PROJECT DESIGN DOCUMENT FORM
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)
Version 04.1

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	Bangkok Kamphaeng Saen East: Landfill Gas to Electricity Project
Version number of the PDD	16
Completion date of the PDD	13th January 2014
Project participant(s)	Bangkok Greenpower Co. Ltd (Host Country) Xentolar Holdings Limited (UK) Sindicatum Carbon Capital Ltd (UK)
Host Party(ies)	The Kingdom of Thailand
Sectoral scope and selected methodology(ies)	Sectoral Scope 13 – Waste Handling and Disposal
Estimated amount of annual average GHG emission reductions	100,538

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

Bangkok Kamphaeng Saen East: Landfill Gas to Electricity Project (hereinafter is referred as "The Project") will extract, capture and utilize landfill gas (LFG) to generate electricity. The LFG will be extracted and captured using Sindicatum Carbon Capital (ordered by Xentolar Holdings Limited, a project participant) proprietary LFG collection system and the electricity generated will be exported to the Thailand grid. Sources & gases included in the project boundary are methane emission from decomposition of waste at the landfill site, CO_2 from Thai grid emission factor and CO_2 from fossil fuel consumption.

The scenario existing prior to the start of the implementation of the project activity is atmospheric release of the landfill gas and existing and/or new grid connected power plants for the power generation. These scenarios are also the only remaining credible and plausible scenarios, and have been identified as the baseline scenario.

Under the project activity, a fully-integrated LFG collection system will be installed and operated. The extracted gas will be utilized to generate electricity. When the yield of gas is insufficient to supply to the generators, or surplus LFG due to engine maintenance or other site factors, LFG will be sent to an enclosed ground flare where the gas will be flared thus minimise methane emissions and maximising carbon abatement. A diesel generator may be used temporarily where there is no on-site electricity and no availability of electricity from the grid (e.g. during the connection of new engines to the grid).The emission reductions will be achieved by LFG utilization that otherwise would be released to the atmosphere and displacing fossil fuel power generation in the Thai grid. This is expected to achieve emission reduction of 703,770 tCO2 over the first 7 years crediting period.

The project activity will bring a number of benefits to sustainable development, explained as follows:

1. Environmental benefits:
   - The project will significantly improve local air quality; and
   - The project will create global benefits through reduced impact upon climate change.

The project activity will also ensure that correct management of the landfill is carried out as to optimise landfill gas recovery.

2. Social impacts:
   - Improved air quality, through the reduction of odours, will have a marked impact upon the quality of life for the neighbouring communities
   - The utilisation of a renewable source of energy to generate electricity will contribute to Thailand's sustainable development.
   - Collection of the landfill gas will improve the safety aspects of the landfill, reducing the dangers of combustion and explosion of methane pockets.
   - Moreover, benefit from an additional source of revenue from sales of electricity and sales of CER, will provide reserve funds to secure the future and the continued provision of sanitary waste disposal

3. Economic impacts:
   - An additional source of revenue (CER) will help to secure the future and the continued provision of sanitary waste disposal.

4. Technology transfer:

   The project will introduce new technology to the landfill management sector in Thailand, demonstrating how improved gas capture techniques can improve the capture of methane, resulting in more power generation. The project will utilise Sindicatum Carbon Capital proprietary LFG collection technology currently installed at similar landfill sites in China. The Project will be the first landfill to use this technology on a Thailand landfill and may be replicated for other landfill in Thailand. Transfer of know-how will be performed directly by training or indirectly through the visibility of the project and its interest as a successful local environmental initiative

A.2. Location of project activity

A.2.1. Host Party(ies)

The Kingdom of Thailand

A.2.2. Region/State/Province etc.

Province of Nakhon Pathom, District of Kamphaeng Saen

A.2.3. City/Town/Community etc.

City of Kamphaeng Saen

A.2.4. Physical/Geographical location

This landfill is located at T. Sasimhum, A. Kamphaeng Saen, Nakhon Pathom, 73140.
Its geographic coordinates are 14° 3'50.62"N 99°56'50.96"E

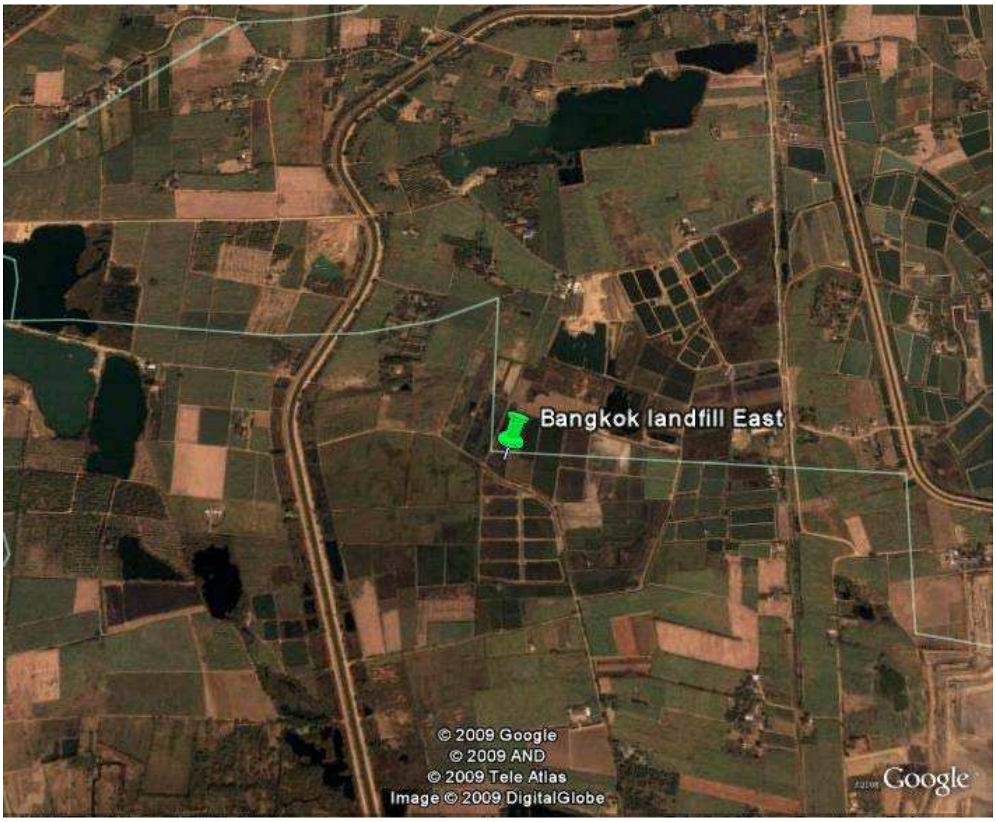

Figure 1 Project coordinate and location

A.3. Technologies and/or measures

As explained in the sustainable development aspect on technology transfer in section A1, the introduction of Sindicatum Carbon Capital proprietary LFG collection system (ordered by Xentolar Holdings Limited) to utilize LFG will directly transfer know-how of the project by training the local staff employed. Indirectly, it may bring new perspective in domestic waste handling in Thailand.

The scenario existing prior to the start of the implementation of the project activity is the atmospheric release of the landfill gas and existing and/or new grid connected power plants. Therefore, there is no list of equipments & systems in operation under this scenario. This existing scenario is also the only remaining credible and plausible scenario, and has been identified as the baseline scenario.

The scope of project activity as illustrated by figure 2, the project will extract, capture and utilize landfill gas (LFG) from Kamphaeng Saen East Landfill to generate electricity. The electricity generated will be exported to the Thailand grid. Whenever there is surplus LFG due to engine maintenance or other site factors, LFG will be sent to an enclosed ground flare where the gas will be flared thus minimise methane emissions and maximise carbon abatement.

The project activity will use Sindicatum Carbon Capital (SCC) state of the art proprietary LFG gas collection system that has been developed for Asian landfill sites. The design takes into account the different waste composition, climatic conditions and tipping practices of landfill sites in the Asian region when compared with more conventional systems and designs. The LFG system will form an integral part of the overall landfill operation and modifications will be made to the current tipping practice to enhance gas generation and recovery by improving surface water and leachate management. The performance of the LFG design will be continually assessed to ensure optimum LFG recovery, and where required modified to reflect actual site conditions and changes in waste composition and/or daily tipping rates.

Landfill gas collection system:

High density polyethylene (HDPE) horizontal collection pipes will be installed in the waste as an integral part of the tipping operation, these collection wells may be augmented by additional horizontal and vertical collection wells. The collection pipes will be connected via main carrier pipes to the LFG extraction plant and a negative pressure applied. The LFG, comprising approximately 50% methane and 50% carbon dioxide will be used for power generation with any surplus gas flared. SCC proprietary LFG system has been design to optimise LFG recovery and utilisation and optimise carbon abatement, and is designed to overcome inherent problems associated with LFG projects in similar conditions.

The recovered LFG will pass through the pre-treatment plant where moisture and particulates will be removed prior to the power generating engine. The specification of the pre treatment plant will be design to ensure that the gas quality reaching the engines is in line with the manufacture requirements. A schematic layout of the pre treatment and utilisation plant is shown in Figure 2 below. Power generation units will be installed in line with electrical infrastructure capacity and also to match the LFG recovery profile, as more LFG is generated additional engines will be added to the project, sufficient flare capacity will be installed to ensure that any surplus LFG is flared if engine capacity is insufficient or during periods of maintenance or breakdown . The interface control and system management will be designed to allow real time adjustment of system performance thus optimising gas utilisation and carbon abatement.

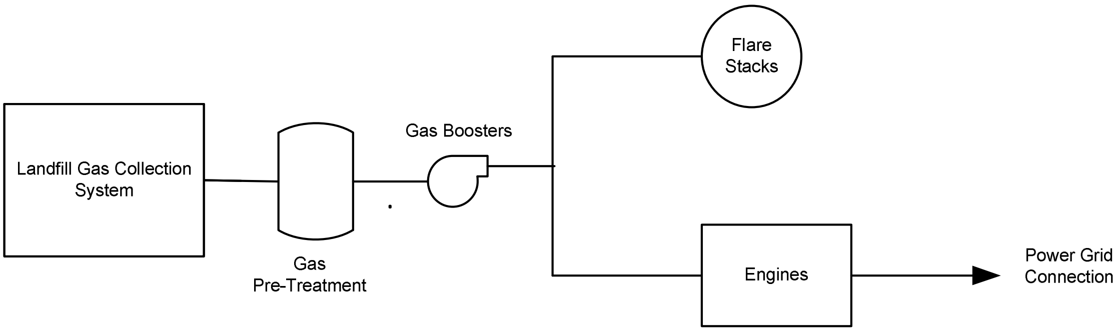

Figure 2 technical diagram of the project activity

LFG generator sets:

After the LFG has passed through the pre treatment plant the gas will be sent to spark ignition power generation units. The electricity produce will be distributed to the grid. For the *ex-ante* emission reduction calculation, it is assumed that all gas engine and generator sets have a capacity of 1.063 MW_e each.

The number of generator sets installed will vary during the life of the project depending on the quantity of gas available. The volume of gas is expected to increase during the first years of the project activity while waste tipping continues and it is expected that up to 15 generators can be installed if the expected increase in gas is confirmed, with a maximum capacity if 16MW feasible that can be exported with two grid connections. After waste tipping ceases, the quantity of gas available is expected to reduce, and generator sets may be decommissioned and sold.

The electrical power required for the operation of project equipment will normally be obtained from that generated on site. However, during periods when the generator sets are not operating (for example, during fault conditions or during planned maintenance) power to operate project equipment will be imported from the grid.

Flaring system

As described above there may be situations because of weather-induced variation in the gas flow rate or generator down-time where there is surplus LFG that can not be used for power generation, under these conditions the surplus gas will be destroyed by a ground flare. The design will allow real time interface between the engines and flares to optimise the destruction of LFG. Each flare considers the capacity to replace up to approximately 4 generator sets to flare the LFG in the case of troubleshooting & maintenance.

The flare installation used by this project meets all of the necessary conditions that are required by "Tool to determine project emissions from flaring gases containing methane" option a) for a default value of flare efficiency for enclosed flares with continuous monitoring of compliance with the flare manufacturer's specification. The flaring system will be equipped with a monitoring system to measure the flow, the pressure, methane concentration and the temperature in order to comply with the tool.

The flaring system employed is an enclosed flaring system. Below is summary of the technical specification of the system:

Table 1 Technical specification for the enclosed flare

Item	Data
Capacity (Nm^3/h)	3 x 2000
Flare temperature (°C)	500-1200
Methane combustion efficiency (%)	>98%

Diesel Generator

A diesel generator may be used temporarily where there is no on-site electricity and no availability of electricity from the grid (e.g. during the connection of new engines to the grid). Typically, the generator would be rented with a capacity of around 800kW. Assuming 5,000 litres per day of diesel fuel are consumed by the diesel generator at 100% load, the fuel consumption rate would be 206.7 litres per hour as specified in manufacturer's technical data.

