than 5.0 mg/l depending of receiving water or type of industry under consideration of PCC but not exceed 15.0 mg/l	Sovent Extraction by Weight
9. Formaldehyde	not more than 1.0 mg/l	Spectrophotometry
10.Phenols	not more than 1.0 mg/l	Distillation and 4-Aminoantipyrine Method
11.Free Chlorine	not more than 1.0 mg/l	lodometric Method
12.Pesticides	not detectable	Gas-Chromatography
13.Biochemical Oxygen Demand (BOD)	not more than 20 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 60 mg/l	-Azide Modification at 20 °C , 5 days
14.Total Kjedahl Nitrogen (TKN)	not more than 100 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 200 mg/l	Kjeldahl
15.Chemical Oxygen Demand (COD)	not more than 120 mg/l depending on receiving water of type of industry under consideration of PCC but not exceed 400 mg/l	Potassium Dichromate Digestion
16.Heavy metals		
1. Zinc (Zn)	not more than 5.0 mg/l	Atomic Absorption Spectro Photometry; Direct Aspiration or Plasma Emission Spectroscopy ; Inductively Coupled Plama : ICP
2. Chromium (Hexavalent)	not more than 0.25 mg/l	
3. Chromium (Trivalent)	not more than 0.75 mg/l	
4. Copper (Cu)	not more than 2.0 mg/l	
5. Cadmium (Cd)	not more than 0.03 mg/l	
6. Barium (Ba)	not more than 1.0 mg/l	
7. Lead (Pb)	not more than 0.2 mg/l	
8. Nickel (Ni)	not more than 1.0 mg/l	
9. Manganese (Mn)	not more than 5.0 mg/l	
10. Arsenic (As)	not more than 0.25 mg/l	Atomic Absorption

		Spectrophotometry; Hydride Generation, or Plasma Emission Spectroscopy; Inductively Coupled Plasma : ICP
11. Selenium (Se)	not more than 0.02 mg/l	
12. Mercury (Hg)	not more than 0.005 mg/l	Atomic Absorption Cold Vapour Techique

【Data - 2】 Balance Calculation

List of balances

<Prerequisites>

			1	2	3	4	5	6	7	8	9	10	($t\text{-}CO_2$)
・Estimated CH_4 generation (in terms of CO_2)	86,993	$t\text{-}CO_2$/6years	29,023	20,393	14,545	10,567	7,370	5,095					86,993
・Collection period (Jan. 2011 to Dec. 2016)	6	years											
・Credit unit	1,800	YEN/$t\text{-}CO_2$											
・Fixed Assets	67,412	Thousand Yen	Area：58,000m^2(measured)										
・G&A Expenses	1,000	Thousand Yen	construction area for vent pipe：39,380m^2(measured)										
・Investment sum	68,412	Thousand Yen	number of vent pipes：39,380m^2/(27m×27m)=54pipes										

(Unit：Thousand Yen)

Items		Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Incomes			0	52,241	36,707	26,181	19,021	13,266	9,171	0	0	0	0	156,587
Project income (none)			0	0	0	0	0	0	0	0	0	0	0	0
・Credit income				**52,241**	**36,707**	**26,181**	**19,021**	**13,266**	**9,171**	**0**	**0**	**0**	**0**	156,587
			0											
Expenses														
・Kyoto Mechanism related			**0**	**1,518**	**1,018**	**684**	**497**	**346**	**239**	**0**	**0**	**0**	**0**	4,302
Inspection/accreditation of 1$=110YEN				474	284	160	116	81	56	0	0	0	0	1,170
2% of credit transfer procedure income			0	1,045	734	524	380	265	183	0	0	0	0	3,132
・Equipment investment			**67,412**											67,412
Material cost			17,531											17,531
Construction cost			36,913											36,913
Transportation cost			1,200											1,200
Surveillance cost			7,425											7,425
Temporary works			840											840
Other expensese			3,503											3,503
・Generation administratio (BT=3YEN)			**1,000**	**4,078**	**4,078**	**4,078**	**4,078**	**4,078**	**4,078**	**0**	**0**	**0**	**0**	25,468
														0
Personnel cost, administ	@BT20,000/mon	60,000		720	720	720	720	720	720					4,320
Fringe benefit	@BT2,000/mon×1person	6,000		72	72	72	72	72	72					432
Utilities cost	@BT1,000/mon	3,000		36	36	36	36	36	36					216
Commuting cost	@BT500/mon×1person	1,500		18	18	18	18	18	18					108
Telephone	@BT2,000/mon×1person	6,000		72	72	72	72	72	72					432
Office supplies	@BT2,000/mon	6,000		72	72	72	72	72	72					432
Land/house rents (office	@BT7,000/mon	21,000		252	252	252	252	252	252					1,512
Audit fee	@300,000YEN/y	300,000		300	300	300	300	300	300					1,800
Tax payment	@50,000YEN/y	50,000		50	50	50	50	50	50					300
Head office support cos	@2,400,000YEN/y	2,400,000		2,400	2,400	2,400	2,400	2,400	2,400					14,400
Other sundry expenses	@BT1,000/mon	3,000		36	36	36	36	36	36					216
Lawyer's fee	@50,000YEN/y	50,000		50	50	50	50	50	50					300
														0
・SPC establishment		1,000	1,000											1,000
・Facility administration cost			**0**	**1,060**	**1,060**	**1,060**	**1,060**	**1,060**	**1,060**	**0**	**0**	**0**	**0**	6,360
Maintenance cost	@BT7,000/mon	21,000		252	252	252	252	252	252					1,512
Monitoring cost	(measurement cost)	808,080		808	808	808	808	808	808					4,848
・Depreciation Cost			**▲ 67,412**	**11,235**	**11,235**	**11,235**	**11,235**	**11,235**	**11,235**	**0**	**0**	**0**	**0**	0
(transfer to fixed assets accounts)			▲ 67,412											▲ 67,412
depreciation				11,235	11,235	11,235	11,235	11,235	11,235					67,412
Total expenses			1,000	17,892	17,391	17,057	16,870	16,720	16,613	0	0	0	0	103,543
Operating profit			▲ 1,000	34,350	19,316	9,124	2,151	▲ 3,454	▲ 7,442	0	0	0	0	53,045
Other income or expense														0
・nonoperating income														
・nonoperating expense	Debt: 80mill Yen, interest(2.2%)	1,760,000		1,760	1,760	1,760	1,760	1,760	1,760					10,560
Profit before taxation			▲ 1,000	32,590	17,556	7,364	391	▲ 5,214	▲ 9,202	0	0	0	0	42,485
taxes	30% in Thailand	0.30	0	9,477	5,267	2,209	117	0	0	0	0	0	0	17,070
Profit (Current Year)			▲ 1,000	23,113	12,289	5,155	273	▲ 5,214	▲ 9,202	0	0	0	0	25,415
Profit (loss) carried forward			▲ 1,000	22,113	34,402	39,557	39,830	34,616	25,415	25,415	25,415	25,415	25,415	
IRR			▲ 68,412	34,348	23,525	16,390	11,509	6,022	2,033	0	0	0	0	15.38%

【Data - 3】 Calculation of GHG emission

(1) Components of wastes at Laemchabang landfill site

Ratios of waste contents (%)

Food waste	Paper/cardboard	Wood	Textiles	Rubber/leather	Plastic	Metal	Glass	Other
64	8	0.2	0.4		17		1	

(2) Baseline Emission (estimation from FOD model)