The lifetime of all of the equipments is expected to meet or to exceed the period of maximum total crediting period (3 x 7 years).

The emission sources and green house gases (GHGs) involved in the project activity as illustrated in figure 2 are:

a) CH_4 emission from decomposition of waste at the landfill site
b) CO_2 emission from grid electricity consumption
c) CO_2 emission from fossil fuel consumption

A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
The Kingdom of Thailand (host)	Bangkok Greenpower Co., Ltd (Private entity)	No
UK (Annex 1)	Xentolar Holdings Limited (Private entity)	No
UK (Annex 1)	Sindicatum Carbon Capital Ltd (Private entity)	No

A.5. Public funding of project activity

There will be no public funding, under any form, for the proposed CDM project. The project will be exclusively supported by private capital.

SECTION B. Application of selected approved baseline and monitoring methodology

B.1. Reference of methodology

- ACM0001 “ Flaring or use of landfill gas ” Version 13.0.0

And following methodological tools:

- “Emissions from solid waste disposal sites” Version 06.0.1
- “Combined tool to identify the baseline scenario and demonstrate additionality” Version 05.0.0
- “Project emissions from flaring” Version 02.0.0
- “Tool to calculate the emission factor for an electricity system” Version 3.0.0
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” Version 01.
- “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” Version 02.0.0
- “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion” Version 02

Detailed information regarding these methodologies and tools please refer to UNFCCC methodology website.

B.2. Applicability of methodology

ACM0001 version 13.0.0 is applicable to landfill gas capture project activity as shown below:

Applicability criteria	**Project Status**
a) Install a new LFG capture system in a new or existing SWDS: or b) Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG provided that: i) The captured LFG was vented or flared and not used prior to the implementation of the project activity; and ii) In the case of an existing active LFG capture system for which the amount of LFG cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available. **c)** Flare the LFG and/or use the captured LFG in any (combination) of the following ways: **i)** Generating electricity **ii)** Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace; and/or **iii)** Supplying the LFG to consumers through a natural gas distribution network **d)** Do not reduce the amount of organic waste that would be recycled in the absence of the project activity	**a)** The project activity involves the installation of a new LFG capture system in an existing SWDS **b)** Not applicable **c)** The project activity flares the LFG and uses the captured LFG for generating electricity. The LFG is flared when there is insufficient gas for the engines or surplus gas due to engine maintenance or shutdown **d)** The project does not reduce the amount of organic waste that would be recycled in the absence of the project activity.
The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is: **a)** Release of LFG from the SWDS; and **b)** In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln: **i)** For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plants; and/or **ii)** For heat generation: that heat	The most plausible baseline scenario is: **a)** Release of LFG from the SWDS **b)** LFG is used in the project activity for generating electricity, in the absence of the project activity the electricity would have been generated in the Thai grid

would be generated compared to the situation prior to the implementation of the project activity	
The methodology is not applicable: **a)** In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at a kiln or glass melting furnace; **b)** If the management of the SWDS in the project activity is deliberately changed during the crediting in order to increase methane generation compared to the situation prior to implementation of the project activity	The methodology is applicable as: **a)** The methodology is not used in combination with other methodologies **b)** The management of the SWDS is not deliberately changed to increase methane generation. The project activity introduces a landfill gas extraction system as described in section A.3 which does not increase methane generation as compared to the baseline

B.3. Project boundary

Project boundary

The Project boundary includes the site where the landfill gas is captured, the generator sets, enclosed flare and auxiliary facilities that are located inside the project site. The electricity generated by this project will be delivered to the Thai Power Grid.

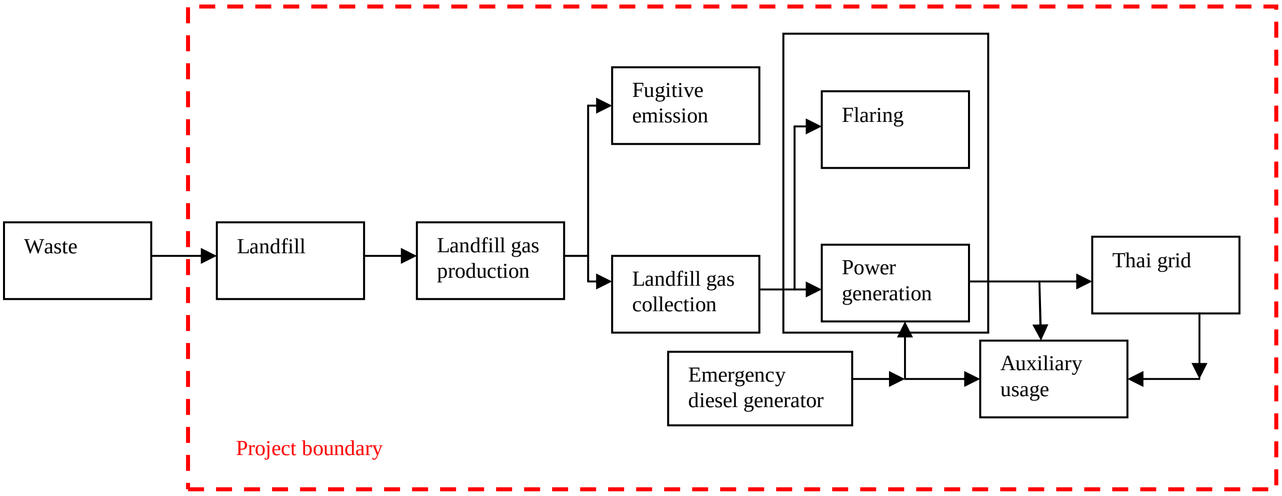

Figure 3 project boundary

The following project activities and emission sources are considered within the project boundary:

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Emissions from decomposition of waste at the SWDS site	CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted since the CO_2 is also released under the project activity.
		CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from landfills. This is conservative.
	Emissions from electricity generation	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from heat generation	CO_2	No	Thermal energy is not included in the project activity.
		CH_4	No	Thermal energy is not included in the project activity.
		N_2O	No	Thermal energy is not included in the project activity.
	Emissions from use of natural gas	CO_2	No	Natural gas is not used in the project activity
		CH_4	No	Natural gas is not used in the project activity
		N_2O	No	Natural gas is not used in the project activity
Project scenario	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CO_2	Yes	Consumption of fossil fuel during the period when there is no on-site generation and grid electricity (e.g. during the connection of new engines)
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from electricity consumption due to the project activity	CO_2	Yes	Consumption of grid electricity during periods when there is no on-site generation
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.

B.4. Establishment and description of baseline scenario

The baseline scenario has been identified using the “Combined tool to identify the baseline scenario and demonstrate additionality” version 05.0.0. and ACM0001 version 13.0.0. As the Gold Standard does not require for the additionality to be revised or re-validated in the case of Gold Standard projects using the retroactive registration option, the “Combined tool to identify the baseline scenario and demonstrate additionality” version 0.5.0.0 will only be applied in the baseline scenario section, and the additionality section remains unchanged. There will be no LFG used in equipment that was in operation prior to the implementation of the project activity, therefore the “Tool to determine the remaining lifetime of equipment” is not applied.

Step 0: Demonstration whether the proposed project activity is the first-of-its-kind

Although there were no other projects operational at the time of the development of this project activity that are similar to the proposed project activity, taking into account a broadly similar technology, similar scale and take place in a comparable environment with respect to regulatory framework and investment climate, the demonstration of first-of-its-kind is not used for the demonstration of additionality. Note that for Gold Standard retroactive projects there is no requirement to revisit the additionality.

Step 1: Identification of alternative scenarios.

Step1a.Define alternatives for baseline scenarios:

Applying Step 1 of the tool, the following baseline alternatives for the destruction of LFG shall be taken into consideration:

- LFG 1: The project activity implemented without being registered as a CDM project activity (i.e. capture and flaring or use of LFG);
- LFG 2: Atmospheric release of the LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, or to address safety and odor concerns;
- LFG3: LFG is partially not generated because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;
- LFG4: LFG is partially not generated because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;
- LFG5: LFG is partially not generated because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

LFG1 is not feasible without CDM, considering the barriers identified in the additionality section.

LFG2 corresponds to the continuation of the current situation. Currently, there are no regulations for controlled capture and destruction of LFG in Thailand. The license declared by Tung Bua Sub-district Administrative Organization, the local administrative in whose area the landfill is located, to the landfill operator does not regulate the LFG. Therefore, the release of the LFG directly into the atmosphere will continue in the foreseeable future.

LFG3-LFG5 are not considered because the Municipality has contracted the landfill operator to indiscriminately accept and tip the waste to be disposed in the SWDS. Under this current contract it is not possible to take the waste for recycling, aerobic treatment or incineration, nor are there facilities to be able to do so.

***(a)*For electricity generation, alternatives shall include:**

- E1. Electricity generated from LFG undertaken without being registered as CDM project activity;
- E2. Electricity generation in existing or new renewable or fossil fuel based captive power plant(s);
- E3. Electricity generation in existing and/or new grid-connected power plants

E1 is possible given local laws and legislation, however is not feasible without CDM given the barriers to its implementation as described in the barrier analysis.

E2 is possible given local laws and regulation; however it is not a feasible alternative given that there is no demand for a new captive power plant, there is no existing plant, and there is no other renewable resource available other than LFG.

E3 is a possible under local laws and regulation and can be considered as an alternative. This scenario represents the current situation.

(b) For heat generation, alternative(s) shall include:

- H1: Heat generation from LFG undertaken without being registered as CDM project activity;
- H2: Heat generation in existing or new fossil fuel fired cogeneration plant(s);
- H3: Heat generation in existing or new renewable based cogeneration plant(s);
- H4: Heat generation in existing or new fossil fuel based boiler(s), air heater(s), glass melting furnace(s) or kiln(s);
- H5: Heat generation in existing or new renewable energy based boiler(s), air heater(s), glass melting furnace(s) or kiln(s);
- H6: Any other source, such as district heat; and
- H7: Other heat generation technologies (e.g. heat pumps or solar energy)

H1-H7 are not considered feasible alternatives as there is no local heat demand.

(c) For the supply of LFG to a natural gas distribution network, the baseline is assumed to be the supply with natural gas.
This option is not considered as a feasible alternative as there is no local natural gas distribution network within the area of the project site.

Overall LFG1, LFG2, E1 and E3 are all possible alternative scenarios.

Step1b. Consistency with mandatory applicable laws and regulations:

The Thailand legislation governing operation of a landfill is the Public Health Act B.E.2535. It states that local administrative body has the authority to establish its own regulations regarding issuance of the license to operate the landfill. For the Bangkok East project, Tung Bua Sub-district Administrative Organization, the local administrative in whose area the landfill is located, currently has not set out any specific regulations relating to issuance of the license, including regulation or policy governing the release of LFG into the atmosphere.

In Thailand, national laws regulating electricity generation do not interfere with the construction of power plants, either producing electricity for internal use or providing power to the grid. National Energy Policy Council (NEPC) on 4th September 2006, prescribes the increasing quantity of power purchase from Very Small Power Producer for generating electricity of renewable energy and primary commercial energy in Cogeneration System[1] It will raise non-conventional renewable energy such as LFG utilization to produce electricity.

Hence alternatives LFG1, LFG2, E1 and E3 are in compliance with mandatory laws and regulations.

Step 2. Barrier analysis
The application of Step 2 of “Combined tool to identify the baseline scenario and demonstrate additionality” version 05.0.0 is described in Section B5, as are any subsequent steps. This analysis shows that scenarios LFG1 and E1, corresponding to the project without CDM revenue would be prevented by barriers relating to investment. The atmospheric release of LFG and refraining from activities at the electricity market do not require any further investment and therefore are not prevented by the same barriers described in Section B5. Therefore, baseline scenario of this project is determined as follows.

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[1] Provincial Electricity Authority, http://www.pea.co.th/vspp/vspp/Announce.pdf

Table 2 Baseline scenario

Scenario	Baseline		Description
	Landfill gas treatment	**Power generation**	
1	LFG 2 (Atmospheric release of the LFG)	E3 (grid supply)	The atmospheric release of LFG is the current practice in Kamphaeng Saen East Landfill. Electricity is obtained from the Thailand Grid.