① Amount of Solid Waste Disposal in a year: 118,990 ton/year SWD: 326 ton/day

②	③	④		⑤	⑥		⑦	⑧	⑨	
φ	f	GWP		OX	Cf		F	DOCf	MCF	year (x)
0.9	0	CH_4	21	0	CH_4(=16/12)	1.333	0.5	0.5	1	1
		CO_2	1		CO_2(=44/12)	3.667				
				unit	Food	Paper/Cardboard	Wood	Textiles	Rubber/Leather	Total
⑩		Waste Composition		%	64	8	0.2	0.4	0	72.6
⑪		Dry matter content in % of wet weight		%	40	90	85	80	84	
⑫		Wwet	①×②×⑩	ton	68,538	8,567	214	428	0	77,748
⑬	Wx	(Wdry)	⑫×⑪	ton	27,415	7,711	182	343	0	35,651
⑭	DOCj			%	38	44	50	30	47	
⑮	Wx×DOCj		⑬×⑭	ton	10,418	3,393	91	103	0	14,004
⑯	kj				0.40	0.07	0.035	0.07	0.17	
GHG Emission			year	unit	Food	Paper/Cardboard	Wood	Textiles	Rubber/Leather	Total
⑰	$Wx \times DOCj \times e^{-kj(y-x)} \times (1-e^{-kj})$		1	ton	3,435	229	3	7	0	3,674
			2	ton	2,302	214	3	6	0	2,526
			3	ton	1,543	199	3	6	0	1,752
			4	ton	1,034	186	3	6	0	1,229
			5	ton	693	173	3	5	0	875
			6	ton	465	162	3	5	0	634
			7	ton	312	151	3	5	0	469
			8	ton	209	141	2	4	0	356
			9	ton	140	131	2	4	0	277
			10	ton	94	122	2	4	0	222
CH_4 Emission			year	unit	Food	Paper/Cardboard	Wood	Textiles	Rubber/Leather	Total
⑱	④×⑥×⑦×⑧×⑨×⑰		1	t-CO_2e	24,042	1,606	22	49	0	25,718
			2	t-CO_2e	16,116	1,497	21	45	0	17,679
			3	t-CO_2e	10,803	1,396	20	42	0	12,261
			4	t-CO_2e	7,241	1,301	20	39	0	8,602
			5	t-CO_2e	4,854	1,213	19	37	0	6,123
			6	t-CO_2e	3,254	1,131	18	34	0	4,438
			7	t-CO_2e	2,181	1,055	18	32	0	3,286
			8	t-CO_2e	1,462	984	17	30	0	2,493
			9	t-CO_2e	980	917	17	28	0	1,941
			10	t-CO_2e	657	855	16	26	0	1,554

(3) Result of estimation

Estimated by FOD model

t-CO_2e/y

Year	1	2	3	4	5	6	7	8	9	10
Emission	25,718	17,679	12,261	8,602	6,123	4,438	3,286	2,493	1,941	1,554

Amount of CH4 emission from year 2004 to year 2008 calculated by FOD model.

t-CO_2e/y

Year	2004	2005	2006	2007	2008	Total
Emission	6,123	8,602	12,261	17,679	25,718	70,383

R:Ratio between the actual methane measured and the methane estimated using the FOD model

①	FOD model	$MB_{bl\_campaign,ad}$		70,383	$t\text{-}CO_2/yr$
②	Measured	$ME_{CH4,bl\_campaign}$		43,589	$t\text{-}CO_2/yr$
③	R			0.619	=②/①

Baseline Emission

t-CO_2e/y

Year		Year(year of disposed waste) 2004	2005	2006	2007	2008	2009	2010	Total
2011	1	2,035	2,748	3,792	5,327	7,593	10,949	15,927	48,372
2012	2	1,544	2,035	2,748	3,792	5,327	7,593	10,949	33,989
2013	3	1,202	1,544	2,035	2,748	3,792	5,327	7,593	24,242
2014	4	962	1,202	1,544	2,035	2,748	3,792	5,327	17,611
2015	5		962	1,202	1,544	2,035	2,748	3,792	12,284
2016	6			962	1,202	1,544	2,035	2,748	8,492
2017	7				962	1,202	1,544	2,035	5,743
2018	8					962	1,202	1,544	3,708
2019	9						962	1,202	2,165
2020	10							962	962
Total		5,743	8,492	12,284	17,611	25,204	36,153	52,081	157,568

Project Emission

t-CO_2e/y

Year		Year(year of disposed waste) 2004	2005	2006	2007	2008	2009	2010	Total
2011	1	814	1,099	1,517	2,131	3,037	4,380	6,371	19,349
2012	2	617	814	1,099	1,517	2,131	3,037	4,380	13,595
2013	3	481	617	814	1,099	1,517	2,131	3,037	9,697
2014	4	385	481	617	814	1,099	1,517	2,131	7,044
2015	5		385	481	617	814	1,099	1,517	4,913
2016	6			385	481	617	814	1,099	3,397
2017	7				385	481	617	814	2,297
2018	8					385	481	617	1,483
2019	9						385	481	866
2020	10							385	385
Total		2,297	3,397	4,913	7,044	10,082	14,461	20,832	63,027

Emission Reduction

t-CO_2e/y

Year		Year(year of disposed waste) 2004	2005	2006	2007	2008	2009	2010	Total
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
Project periods (2011～2016)		3,446	5,095	7,370	9,989	13,824	19,467	27,802	86,993
Total		3,446	5,095	7,370	10,567	15,123	21,692	31,248	94,541

Annex 4

MONITORING INFORMATION

The following provides monitoring information for items of monitoring measurement.

・CH_4: Concentration of methane gas emitted from the landfill site, the gas vent pipes (ventilation pipes) and the landfill ground

1) For the emission from Ventilation wells

(1) Gas concentration

The methods for measuring the concentration of methane gas contained in the gases emitted from the landfill site include analysis with gas chromatography, using a concentration meter based on optical sensor and a concentration meter based on fixed sensor. The required performance of the concentration meter consists of a high diffusion rate and a high accuracy that sufficiently supports gas concentration change. In addition, since the purpose is to measure the concentration in the landfill site, the meter is also required to allow easy measurement, be sturdy and fuss-free in maintenance and inspection. The concentrations of CH_4 and CO_2 in the gas vent pipes are approximately 0 to 70%. Optical sensor based concentration meters would meet these requirements, and a dual-wavelength infrared methane gas concentration meter is the most appropriate type of concentration meter.

A dual-wavelength infrared-ray methane gas concentration meter can be easily calibrated. Its calibration can be performed with the gas for calibration whose methane concentration is zero.

The LFG concentration meter must preferably be capable of measuring concentrations of O_2, CO and H_2S gases in addition to CH_4 and CO_2 concentrations.

(2) Gas flow speed

The speed of GHG flowing inside the vent pipe is measured using a vane type anemometer or a hot-wire anemometer. Since both types of anemometers are widely used, there will be no problem using them in the site. The gas concentration inside the vent pipe is measured at a point approximately 3 m into the pipe from the top of the vent pipe in order to prevent the measurement from being affected by the outside air.

2) For the emission from surface

The concentration of methane gas emitted from the landfill ground may be only several ppm. Such a low concentration cannot be measured with the above dual-wavelength infrared methane gas concentration meter.

The concentration of methane gas on the landfill ground can be measured with Flux box method. Thailand has an organization capable of performing analysis for the captured gas by the Flux box.

APPENDIX 1 : Reference list of the PDD

1) Matsufuji etal; Generation of greenhouse effect gases from different landfill types, Engineering Geology, 34(1993) 181-187, 1993.March 30

2) Matsufuji etal; Generation of Greenhouse Effect Gases by Defferent Lanfill Types and Methane Gas Control,Proceedings of 7th ISWA International Congress and Exhibition,No.1,253-254,1996.10

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