Based on the analysis above, LFG2 (atmospheric release of the landfill gas) and E3 (existing and/or new grid connected power plants) are the only remaining

B.5. Demonstration of additionality

The demonstration of additionality is exactly the same as the registered CDM PDD (http://cdm.unfccc.int/filestorage/u/l/ZGIA96UO8PR45C0VM23NWFHXELDKJQ.pdf/The%20revised%20PDD_Bangkok_kamphaeng_saen_east_v09_02072012.pdf?t=UnJ8bW5qdnNmfDD0UnTow0zLg2vffC-0vwiF).

Carbon finance has been considered prior to the investment decision with revenues from CERs essential for the financial viability of the project. Below is the chronology of events leading up to the financial closure of the project.

Date	Description	Amount transacted	Evidence
Apr-08	Feasibility study done by Royal Haskoning		
Jun-08	Sindicatum began involvement.	Nil	
Jul-08	Closing to start 3 month due diligence	50 mil THB (refundable if project does not go ahead)	Security Deposit Agreement, Fee receipt for bank guarantee.
Aug-08	Due Diligence	Nil	
Sep-08	Due Diligence	Nil	
Oct-08	Due Diligence	Nil	
Nov-08	SCC Board Internal Approval - Conditional approval with conditions for renegotiations		
Dec-08	Commercial negotiations	Nil	
Jan-09	Commercial negotiations	Nil	
Feb-09	Commercial negotiations	Nil	
14 Mar 09	Submission for validation		
24 Mar 09	Loan agreed with payments for CERs	Confidential	Loan facility agreement & ERPA
30 Mar 09 Project Start Date)	Financial close of Bangkok East	THB 77,500,000	Bank transfer for Gas rights payment

Additionality is demonstrated using the CDM *Tool for the demonstration and assessment of additionally* version 05.2 and the *Guidelines for Objective Demonstration and Assessment of Barriers* version 01. The implementation of step 1 is described in section B.4 above. Step 2 (investment analysis), is not applied since step 3 (barrier analysis) shows a clear conclusion. Step 4 (common practice analysis) is described as the last sequence of the additionality test.

Step 3. Barrier Analysis

In line with the latest approved version of the "*Guidelines for Objective Demonstration and Assessment of Barriers"* (Version 01) published on the UNFCCC website, the following section provides information on the nature of the companies involved in the ownership and operation of the project and baseline scenarios, their organization, ownership and financial status (following Guideline 1 of the *Guidelines for Objective Demonstration and Assessment of Barriers,* Version 01). The text then proceeds to identify and describe an investment barrier (following Guideline 6 of the *Guidelines for Objective Demonstration and Assessment of Barriers,* Version 01) with relevance to scenario LFG1 (the project activity conducted without CDM) and concludes by showing how the CDM overcomes this investment barrier.

The following companies are involved in the ownership and operation of the project by virtue of their roles in the handling of the gas rights and CER rights as follows:

COMPANIES TO WHICH THE BARRIER APPLIES

Wasaduphan Turakit Co. Ltd ("Wasaduphan") owns the Kamphaeng Saen East Landfill. Wasaduphan's sole business is the collection and disposal of waste in modern sanitary landfills. Wasaduphan and an associated company, Group 79[2], have been managing disposal of Bangkok's waste at Kamphaeng Saen for over 20 years and possess a contract to do so placed by the Bangkok Municipal Authority (BMA) . Wasaduphan is privately owned by a Thai family and is organized around the ownership and operation of the Bangkok Kamphaeng Saen East Landfill site. Wasaduphan is not related to (ie it is not a parent or subsidiary of nor does it have any shareholders in common with) any of the other parties described herein.

Group 15 was formed by the descendants of the owners of Group 79 andWasaduphan as a separate independent and unrelated company with different shareholders. It was established as a means to commercialize various opportunities arising from the operation of the Kamphaeng Saen landfills – including all of the non-core business opportunities that arise from Group 79's activities. Group 15 is privately owned and it is not related to any of the other parties described herein.

COMPANIES INVOLVED TO ALLOW CDM TO OVERCOME THE BARRIER

GRT Ecosystems Company Ltd (GRTE) is a single-purpose company established to transfer the gas and CER rights from Group 15 to the companies listed below involved in building and operating a LFG to-energy project at the site. GRTE was established in March 2007. GRTE is privately owned, is operated as a single-purpose vehicle and is not related to any of the other parties described herein[3].

Bangkok Green Power Co. Ltd is a single-purpose company (the "Project Company") established to build and operate the LFG to-energy project. Bangkok Green Power Co Ltd is registered in Thailand and is a host country Project Participant. Bangkok Green Power will be the first company to receive gas and CER rights. Bangkok Green Power is owned 99.99% by Central Waste Water Developments Limited.

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[2] Note: Group 79 operates adjacent landfill that is being developed as another CDM project "Bangkok Kamphaeng Saen West Landfill site".

[3] Note: GRTE operates adjacent landfill that is being developed as another CDM project "Bangkok Kamphaeng Saen East Landfill site".

Central Waste Water developments Limited is a single purpose company established to own and capitalise Bangkok Green Power. Central is privately owned by individual shareholders and, other than its ownership of Bangkok Green Power, is not related to any of the parties described herein.

PS Natural Co Ltd are single-purpose company (the "Project Company" or together with Bangkok Green Power the "Project Companies") established to receive gas if there is more than sufficient gas for Bangkok Green Power. PS Natural Energy Co Ltd is registered in Thailand.
PS Natural Co Limited is privately owned and is not related to any of the other parties described herein. If sufficient gas is forthcoming it will be restructured with the addition of a new Parent to be the same as the structure of Bangkok Green Power and Central.

Progress Energy Company Ltd is a single purpose company established to own and capitalise Creative Energy Company. Progress Energy Company is registered in Thailand and is a host country Project Participant. Progress Energy Company is privately owned by individual shareholders and, other than its ownership of Creative Energy, is not related to any of the parties described herein.

Sindicatum Carbon Capital (SCC, www.carbon-capital.com) is a privately owned company registered in the UK. SCC is a principal developer of carbon projects. SCC has raised a co-investment fund to finance its project. To ensure the effective implementation of these projects, SCC also employs relevant technical expertise and has developed its own proprietary "OBC"© technology for the efficient collection of landfill gas.

International Sindicatum Climate Change Partnership (ISCCP) ((http://www.carbon-financeonline.com/index.cfm?section=lead&action=view&id=12542).
The ISCCP, which is registered in the Cayman Islands, is specifically formed to invest in projects which exploit the newly developing environmental markets, carbon and the CDM being the principle market at present. SCC is a 20% owner of the ISCCP. Information on the investment history of the fund, in the form of a monthly newsletter to the investors, is available to the DOE to show how much of the fund has been invested in CDM and carbon related projects to date. Most of this information may be corroborated from SCC's existing portfolio of CDM projects, either registered or under validation.
Xentolar Holdings Limited, which is registered in Cyprus, is a wholly owned subsidiary of ISCCP Investment Platform, Limited, which in turn is registered in the Cayman Islands.

Xentolar Holdings Ltd ("XHL") and SCC Ltd are non-host Project Participants.

Step 2a: Identify barriers that would prevent the implementation of the proposed CDM project activity

Investment Barriers

The development of the project activity described in the PDD requires a capital investment of USD 14.3m. This investment is required under LFG1, i.e. the project activity implemented without CDM is - with minor differences for monitoring efforts – the same amount to be invested in the CDM activity. Applying the project without CDM is from an initial perspective an option which is available for the operator of the landfill, Wasaduphan.

Audited financial statements for Wasaduphan in respect of the financial year 2007 (confidential documents provided to the DOE) show that Wasaduphan had insufficient assets to develop such a project. The audited accounts show income and expenditure consistent with the operation of the landfills, but insufficient income or assets to develop a Landfill Gas ("LFG") to-energy project directly. Furthermore, Wasaduphan would be unable to raise finance to facilitate such a project, as the land on which the landfill is constructed is the most significant asset of the company, and this is not available to be offered as security to raise further funds (confidential documents supporting this have been shown to the DOE).

Considering that the net assets of Wasaduphan are significantly below the total required funding for this project, and that Wasaduphan has no other assets that could be offered as security to raise funds it is clear that they lack sufficient capital to finance the investment in infrastructure and equipment required to construct the landfill gas to energy project described in this PDD. It therefore follows that they would need to source external, unsecured or non-recourse investment to develop this project.

Raising finance for such a project in Thailand is difficult due to several considerations:

1) In Thailand, there are no other projects that are operational and that are similar to the proposed project activity, taking into account a broadly similar technology, similar scale and that take place in a comparable environment with respect to regulatory framework and investment climate. The Journal of the Air and Waste Management Association vol. 58 (2008) page 634[4] states "However, LFG utilization in Thailand is currently at a very infant stage. Only one sanitary landfill where MSW from Bangkok is being deposited and is under the process of examining its gas recovery project". This is the Kasetsart University research project funded by King Rama IX Chaipattana Foundation. The foundation allocates 1 million baht to support the research project. A small number of other LFG projects are currently being developed under the CDM, including the Bionersis project at Kamphaeng Saen (which is now registered, project number 2514) and the Active Synergy Project, under Validation and also at Kamphaeng Saen.
2) There is a shortage of technology providers because there is no domestic market for such equipment
3) There is a shortage of experienced developers, staff and labour to design, build, operate and manage such a project

Under these circumstances, it is not possible for a company such as Wasaduphan, with no experience in LFG capture and power generation, to raise un-secured or non-recourse finance. Potential lenders would not be able to obtain the comfort they would require about the ability of the project to repay an investment, and would therefore not agree to provide financing. Consequently Wasaduphan's only option would be to partner with other organizations which have the necessary expertise and access to finance.

These facts are further supported by the Clean Technology Investment Plan presented by the Government of Thailand at the recent World Banks Clean Technology Fund Trust Fund Committee meeting in December 2009 available at http://siteresources.worldbank.org/INTCC/Resources/thailand_ctf_investment_plan_111209.pdf. In particular, paragraphs 47, 60 and 111 support the conclusions that the renewable energy sector in Thailand faces a number of barriers including finance, technology and know-how.

These facts are presented as objective evidence supporting the conclusion that an investment barrier is the predominant barrier stopping the development of landfill gas to energy projects in Thailand.

Sub-step 3b: Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)

The investment barrier identified above, would not prevent the alternative scenario, LFG2, which is the release of LFG to the atmosphere and refraining from activities at the electricity market. This scenario requires no new equipment, construction, or additional skilled staff for operation, has been implemented already (i.e. is the existing scenario) and consequently requires no investment.

Overcoming the investment barrier

The existence of this investment barrier and the role of CDM in overcoming this barrier are confirmed by:

1) Wasaduphan subcontracting the rights to this non-core business to Group 15; and,

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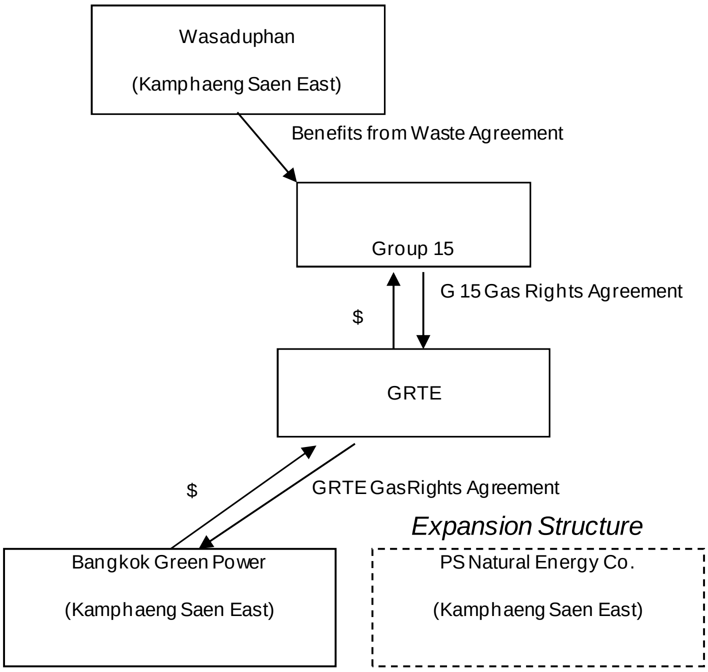
[4] Chiemchaisri, C and Chettiyappan, V: Greenhouse Gas Emission Potential of the Municipal Solid Waste Disposal Sites in Thailand, *J. Air & Waste Manage. Assoc.* **58**:629–635

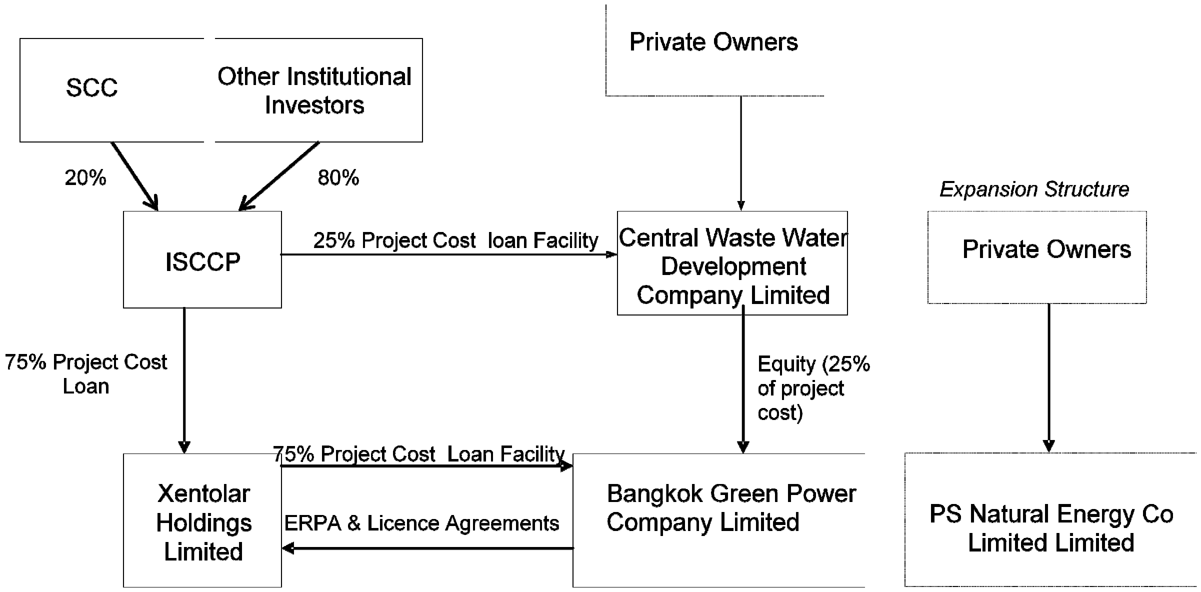
2) Group 15's selection of a partner to develop this project and
3) The financing structure which has been developed between the PPs to finance and implement this project activity.

The existence of the barrier required that a structure suitable for the provision of the necessary funds, and, expertise be developed, and also required that the rights necessary to collect and utilise the gas be adequately created and transferred to the Project Developer.

This resulted in the following Gas Rights and Financing structures between the parties identified above:



Chain of gas rights created to Overcome Investment Barrier



Ownership / financing Structure Created to Overcome The Investment Barrier

Group 15 received the Gas Rights from Group 79 who had no wish to involve itself in this non core business. Group 15 in turn, after seeking to identify a CDM developer themselves, contracted the Gas Rights to GRTE who had identified ISCCP as a potential CDM developer and assisted with the structuring of the investment using the Project Companies. All documents supporting the gas and CER rights have been provided to the DOE. The figure above explains the chain of gas rights.

ISCCP, through its wholly owned subsidiary XHL has loaned the project company (Bangkok Green Power Co. Ltd) 75% of the expected project costs (370 Million THB and €0.88 million). The remaining 25% of the project costs (€2.979 Million) have been loaned to the Parent Company (“Central Waste Water Development Company”) by ISCCP Investment Platform Ltd.

The loans were divided in this way because, as has been demonstrated in the Investment Barrier, funds for this project had to come from outside Thailand. To repatriate these funds the project required registration with the Board of Investment in Thailand to be able to receive repayments without the deduction of irrecoverable taxation in Thailand. Bangkok Green Power is therefore registered with the Board of Investment (and PS Natural would be). One of the requirements for such registration by the Board of Investment is that only 75% of Bangkok Green Power’s funding may be by way of Debt, hence the structure described above was required.

These loans are documented in the Bangkok Green Power Facility Agreement and Central Waste Water Development Company Facility Agreement respectively, were both signed on 24th March 2009, and are available to the DOE. If more gas becomes available, it will result in a additional loans being required to be made available to PS Natural Energy Co. Ltd and its (yet to be incorporated) parent.

ISCCP has experience in the design and implementation of LFG-to-energy projects. ISCCP employs SCC, which in turn employs experienced staff and has developed its own proprietary technology for the efficient collection of LFG.

Both loans are repaid by an ERPA (i.e. the loan is repaid through CERs) between XHL and Bangkok Green Power, a copy of which is available to the DOE. In the event of expansion, further loans will be repaid via an ERPA with PS Natural Energy.

Wasaduphan's core business is Waste Disposal so on 8th August 2008 it contracted the rights for any Gas to Group 15 for the purposes of securing a CDM developer. Group 15 in turn, after seeking to identify a CDM developer themselves, contracted the Gas Rights to GRTE who had identified ISCCP as a potential CDM developer and assisted with the structuring of the investment using the Project Companies. All documents supporting the gas and CER rights have been provided to the DOE. The figure above explains the chain of gas rights.

Conclusion

In conclusion, an investment barrier exists in the landfill gas to energy sector in Thailand, which would not prevent the baseline/alternative scenario but would prevent the development and implementation of the project activity without CDM. The financing of the project was assured only due to the benefit of the CDM. This is evidenced by the contractual structure, which relies on CDM for the project to occur and has been drawn up to enable:

a) The rights to gas and CERs to be passed from the original owner to the Project Companies;
b) the lender to lend money for the development of the project by the Project Companies; and
c) The Project Companies to repay the money from the proceeds of the sale of energy and CERs.

These contracts therefore demonstrate that the loan approval by the lender explicitly takes the CDM registration into account. Therefore, both Sub-steps 3a and 3b are satisfied, and the project activity required CDM to overcome the identified barrier.

Step 4. Common practice analysis

Sub-step 4a. Analyze other activities similar to the proposed project activity:

In Thailand, there are no other projects that are operational and that are similar to the proposed project activity, taking into account a broadly similar technology, similar scale and take place in a comparable environment with respect to regulatory framework and investment climate. The Journal of the Air and Waste Management vol. 58 page 634 states "However, LFG utilization in Thailand is currently at a very infant stage. Only one sanitary landfill where MSW from Bangkok is being deposited and is under the process of examining its gas recovery project"[5] which is the Kasetsart University research project funded by King Rama IX Chaipattana Foundation[6]. The foundation allocates 1 million baht to support the research project.

Sub-step 4b. Discuss any similar options that are occurring:

No similar privately financed activities are observed and being carried out in a comparable environment . The Kasetsart University research project to extract, capture and utilize the LFG is funded 1 million Bhat by King Rama IX Chaipattana Foundation. In conclusion similar projects can be developed only through the assistance of donor funding.

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The proposed project activity is therefore additional.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

Baseline scenario

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[5] Chiemchaisri, C and Chettiyappan, V: Greenhouse Gas Emission Potential of the Municipal Solid Waste Disposal Sites in Thailand, *J. Air & Waste Manage. Assoc.* **58**:629–635

[6] http://www.phtnet.org/news51/view-news.asp?nID=521 cited in http://www.thairath.co.th/news.php?section=agriculture&content=101801

According to methodology ACM0001 Version 13.0.0, baseline emissions in year y are calculated as follows:

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \tag{1}$$

Where:

BE_y = Baseline emission in year y(tCO_2e)

$BE_{CH4,y}$ = Baseline emission of methane from the SWDS in year *y* (tCO_2e/yr)

$BE_{EC,y}$ = Baseline emissions associated with electricity generation in year *y* (tCO_2e/yr)

$BE_{HG,y}$ = Baseline emissions associated with heat generation in year *y* (tCO_2e/yr)

$BE_{NG,y}$ = Baseline emissions associated with natural gas use in year *y* (tCO_2e/yr)

In this project there will be no heat generation or natural gas use from LFG therefore:

$$\boldsymbol{BE_{HG,y}} \textbf{ and } \boldsymbol{BE_{NG,}} \mathbf{= 0} \tag{2}$$

Step A: Baseline emissions of methane from the SWDS ($BE_{CH4,y}$)

Baseline emissions of methane from SWDS are determined as follows, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as due to regulations). In addition, the effect of methane oxidation that is present in the baseline and absent in the project is taken into account.

$$\mathbf{BE_{CH4,y} = (1-OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4}} \tag{3}$$

Where:

$BE_{CH4,y}$ = Baseline emissions of LFG from the SWDS in year (tCO_2e/yr)

OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)

$F_{CH4,PJ,y}$ = Amount of methane in the LFG that would be flared and/or used in the project activity in year ($tCH_{4/yr}$)

$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year (tCH_4/yr)

GWP_{CH4} = Global warming potential of CH_4 (tCO_2e/tCH_4). Note for the first commitment period this is 21 and for the second commitment period it is 25.

Step A.1: Ex post determination of $F_{CH4,PJ,y}$

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in power plant(s), boiler(s), air heater(s), glass melting furnace(s), kiln(s) and natural gas distribution network, as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y} \quad \textbf{\textit{(4)}}$$

Where:

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year (tCH_4/yr)

$F_{CH4,flared,y}$ = Amount of methane in the LFG which is destroyed by flaring in year (tCH_4/yr)

$F_{CH4,EL,y}$ = Amount of methane in the LFG which is used for electricity generation in year ($tCH_{4/yr}$)

$F_{CH4,HG,y}$ = Amount of methane in the LFG which is used for heat generation in year (tCH_4/yr)

$F_{CH4,NG,y}$ = Amount of methane in the LFG which is sent to the natural gas distribution network in year (tCH_4/yr)

As the project activity does not include heat generation from LFG or sent to the natural gas distribution network, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ = 0.

$F_{CH4,EL,y}$ is *determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous steam*" and the operational hours of the power plant., so that no emission reductions are claimed for methane destruction during non-working hours. This is taken into account by monitoring the hours that the equipment utilizing the LFG is operating in year ($Op_{j,h,y}$).

The following requirements apply:

- The gaseous stream tool shall be applied to the LFG delivery pipeline to each item of electricity. $F_{CH4,EL,y}$ is then calculated as the sum of mass flows of electricity generation equipment *j*;
- CH_4 is the greenhouse gas for which mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool);
- The mass flow should be calculated on an hourly basis for each hour *h* in year *y*;
- The mass flow calculated for hour *h* is 0 if the equipment is not working in hour *h* ($Op_{j,h}$ = not working), the hourly values are then summed to a yearly unit basis.

Applying Option A as the chosen measurement option, methane content will be measured on a wet basis and volumetric flow will be measured on a dry basis. If flow measurement on a dry basis is not doable for a wet gaseous stream, it is necessary to demonstrate that the gaseous stream is dry to use this option. This is done by either:

a) Measuring the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas: or
b) Demonstrate that the temperature of the gas stream (T_t) is less than 60°C (333.15 K) at the flow measurement point.

Option A being applied, the mass flow of methane will be determined as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad \textbf{\textit{(5)}}$$

With

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad \textbf{\textit{(6)}}$$

Where:

$F_{i,t}$ = Mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas/h)
$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$V_{i,t,db}$ = Volumetric fraction of greenhouse gas *i* in the gaseous stream in a time interval *t* on a dry basis (m^3 gas *i*/m^3 dry gas)
$\rho_{i,t}$ = Density of greenhouse gas *i* in the gaseous stream in time interval *t* (kg gas *i/m^3*gas *i*)
P_t = Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_i = Molecular mass of greenhouse gas *i* (kg/kmol)
R_u = Universal ideal gases constant (Pa.m^3/kmol.k)
T_t = Temperature of the gaseous stream in team interval *t* (K)

Amount of methane destroyed by flaring ($F_{CH4,flared,y}$)

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare(s) and any methane emissions from the flare(s), as follows:

$$F_{CH4,\ flared,\ y} = F_{CH4,\ sent\_flare,y} - PE_{flare,y}/GWP_{CH4} \qquad (7)$$

Where:

$F_{CH4,\ flared,\ y}$ = Amount of methane in the LFG which is destroyed by flaring in year (tCH_4/yr)
$F_{CH4,sent\_flare,y}$ = Amount of methane in the LFG which is sent to the flare in year (tCH_4/yr)
$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year (tCO_2e/yr)
GWP_{CH4} = Global warming potential of CH_4 (t CO_2e/t CH_4)

$F_{CH4,sent\_flare,y}$ is determined directly using the requirements stated earlier whereby the gaseous stream tool is applied to the LFG delivery pipeline to each flare. $F_{CH4,sent,flare,\ y}$ is then calculated as the sum of mass flows to each flare;

$PE_{flare,y}$ is calculated as per the methodological tool “Project emission from flaring”. As there are more than one flare then $PE_{flare,y}$ is the sum of the emissions for each flare determined separately. The following steps will be used as per the tool:

Step 1: Determination of the methane mass flow in the residual gas

The “Tool to determine the mass flow of a greenhouse gas in a gaseous stream “shall be used to determine the following parameter:

Parameter	**SI Unit**	**Description**
$F_{CH4,m}$	Kg	Mass flow of methane in the residual gaseous stream in the minute *m*

The following requirements apply:

- The gaseous stream tool shall be applied to the residual gas;
- The flow of the gaseous stream shall be measured continuously;
- CH_4 is the greenhouse gas *i* for which the mass flow should be determined;
- The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations3 and 17 in the tool): and
- The time interval *t* for which mass flow should be calculated is every minute *m*.

$F_{CH4,,m}$ which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$). $F_{CH4,RG,m}$ shall be determined on a dry basis.

Step 2: Determination of flare efficiency

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. For determining the efficiency of combustion of enclosed flares there is the option (Option A) to apply a default value to determine the efficiency based on monitored data.

In the case of enclosed flares as used in this project activity, and Option A: Apply a default value for flare efficiency is selected from the tool “Project emissions from flaring” (Version 02.0.0).

Option A: Default value

The flare efficiency for the minute *m* ($\eta_{flare,\ m}$) is 90% when the following two conditions are met to demonstrate that the flare is operating:

1) The temperature of the flare ($T_{EG,m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer’s specification for the flare ($SPEC_{flare}$) in minute *m* and
2) The flame is detected in minute *m* ($Flame_m$)

Otherwise $\eta_{flare,\ m}$ is 0%.

As the enclosed flares used in this project activity are low height, an additional conservative factor of 0.1 is applied to the efficiency. Therefore, if the flare efficiency is 90% as described above, the actual applied efficiency will be 80%.

Step 3: Calculation of project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions for each minute *m* in the year *y*, based on the methane mass flow in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare\,y} = GWP_{CH4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \times \left(1 - \eta_{flare\,m}\right) \times 10^{-3} \qquad \textbf{\textit{(8)}}$$

Where:

$PE_{flare,y}$ = Project emissions from flaring of the residual gas in year *y* (tCO_2e)

GWP_{CH4} = Global warming potential of methane valid for the commitment period (tCO_2e/tCH_4)

$F_{CH4,RG,m}$ = Mass flow of methane in the residual gas in the minute *m* (kg)

$\eta_{flare,m}$ = Flare efficiency in minute *m*

Step A.1.1: Ex ante estimate of $F_{CH4,PJ,y}$

An ex-ante estimate of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from SWDS (according to equation 3) in order to estimate the emission reductions of the proposed project activity in the PDD. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4} \qquad \textbf{\textit{(9)}}$$

Where:

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year (tCH_4/yr)

$BE_{CH4,SWDS,y}$ = Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year (tCO_2e/yr)

η_{PJ} = Efficiency of the LFG capture system that will be installed in the project activity.

GWP_{CH4} = Global warming potential of CH_4 (tCO_2e/tCH_4)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool “Emissions from solid waste disposal sites” (Application A). The following guidance should be taken into account when applying the tool:

- f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation 2 of the methodology v13.0.0 (or equation 3 in the PDD);
- In the tool, *x* begins with the year that the SWDS started receiving wastes (e.g. the first year of SWDS operation); and
- Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies

Following the tool, $BE_{CH4,SWDS,y}$ is calculated as:

$$BE_{CH4,SWDS,y} = \varphi_y \times GWP_{CH4} \times (1 - OX) \times \frac{16}{12} \times F \times DOC_{f,y} \times MCF_y \times \sum_{x=1}^{y} \sum_{j} W_{j,x} \times DOC_j \times e^{-k_j(y-x)} \times \left(1 - e^{-k_j}\right) \qquad \textit{(10)}$$

Where:

x = Years in the time period in which waste is disposed at the landfill, extending from the first year in the time period (*x*=1) to year *y* (*x*=*y*). X = 1 is year 2005

y = Year of the crediting period for which methane emissions are calculated (*y* is a consecutive period of 12 months)

φ_y = Model correction factor to account for model uncertainties for year *y*.

OX = Oxidation factor (reflecting the amount of methane from landfill that is oxidised in the soil or other material covering the waste

F = Fraction of methane in the landfill gas (volume fraction).

$DOC_{f,y}$ = Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction

MCF_y = Methane correction factor for year *y*

$W_{j,x}$ = Amount of solid waste type *j* disposed or prevented from disposal in the landfill in the year *x* (t).

DOC_j = Fraction of degradable organic carbon in the waste type *j* (weight fraction).

k_j = Decay rate for the waste type *j* (1/yr)

j = Type of residual waste or types of waste in the MSW

Note f_y (Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*) was not included in the equation as there is no methane capture in the baseline.

Step A.2: Determination of $F_{CH4,BL,y}$

In the project situation $\mathbf{F_{CH4,BL,y}}$ as there are currently no regulations or contractual requirements that mandate LFG collection and destruction at landfill sites in Thailand which follows Case 1 in Table 2 of the methodology ACM0001 version 13. As such $F_{CH4,BL,y}$=0.

Step B: Baseline emissions associated with electricity generation ($BE_{EC,y}$)

The baseline emissions associated with electricity generation in year *y* ($BEC_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" version 01. When applying the tool:

- The electricity sources *k* in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and
- $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year *y* ($EG_{PJ,y}$)

Following Scenario A (Electricity consumption from the grid) in the tool, $BE_{EC,y}$ is calculated as follows:

$$BE_{EC,y} = \sum_{k} EC_{BL,k,y} \times EF_{EL,k,y} \times (1 + TDL_{k,y}) \tag{11}$$

Where:

k = Sources of electricity consumption in the baseline

$EG_{PJ,y}$ = Quantity of electricity that would be consumed by the baseline electricity consumption source *k* in year *y* (tCO_2/MWh)

$TDL_{k,y}$ = Average technical transmission and distribution losses for providing electricity to source *k* in year *y*

Since the project will export the electricity generated to the Thai Grid, the grid emission factor is calculated as the combined margin emission factor using the procedures in the Tool to calculate the emission factor for an electricity system. Hence $EF_{EL,k,y} = EF_{grid,CM,y}$

Step C and D baseline emissions in ACM0001 version 13.0.0 are not applicable as there is no heat generation or natural gas use in the proposed project activity.

Project emissions

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \tag{12}$$

Where:

PE_y = Project emissions in year *y* (tCO_2/yr)

$PE_{EC,y}$ = Emission from consumption of electricity due to the project activity in year *y* (tCO_2/yr)

$PE_{FC,j,y}$ = Emission from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (tCO_2/yr)

Although $PE_{FC,j,y}$ does not normally need to be accounted for as there is no thermal generation by the project activity. In the case where fossil fuel is used in the project activity, CO_2 emission from fossil fuel combustion in process j are calculated based on the quantity of fuels combusted and the CO_2 emission coefficient of those fuels, $PE_{FC,j,y}$ is determined using the procedure described in Methodological " Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" Version 02, follows.

$$PE_{FC,j,y} \;=\; \Sigma_i\, FC_{i,j,y} \times COEF_{i,y} \tag{13}$$

Where:

$PE_{FC,j,y}$ = Are the CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr);

$FC_{i,j,y}$ = Is the quantity of fuel type i combusted in process *j* during the year *y* (mass or volume unit/yr);

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)

i = Are the fuel types combusted in process *j* during the year *y*

The CO_2 emission coefficient $COEF_{i,y}$ can be calculated using Option B of the tool “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion” Version 02 as follows:

Option B: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type *i*, as follows:

$$\mathbf{COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y}} \qquad \textbf{\textit{(14)}}$$

Where:

$COEF_{i,y}$ = Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)

$NCV_{i,y}$ = Is the weighted average net calorific value of the fuel type *i* in year *y* (GJ/mass or volume unit)

$EF_{CO2,i,y}$ = Is the weighted average CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)

i = Are the fuel types combusted in process *j* during the year *y*

Project emissions from consumption of electricity by the project activity ($PE_{EC,y}$) shall be calculated using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. When applying the tool:

- $EC_{PJ,j,y}$ in the tool is equivalent to the amount of electricity consumed by the project activity in year *y* ($EC_{PJ,y}$); and
- If in the baseline a proportion of LFG is destroyed ($F_{CH4,BL,y}>0$), then the electricity consumption in the tool ($EC_{PJ,j,y}$) should refer to the net quantity of electricity consumption (i.e. the increase due to the project activity). The determination of the amount of electricity consumed in the baseline shall be transparently documented in the CDM-PDD.

$$PE_{EC,y} = EC_{PJ,y} \times EF_{EL,j,y} \times \left(1 + TDL_{j,y}\right) \qquad \textbf{\textit{(15)}}$$

Where:

$EC_{PJ,y}$ = Electricity imported from the grid and used in the project in year *y* (MWh/yr)

$EF_{EL,j,y}$ = CO_2 emission factor of the Thailand Grid in year *y* (tCO_2e/MWh)

$TDLj,_y$ = Average technical transmission and distribution losses for providing electricity to the project in year *y* (fraction)

$EC_{PJ,y}$ is estimated by assuming that a power requirement equals to the parasitic losses when power is being generated is replaced by power imported from the grid for 65 days per year.

Leakage

No leakage effects need to be accounted under ACM0001 version 13.0.0.

Emission reduction

$$\boldsymbol{ER_y = BE_y - PE_y} \qquad \textbf{\textit{(16)}}$$

Where:

ER_y = Emission reductions in year *y* (tCO_2e/yr)

BE_y = Baseline emissions in year *y* (tCO_2e/yr)

PE_y = Project emissions in year *y* (tCO_2e/yr)

Ex-ante estimate of emission reductions is provided in section B.6.3 of this CDM-PDD.

B.6.2. Data and parameters fixed ex ante

Data/Parameter	GWP_{CH4}
Unit	$tCO2e/tCH_4$
Description	Global warming potential of CH_4
Source of data	IPCC
Value(s) applied	21 for first commitment period (up to Dec 31st, 2012), 25 for second commitment period starting January 1st, 2013
Choice of data or Measurement methods and procedures	As per ACM0001 version 13.0.0.
Additional comment:	Shall be updated according to any future COP/MOP decisions

Data/Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	ACM0001 ver 13.0.0 (technical literature)
Value(s) applied	50%
Choice of data or Measurement methods and procedures	Default value as per ACM0001 version 13.0.0.
Any comment:	Applicable to Step A.1.1 of the methodology

From the Tool "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" Version 01:

Data/Parameter	$EF_{grid,CM,y}$
Unit	tCO_2/MWh
Description	Combined margin emission factor for the grid in year *y*
Source of data	Calculate the combined margin emission factor, using the procedures in the Tool to calculate the emission factor for an electricity system version 03.0.0
Value(s) applied	0.5113 tCO_2/MWh
Choice of data or Measurement methods and procedures	As per the tool to calculate the emission factor for an electricity system version 03.0.0
Any comment:	Only applicable to scenarios A and C (cases C.I and C.III)

From the Tool for "Project emissions from flaring" Version 02.0.0:

Data/Parameter	$SPEC_{flare}$
Unit	Temperature - °C Flow rate or heat flux – kg/h or m^3/h
Description	Manufacturer's flare specifications for temperature and flow rate
Source of data	Flare manufacturer
Value(s) applied	**a)** Minimum/maximum temperature: 500-1200 °C **b)** Minimum/maximum flow rate: 300-2000 Nm^3/h
Choice of data or Measurement methods and procedures	As per Tool "Project emissions from flaring"
Any comment:	Only applicable for enclosed flares. The maintenance schedule is not required if Option A is selected to determine flare efficiency of an enclosed flare. Option A is selected for this project activity

From the Tool “Emissions from solid waste disposal sites” (Version 06.0.1)

Data/Parameter	$\Phi_{default}$
Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	Tool “Emissions from solid waste disposal sites” (Version 06.0.1)
Value(s) applied	0.75
Choice of data or Measurement methods and procedures	Default value for Application A in humid/wet conditions
Any comment:	

Data / Parameter	OX
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Tool “Emissions from solid waste disposal sites” based on an extensive review of published literature on this subject, including IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	As per Tool Emissions from solid waste disposal sites”
Any comment:	When methane passes through the top-layer, part of it is oxidized by methanotrophic bacteria to produce CO_2. The oxidation factor represents the proportion of methane that is oxidized to CO_2. This should distinguish from the methane correction factor (MCF) which is to account for the situation that ambient air might intrude into the SWDS and prevent methane from being formed in the upper layer

Data / Parameter	F
Unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	As per Tool “Emissions from solid waste disposal sites” Version 06.0.1
Any comment:	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

Data / Parameter	$DOC_{f,default}$
Unit	Weight fraction
Description	Default value for fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	As per Tool “Emissions from solid waste disposal sites” Version 06.0.1
Any comment:	This factor reflects the fact that some degradable organic carbon does not

	degrade, or degrades very slowly, in the SWDS. This default value is used for Application A of the Tool, which is applied to this project activity

Data / Parameter	$MCF_{default}$
Unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	1.0
Choice of data or Measurement methods and procedures	As per Tool "Emissions from solid waste disposal sites" Version 06.0.1, Kamphaeng Saen Bangkok landfill is an anaerobic managed solid waste disposal site and has controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and includes the following: (i) cover material; (ii) mechanical compacting; and (iii) levelling of the waste.
Any comment	MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS. In the case of a water table above the bottom of the SWDS, a larger portion of the SWDS is anaerobic and MCF shall be estimated according to equation (12) of the Tool

Data / Parameter	DOC_j
Unit	-
Description	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from volume 5, table 2.4 and 2.5)
Value(s) applied	For MSW, the following values for the different waste types *j* should be applied: **Table 4 Default values for DOC_j**

Waste type j	DOC_j (%wet waste)
Wood & wood product	43
Pulp, paper & cardboard (other than sludge)	40
Food, food waste, beverage & tobacco (other than sludge)	15
Textile	24
Garden, yard & park waste	20
Glass, plastic, metal, other inert waste	0

Choice of data or Measurement methods and procedures	As per Tool "Emissions from solid waste disposal site" Version 06.0.1
Any comment	The procedure for the ignition loss test is described in *BS EN 15169:2007 Characterisation of waste. Determination of loss on ignition in waste, sludge and sediments.* The percentages listed in Table 4 are based on a wet waste basis which are concentrations in the waste as it is delivered to the SWDS. The IPCC Guidelines also specify DOC values on a dry waste basis, which are the concentrations after complete removal of all moisture from the waste, which is not believed practical for this situation.

Data / Parameter	k_j
Unit	1/yr

<table>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from volume 5, table 3.3)</td></tr>
<tr><td>Value(s) applied</td><td>Applying the following default values for different waste types <i>j</i>
Table 5: Default values for the decay rate (k_j)
<table>
<tr><th colspan="2">Waste type j</th><th>Tropical (MAT>20^0C) Wet (MAP>1000mm)</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textile</td><td>0.07</td></tr>
<tr><td>Wood, wood product & straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden & park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewerage sludge, beverages & tobacco</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>As per Tool ”Emissions from solid waste disposal sites” Version 06.0.1</td></tr>
<tr><td>Any comment</td><td>Climatic condition reference: http://www.tmd.go.th/en/archive/rainfall.php</td></tr>
</table>

B.6.3. Ex ante calculation of emission reductions

This section provides an *ex-ante* estimate of emission reductions, using the calculation methods and values described in sections B.6.1 and B.6.2.

Step A: Baseline emissions of methane from landfill ($BE_{CH4,y}$)

$$BE_{CH4,y} = (1 - OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP_{CH4}$$

Year	$OX_{top\ layer}$	$F_{CH4,PJ,y}$	$F_{CH4,BL,y}$	GWP_{CH4}	$BE_{CH4,y}$
2012	0.1	7,179	0	21	135,692
2013	0.1	7,335	0	25	165,044
2014	0.1	5,794	0	25	130,360
2015	0.1	4,412	0	25	99,277
2016	0.1	3,427	0	25	77,101
2017	0.1	2,714	0	25	61,074
2018	0.1	2,192	0	25	49,320

Step A.1.1: Ex-ante estimation of $F_{CH4,PJ,y}$

$$F_{CH4,PJ,y} = \eta_{PJ} \times \frac{BE_{CH4,SWDS,y}}{GWP_{CH4}}$$

Year	η_{PJ}	$BE_{CH4,SWDS,y}$	GWP_{CH4}	$F_{CH4,PJ,y}$
2012	0.5	301,537	21	7,179
2013	0.5	366,764	25	7,335
2014	0.5	289,689	25	5,794
2015	0.5	220,615	25	4,412
2016	0.5	171,335	25	3,427
2017	0.5	135,719	25	2,714
2018	0.5	109,601	25	2,192

Step A.2: Determination of $F_{CH4,BJ,y}$

For the proposed project activity $F_{CH4,BJ,y}$ is zero.

Step B: Baseline emissions associated with electricity generation

$$BE_{EC,y} = \sum_{k} EG_{PJ,y} \times EF_{EL,k,y} \times \left(1 + TDL_{k,y}\right)$$

Year	$EG_{PJ,y}$	$EF_{EL,k,y}$	$TDL_{k,y}$	$BE_{EC,y}$
2012	35,385	0.5113	8.58%	19,645
2013	35,385	0.5113	8.58%	19,645
2014	21,813	0.5113	8.58%	12,110
2015	14,542	0.5113	8.58%	8,073
2016	14,542	0.5113	8.58%	8,073
2017	7,271	0.5113	8.58%	4,037
2018	7,271	0.5113	8.58%	4,037

Project Emissions

$$PE_{EC,y} = \sum_{k} EC_{PJ,y} \times EF_{EL,j,y} \times \left(1 + TDL_{j,y}\right)$$

Year	$EC_{PJ,y}$	$EF_{EL,j,y}$	$TDL_{j,y}$	$PE_{EC,y}$
2012	332	0.5113	8.58%	184
2013	332	0.5113	8.58%	184
2014	204	0.5113	8.58%	114
2015	136	0.5113	8.58%	76
2016	136	0.5113	8.58%	76
2017	68	0.5113	8.58%	38
2018	68	0.5113	8.58%	38

The project emissions from the consumption of fossil fuel are assumed to be 14 tCO_2e/year in 2012, 2013 and 2014 assuming 5,000 litres are consumed each day by the 800 kWe diesel generator during the COD. Diesel fuel consumption referenced as the manufacturer’s technical data, 206.7 litres per hour of diesel oil consumed at 100% load of generator.

B.6.4. Summary of ex ante estimates of emission reductions

Year	**Baseline emissions (t CO_2e)**	**Project emissions (t CO_2e)**	**Leakage (t CO_2e)**	**Emission reductions (t CO_2e)**
*2012	116,715	149	0	116,566
2013	184,689	198	0	184,492
2014	142,470	127	0	142,343
2015	107,350	76	0	107,274
2016	85,174	76	0	85,098
2017	65,110	38	0	65,072
2018	2,924	2	0	2,922**
Total	704,433	665	0	703,768
Total number of crediting years	7 Years			
Annual average over the crediting period	100,633	95	0	100,538

**N.B. Ex ante estimates of emission reductions in year 2012 is from 1 April 2012 to 31 December 2012.*
***N.B. Ex ante estimates of emission reductions in year 2018 are only include 1-20 January, 2018.*

A renewable crediting period (7 years x 3) is adopted by the Project. It is expected that the project activities will generate total emission reductions of 100,538 tCO_2e per year over the first 7-year crediting period from 1 April 2012 to 20 January 2018.

Note there is a significant difference between the estimated LFG collected, electricity generation and overall emission reductions in the CDM-PDD compared to this GS-PDD. This is because more conservative assumptions have been included in the GS-PDD which are all lower values such as a default collection efficiency of 50%, a maximum flare efficiency of 80%, lower transmission and distribution losses of 8.58% which applied from 2012 onwards, lower grid emission factor of 0.5113 tCO2/GJ, However, realistically these estimates are significantly different to the actual project operations where 8 engines are being utilized for electricity generation rather than 5 assumed by using the parameters above. Hence the ex-ante estimate in the GS-PDD is significantly underestimating actual emission reductions,

The baseline and project emissions study has been developed by Jay Mariyappan, Sindicatum Sustainable Resources. Email: jay.mariyappan@sindicatum.com Tel: +65 6732 8897

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

From ACM0001 version 13.0.0

Data / Parameter	**Management of SWDS**
Unit	n/a
Description	Management of the SWDS
Source of data	Use different sources of data • Original design of landfill • Technical specifications for the management of SWDS • Local or national regulations
Value(s) applied	n/a
Measurement methods and procedures	n/a
Monitoring frequency	Annually
QA/QC procedures	Original design of the landfill should be referred to in order to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity. Any change in the management of the landfill after the implementation of the project activity shall be justified by referring to technical or regulatory specifications
Purpose of data	Justification for any changes in the management of the SWDS as there would be an impact on baseline emissions
Additional comment	-

Data / Parameter	**$Op_{j,h}$**
Unit	-
Description	Operation of the equipment that consumes the LFG
Source of data	Project participants
Value(s) applied	-
Measurement methods and procedures	For each equipment unit *j* using the LFG, monitoring will be carried out for one or more of the following three parameters to ascertain that the plant is operating in hour *h*: • Temperature. Measure the temperature of the exhaust gas in the flare by appropriate temperature measure equipment. • Flame. Flame detection system is used to ensure that the equipment is in operation; • Products generated. Monitor the generation of electricity $Op_{j,h} = 0$ when: • One or more temperature measurements are missing or below the minimum threshold in hour *h* (instantaneous measurements are made at least every minute). • Flame is not detected continuously in hour *h* (instantaneous measurements are made at least every minute) • No electricity is generated in the hour *h*. Otherwise, $Op_{j,h}$=1 Measurements refer to individual parameters: Flare temperature ($T_{EG,m}$), Flame detection ($Flame_m$) and for electricity generated ($EG_{PJ,y}$)
Monitoring frequency	Hourly unless otherwise stated
QA/QC procedures	-
Purpose of data	If equipment is not working properly as stated above then then the baseline and project emission calculations may be affected
Additional comment	-

Data / Parameter	**$EG_{PJ,y}$**
Unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year y
Source of data	Electricity meter
Value(s) applied	-
Measurement methods and procedures	Net electricity generation by the project activity using LFG
Monitoring frequency	Continuously
QA/QC procedures	a) The electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings will be double checked by the distribution company via the backup meter.
Purpose of data	For baseline emission calculation
Additional comment	This parameter is required for calculating baseline emissions associated with electricity generation ($BE_{EC,y}$) using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”

Data / Parameter	**$EG_{EC,y}$**
Unit	MWh
Description	Amount of electricity consumed by the project activity in year y
Source of data	Electricity meter
Value(s) applied	-
Measurement methods and procedures	Total electricity imported
Monitoring frequency	Continuously
QA/QC procedures	The electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings will be double checked by the distribution company via the backup meter.
Purpose of data	For project emission calculation
Additional comment	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process ($PE_{EC,y}$) using the 'Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

From "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" version 02.0.0.

Data / Parameter	**$V_{t,db}$**
Unit	m^3dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Source of data	Project participants
Value(s) applied	-
Measurement methods and procedures	Volumetric flow measurement should always refer to the actual pressure and temperature. Calculated based on the wet basis flow measurement plus water concentration and measurement
Monitoring frequency	Continuously
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data	For baseline emission calculation
Additional comment	In the case where Option A of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" is applied

Data / Parameter	$V_{i,t,db}$
Unit	m3 gas i/m3 dry gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Source of data	Project participants
Value(s) applied	-
Measurement methods and procedures	Continuous gas analyser operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature
Monitoring frequency	Continuously
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Purpose of data	For baseline emission calculation
Additional comment	Demonstrate that the gaseous stream is dry to use Option A of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”. This is done by either: a) Measuring the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or b) Demonstrate that the temperature of the gas stream (T_t) is less than 60°C (333.15 K) at the flow measurement point. When Option A is applied, this parameter will be monitored

Data / Parameter	T_t
Unit	K/°C
Description	Temperature of the gaseous stream in time interval *t*
Source of data	Measured by temperature probe in LFG pipe work between the gas treatment package and the generator sets / flares.
Value(s) applied	
Measurement methods and procedures	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalised cubic meters (Nm3)
Monitoring frequency	Measured continuously to determine the density of CH_4 (D_{CH4}).
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency is according to manufacturer’s specifications
Purpose of data	For baseline and project emission calculation
Additional comment	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency). However, if the applicability condition related to the gaseous stream flow temperature being below 60°C is adopted, this parameter must be monitored continuously to assure the applicability condition is met

Data / Parameter	P_t
Unit	Pa
Description	Pressure of the gaseous stream in time interval *t*
Source of data	Transmitter mounted in the LFG pipe work between the gas treatment package and the generator sets / flares.
Value(s) applied	-
Measurement methods and procedures	No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalised cubic meters (Nm3).
Monitoring frequency	Measured continuously to determine the density of CH_4 (D_{CH4}).
QA/QC procedures	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly
Purpose of data	For baseline emission calculation
Additional comment	Provided all parameters are converted to normal conditions during the monitoring process, this parameter may not be needed except for moisture content determination and therefore it should be metered only when performing such measurements (with same frequency)

From methodological tool “Project emissions from flaring” version 02.0.0

Data / Parameter	**TEG_m**
Unit	°C
Description	Temperature in the exhaust gas of the enclosed flare in minute *m*
Source of data	Project participants
Value(s) applied	n/a
Measurement methods and procedures	Measure the temperature of the exhaust gas in the flare by an appropriate temperature measure equipment. Measurement outside the operational temperature specified by the manufacturer may indicate that the flare is not functioning correctly and may require maintenance. Flare manufacturers must provide suitable monitoring ports for the monitoring of the temperature of the flare. Where more than one temperature port is fitted to the flare, the flare manufacturer must provide written instructions detailing the conditions under which each location shall be used and the port most suitable for monitoring the operation of the flare according to manufacturers specifications for temperature
Monitoring frequency	Once per minute
QA/QC procedures	Temperature measurement equipment should be replaced or calibrated in accordance with their maintenance schedule
Purpose of data	For project emission calculation and baseline emission calculation
Additional comment	Unexpected changes such as a sudden increase/drop in temperature can occur for different reasons. These events should be noted in the site records along with any corrective action that was implemented to correct the issue. Monitoring of this parameter is applicable in case of enclosed flares.

	Measurements are required to determine if manufacturer's flare specifications for operating temperature are met

Data / Parameter	**$Flame_m$**
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute *m*
Source of data	Project participants
Value(s) applied	n/a
Measurement methods and procedures	Measure using a fixed installation optical flame detector. Ultra violet detector: Ultra Violet detector or Infra Red or both
Monitoring frequency	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off.
QA/QC procedures	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations
Purpose of data	For project emission calculation and baseline emission calculation
Additional comment	

Data / Parameter	**$Maintenance_y$**
Unit	Calendar dates
Description	Maintenance events completed in year *y*
Source of data	Project participants
Value(s) applied	-
Measurement methods and procedures	Record the date that maintenance events were completed in year *y*. Records of maintenance logs will include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers and calibration certificates.
Monitoring frequency	Annual frequency
QA/QC procedures	Records must be kept in a maintenance log for two years beyond the life of the flare
Purpose of data	For project emission calculation and baseline emission calculation
Additional comment	These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{flare}$)

$PE_{FC,j,y}$ (Project Emission from consumption of fossil fuel during the period when emergency or temporary) is determined using the procedure described in Methodological " Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" Version 02, The following parameters are required to monitor according to the tool.

Data / Parameter:	$FC_{i,j,y}$
Unit:	Mass or volume unit per year (e.g. ton/yr or m^3/yr)
Description:	Quantity of fuel type i combusted in process j during the year y. In an emergency situation, diesel oil may be used in the project activity as fuel type i.

Source of data	Onsite measurements by project participants
Value(s) applied	5,000 litres per day (once in 2012, 2013, and 2014)
Measurement methods and procedures to be applied:	Fuel is supplied from small daily tanks and rulers are used to determine mass or volume of the fuel consumed. The consumption is recorded in the record sheet on daily basis.
Monitoring frequency	Continuously
QA/QC procedures to be applied:	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Purpose of data	For project emission calculation
Any comment:	-

<table>
<tr><td>Data / Parameter:</td><td>$NCV_{i,y}$</td></tr>
<tr><td>Unit:</td><td>GJ per mass or volume unit (e.g. GJ/m^3, GJ/ton)</td></tr>
<tr><td>Description:</td><td>Weighted average net calorific value of fuel type i in year y. In an emergency situation, diesel oil may be used in the project activity as fuel type i.</td></tr>
<tr><td>Source of data</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><td>Data source</td><td>Conditions for using the data source</td></tr>
<tr><td>a) Values provided by the fuel supplier in invoice</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (Option A)</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If a) is not available
These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr>
<tr><td>d) IPCC default values at the upper limit of the uncertainly at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG inventories</td><td>If a) is not available</td></tr>
</table>
</td></tr>
<tr><td>Value(s) applied</td><td>0.03642 GJ/litre (Reference to Summary Report – the Study of Emission factor for an electricity generation of Thailand in Year 2010.</td></tr>
<tr><td>Measurement methods and procedures to be applied:</td><td>For a) and b): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Monitoring frequency:</td><td>For a) and b): The NCV should be obtained for each delivery, from which weighted average annual values should be calculated
For c): Review appropriateness of the values annually
For d): Any future revision of the IPCC Guidelines should be taken into</td></tr>
</table>

	account
QA/QC procedures to be applied:	Verify if the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standard
Purpose of data	For project emission calculation
Any comment:	Applicable where Option B is used

Data / Parameter:	$EF_{CO2,i,y}$
Unit:	tCO_2/GJ
Description:	Weighted average CO_2 emission factor of fuel type i in year *y*. In an emergency situation, diesel oil may be used in the project activity as fuel type i.
Source of data	The following data sources may be used if the relevant conditions apply:
Value(s) applied	0.07480 tCO_2/GJ Refer to 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 by Intergovernmental Panel on Climate Change.
Measurement methods and procedures to be applied:	For a) and b): Measurements should be undertaken in line with national or international fuel standards
Monitoring frequency:	For a) and b): The CO_2 emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For c): Review appropriateness of the values annually For d): Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures to be applied:	Applicable where option B is used. For a): If the fuel supplier does provide the NCV value and the CO_2 emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO_2 factor should be used. If another source for the CO_2 emission factor is used or no CO_2 emission factor is provided, Options b), c) or d) should be used.

Source of data (nested table):

Data source	Conditions for using the data source
a) Values provided by the fuel supplier in invoice	This is the preferred source
b) Measurements by the project participants	If a) is not available
c) Regional or national default values	If a) is not available
d) IPCC default values at the upper limit of the uncertainly at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG inventories	If a) is not available

Purpose of data	For project emission calculation
Any comment:	

From the Tool "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" Version 01:

Data / Parameter:	$TDL_{j,y}$ and $TDL_{k,y}$
Unit:	Dimensionless
Description:	Average technical transmission and distribution losses for providing electricity to source *j* or *k* in year *y*
Source of data	Use recent, accurate and reliable data available within the host country
Value(s) applied	For year 2005 – 2012 the actual TDL from published data will used for each year and from 2013 onwards, The latest figure of 8.58% will be applied for ex ante calculation in section B.6.3 as the following values:
Measurement methods and procedures to be applied:	The distribution losses can be calculated by the project participants or be based on references from utilities, network operators or other official documentation.
Monitoring frequency:	Annually
QA/QC procedures to be applied:	
Purpose of data	For project emission calculation
Any comment:	In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.

Year	**$TDL_{j,y}$ and $TDL_{k,y}$**
2005	10.84%
2006	10.72%
2007	9.37%
2008	9.11%
2009	9.42%
2010	9.61%
2011	9.29%
2012	8.58%
2013	8.58%
2014	8.58%
2015	8.58%
2016	8.58%
2017	8.58%

B.7.2. Sampling plan

There is no sampling plan used in this monitoring plan/project activity

B.7.3. Other elements of monitoring plan

A monitoring plan will be implemented to ensure that the approved monitoring methodology is correctly implemented in order to enable the accurate and transparent determination of avoided emissions. The plan will incorporate the QA/QC procedures described in B.7.1 above. Since the proposed project involves flaring and electricity generation, referring to ACM0001 version 13.0.0, the monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed in the flare(s) and the electricity generating unit(s) to determine the quantities as shown in Figure 5.

The schematic monitoring system is shown in Figure 5 below.

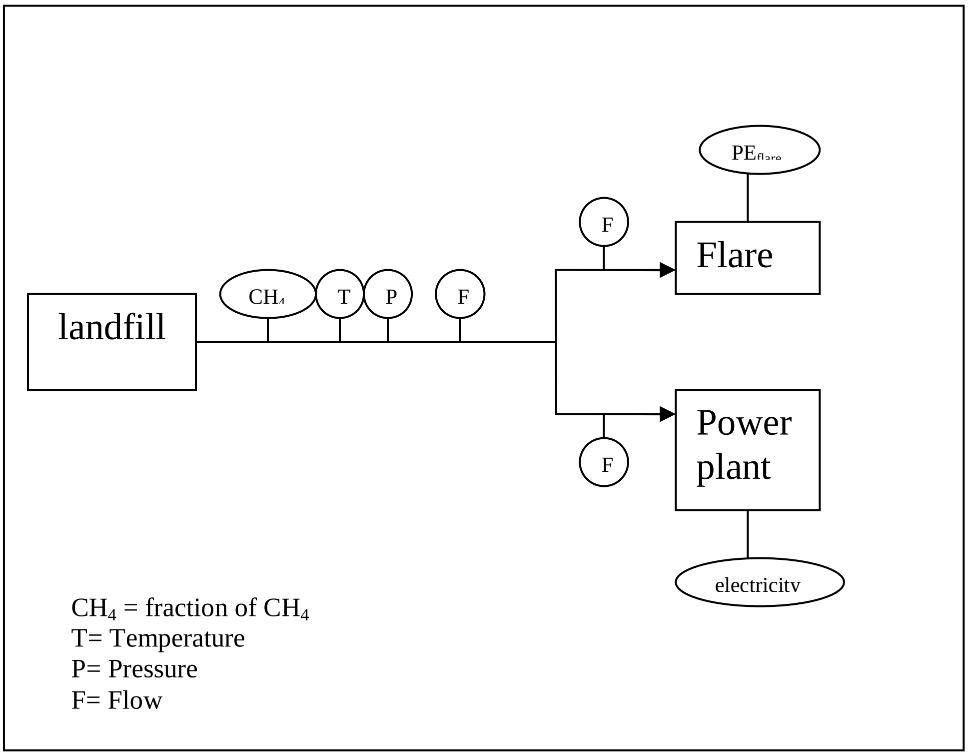


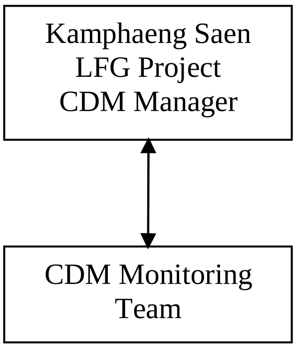
Figure 5 Schematic of monitoring system

Parameters to be monitored

The variables to be monitored were all listed and described in Section B.7.1.

Management structure for the implementation of monitoring plan

A specific CDM department will be established by the project owner and a CDM manager will be appointed to oversee that activities are carried out according to the monitoring plan. The organizational structure for the CDM department is shown below.



Responsibility and CDM management: A CDM manager will be appointed at the landfill with responsibility for monitoring all project related activities and organising training. Competency requirements for the all positions will be defined and applied.
All calculations will be checked and signed off by the CDM manager who will also be responsible for preparing and checking documents required for verification.

A CDM monitoring team (reporting to the CDM manager) will have day to day responsibilities for checking instrumentation, record keeping, data handling and data processing, filing, reporting, organising repair and maintenance of monitoring equipment and ensuring the monitoring plan is adhered to as indicated in the approved PDD. The monitoring staff will receive technical training and refresher training as well as safety training to minimise exposure to workplace hazards.
A management level link will be established to ensure effective co-operation between landfill staff and CDM monitoring staff.

All relevant information, notes of meetings, data files, maintenance records, defect reports, hard copy and computerised records of monitoring will be kept at a designated location and arranged in an orderly and transparent manner to facilitate audit as and when required.

Responsibilities, procedures, methods, equipment types and specifications are described in detail in a site-specific CDM monitoring manual.

Data collection and management

- On-line monitoring

All key meters required to determine GHG emissions and emission reductions will be monitored from a central control point which will record meter readings at a pre-determined interval as specified in the CDM monitoring manual. These data will be used to continually update total emission reductions as long as the generating plants are in operation.

- Manual data recording system

The CDM Manager will implement a manual data recording system to act as a back-up for the on-line monitoring system. This will involve completion of a log sheet that records flow meter readings. Spot readings of other values (methane concentration, temperature and pressure) will also be recorded periodically and at the times when flow meter readings are taken.

- Regulatory requirements related to landfill gas projects

Although the methodology only requires recording at the renewal of the crediting period, the information related to all relevant policies and circumstances will be collected and recorded annually. Information will be kept during crediting period and two years after.

- Data archiving

The on-line monitoring system will automatically and periodically (eg. weekly) archive data in a safe manner. Electronic documents will be saved for backup, with written documents and back-ups safely kept. Calibration data should be saved electronically. All information related to monitoring such as meeting minutes, data documents, maintenance records, accident reports, hard copies as well as computer records, should be kept in order at designated locations to ensure examination process transparent and highly effective. These data will be stored until 2 years after the end of the crediting period.

Maintenance and calibration of meters

All meters will be purchased and maintained as specified in the CDM monitoring manual according to manufacturer specifications. All key meters will be subject to a quality control regime that will include regular maintenance and calibration. Calibrations will be carried out by the manufacturer or a suitably qualified external company. A record will be maintained showing the location and unique identification number of each meter, the calibration status of that meter (when last calibrated, when next due for calibration) and who performs the calibration service. Calibration certificates will be retained for all meters until two years after the end of the crediting period.

Mass flow of methane supplied to the engines will be corroborated by comparison with the sum of the gross engine power outputs, the relationship being a function of engine efficiency which can be considered a constant under the proposed maintenance regime.

Treatment of missing or corrupted data

When data in the on-line system are corrupted or missing whilst the generators are operating (as shown, for example, by electricity output) the missing data can be estimated by taking the lower value of the parameter one hour before the error and one hour after the system restart. If there is evidence that neither of these values is representative, use the average value of the parameter from the previous 24 hours.

The error will be recorded in the log sheet and the occurrence of the error will be investigated and rectified as soon as possible. If the on-line system is compromised for more than 24 hours, data will be manually recorded. Manually recorded data table will be backup data for methane destruction amount and other key parameters. Any deficiencies in methane flow monitoring data will be rectified by calculation from power generation data.

Non essential data

The on-line monitoring system will also record “non-essential” data. Such data is termed non-essential because it is not directly listed in the CDM Monitoring Methodology, but it will constitute a means of corroborating the on-line system. Non-essential data may include measurements of net and gross output from individual generators, certificated conversion efficiency, waste deposition and any other data considered relevant to the project activity.

Document Control

The CDM Manager will implement a document control system that ensures that the current versions of necessary documents are available at the point of use.

Preparation of monitoring report

A monitoring report will be prepared by CDM department at periodic intervals (at least once per year). The monitoring report will serve as basis for verification by a DOE. The content of the monitoring report should include as minimum information concerning the project activity, monitoring data, calculation of emission reductions and records on maintenance and calibration of monitoring meters.

Audit function and management review

The CDM Manager will arrange for an independent internal audit of the management system periodically and at least once per year. The auditor will not be involved in the daily operation of the landfill and if necessary, may be sourced from a third party. The auditor will assess the implementation of the monitoring procedure and the preparation of the monitoring report. Audit findings, and steps taken to address findings will be recorded and reviewed in a Management Review meeting (convened at least annually) at which time the effectiveness of these procedures will be reviewed and necessary changes implemented.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

30/03/2009

C.1.2. Expected operational lifetime of project activity

21 years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

Renewable (3x7 years)

C.2.2. Start date of crediting period

1st April 2012

C.2.3. Length of crediting period

7 years

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The analysis of the project’s environmental impacts has been performed. Following the host country regulation, the Initial Environmental Examination (IEE) is required for the specific electricity project with the capacity less than 10 MW. The processes that have been performed to conduct IEE are as follows:

1. Investigation of the study area
2. Characterization of the environmental aspects.
3. Identification of the environmental principal change
4. Evaluation and prediction of short and long term impacts
5. Recommendation of short and long term mitigation measures

The project has been analyzed based on 13 (thirteen) aspects for both construction and operation phase, as follows

1. Topography/geology
2. Air quality
3. Noise
4. Hydrology
5. Water Quality
6. Aquatic Ecology
7. Terrestrial Ecology
8. Land Use
9. Transportation
10. Public Utilities
11. Socio-Economic
12. Public Health & Safety
13. Cultural, Heritage, Aesthetic and Tourism

There are no significant impacts identified for all the environmental aspects mentioned above. Low impact may occur from noise during the construction phase. At the working area where there is high level of noise source, such as at the genset house, health and safety equipment is strictly required to be used by operators. The impact on air quality is also considered insignificant but a monitoring program will confirm the compliance with the host country regulation on air quality[7]. To some extend, local workers will be hired and community development will be established in order to contribute positively on socioeconomic life of the local communities. Safety & Public Health regulation will be strictly applied to mitigate the low impact of construction stage.

D.2. Environmental impact assessment

No impacts are considered significant from the above analysis.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

A public consultation event was held on December 19th, 2008 at Sub district Administration Organization: Tungbua, Kampheang Sean district, close to the project site. The event was organized by Bangkok Green Power Co., Ltd; PS Natural Energy Co., Ltd and Xentolar Holdings Limited (SCC).

AIMS OF THE EVENT

To allow the stakeholders to express their concerns regarding the project.

Invitation process and compilation of comments.

The invitation was distributed by project participants. The invitation is distributed to all relevant stakeholders that were identified as representatives of the government, local officials, NGOs, academic institutions, members of the local community living in the project area and others. Public announcement in Thai was advertised in the local newspaper named Ban Muang Biweekly year 7 number 95 .

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There are 118 stakeholders who attended the consultation. Project participants described the project in a manner that allows the stakeholder to understand. A special animation of project description was presented for this purpose. During the event, the attendees were given the opportunity to raise their concern by filling up the questionnaire. Opportunity to raise their concern orally was given during question and answer session. In conjunction with the compilation of the oral comments, the result of questionnaire was also compiled. Both are available in section E.2 below.

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[7] Ministry of National Resources and Environment, Pollution Control Department
http://www.pcd.go.th/info_serv/en_reg_std_airsnd.html

Figure 3 stakeholder consultation event

E.2. Summary of comments received

During stakeholder consultation, detailed information about the project and its benefits were presented. The event provided a forum for all stakeholders to raise questions, concern and any other issues related to the project including sharing opinions. The landfill and brief of existing wastewater treatment, was presented by the project engineer. Xentolar Holdings Limited presented the CDM aspect of the project. The technology supplier presented the landfill collecting gas system and gas engine technology**.** The advantages and key features of the technology employed at Kampheang Saen to collect & utilize GHG to produce electricity were highlighted. The impact of the new technology to the community and global environment at large were also discussed.

The summary of the comment received is presented below:

- *How to solve the problem of rotten egg gas?*

This project can reduce the rotten egg gas because rotten egg gas is a part of landfill gas which will be utilized (burned) for the project. When the project burns landfill gas, it will be destroyed too.

- *How much of electricity does the project generate?*

Landfill was separated in two parts called west site and east site. The west and east site accept solid waste 2,000 tons/day and 3,000 tons/day. The project will generate less than 10 MW per site according to calculation and experience. The project was separate into 4 companies in order to join in the VSPP project (Very Small Power Producer). Each company will generate 8 MW but in the start time, it will generate 5 MW.

- *Has the project estimated the amount of methane from the landfill? Is this amount enough for the project?*

This project has estimated the amount of methane. In generating 1 MW, it will utilize 500 m3 at the concentration of 50-55% methane so the amount is enough for the project.

- *Where is the landfill that accepts solid waste 5,000 tons/day?*

The landfill is located in the entrance of Wat Paireunrom, Tungbua Sub district.

- *Where is the solid waste sent from?*

Bangkok, Kasetsart University (Kamphaeng Sean Campus) and Kamphaeng Sean District.

- *Has the methane of landfill been finished? How will the owner manage the power plant when the methane is finished?*

In the operating landfill, landfill always produces methane. Normally, the methane will be utilized around 3 months after waste is buried. If methane is not utilized, it will release to the atmosphere. The end time of the landfill gas will be faster. When the landfill gas is finished, the power plant will be move to the other sites.

- *What is the advantage and disadvantage from the project which is located in Tungbua Sub district?*

1. The project will give advantage to the locality because it will employ local people. Employment will bring about income to this area. It will form Community Department Fund. It will deduct from the selling electricity to this fund. For local tax, 10% deduction of tax that the companies pay will be returned to the local community.
2. Energy from the project is clean energy. It will decrease the construction of power plant that used fossil fuel.
3. The project will reduce the odor of the landfill because the landfill gas is utilized to generate electricity.
4. After the landfill gas is finished, the solid waste will be dug to make compost.
5. The project is not concerned in secondary pollutant (Dioxin) from burning fuel and coal.

- *Will the project make vibration, noise, heat wave and magnetic wave?*

In the operating time, it will set up a small office in the container. The officer will work in this area 24 hours. The small office will be designed as Department of Labor Standard. Moreover, the container is like a buffer to protect the heat and noise from the engine. If the heat releases, the painted color of the container will be swell. Anyway, noise at the distance 1 meter from the container is estimated at 45-50 dB, which is less than the roadside. For magnetic wave, the project will use general generator.

E.3. Report on consideration of comments received

Beside the direct oral comments as described above at section E2, questionnaires were distributed to all participants in the event. The summary is shown below.

Summary of the project	**Agree**	**Disagree**	**No vote**
Environmental impact (The project will not provide the environmental impact)	598	3	9
%	93.44%	5.16%	1.41%
Social and public health (The project will not provide the social and public health impact)	797	27	8
%	95.79%	3.25%	0.96 %

Overall	43	1	20
%	67.19%	1.56%	31.25%

From the result above, most of the participants understand that the project will have no negative impact on environment, social and public health.

SECTION F. Approval and authorization

A letter of approval has been issued by the Host party and the Annex 1 party

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Appendix 1: Contact information of project participants

Organization name	Bangkok Green Power Co., Ltd
Street/P.O. Box	105 Moo 11, Tambol Sa Si Mum
Building	
City	Amphur Kamphaengsan
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Fax	+ 66 34 352 476
E-mail	
Website	
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Salutation	Ms
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Middle name	
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Middle name	
First name	Jay
Department	
Mobile	
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Direct tel.	+65 67329767
Personal e-mail	jay.mariyappan@sindicatum.com

Appendix 2: Affirmation regarding public funding

There will be no public funding, under any form, for the proposed CDM project. It will be exclusively supported by private capital that is being raised from investment funds.

Appendix 3: Applicability of selected methodology

This section has been intentionally left blank as applicability of selected methodology is detailed in section B

Appendix 4: Further background information on ex ante calculation of emission reductions

Calculation for the emission factor of electricity generation ($EF_{EL,y}$)

The methodological "Tool to calculate the emission factor for an electricity system" version 03.0.0 is applied to determine the CO2 emission factor for replace of electricity generated by power plants in an electricity system, by calculating the “operating margin” (OM) and “build margin” (BM) as well as the “combined margin” (CM).

Therefore, we apply the baseline methodology procedure according to the tool:
STEP 1 Identify the relevant electricity systems
STEP 2 Choose whether to include off-grid power plants in the project electricity system (optional)
STEP 3 Select a method to determine the operating margin (OM)
STEP 4 Calculate the operating margin emission factor according to the selected method
STEP 5 Calculate the build margin (BM) emission factor
STEP 6 Calculate the combined margin (CM) emission factor

STEP 1 Identify the relevant electricity systems

In Thailand, the electricity transmission line system is considered as a single grid system due to the transmission lines are networked all of the country area.

Electricity Generating Authority of Thailand (EGAT) regulate electricity generation and main transmission system, meanwhile Metropolitan Electricity Authority (MEA) is responsible for electricity distribution system in Bangkok and vicinity area, and Provincial Electricity Authority (PEA) is responsible for electricity distribution system in the rest of country.

STEP 2 Choose whether to include off-grid power plants in the project electricity system (optional)

For calculating the operating margin and build margin emission factor two options are available:

Option I: Only grid power plants are included in the calculation

Option II: Both grid power plants and off-grid power plants are included in the calculation

For this project activity, Option I is applied and only grid power plants are included in the calculation which corresponds to the procedure in the earlier versions of the tool.

STEP 3 Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor (EFgrid,OM,y) is based on one of the following methods:

1. Simple OM, or
2. Simple adjusted OM, or
3. Dispatch data analysis OM, or
4. Average OM

According to Thailand's data, the Simple OM method (ex ante option) is the most appropriate method that requires the latest 3 years data including the quantity of electricity generation, fuel types and fuel consumption of each fuel type. In this study, used the electricity statistic data in the years 2008 – 2010 due to as the following:

1. In Thailand, the electricity data that generate and transmit to the national grid system are available. While, the off-grid electricity data are not available.
2. The low-cost/must-run (LC/MR) power plants include hydropower and renewable power plants. The quantity of electricity that was generated by LC/MR, constitute less than 50% of the total grid generation in average of the 5 most recent years (in the years 2006-2010). Therefore, LC/MR data are not included in the OM calculation.

The quantity of electricity was generated and transmitted to the national grid can be obtained from the Electricity Statistic Annual Report 2008 – 2010 that provided by EGAT.

The quantity of electricity generation data is categorized by electricity generation system, group of power producer (EGAT, IPP and SPP) and type of power plant (LC/MR and Non LC/MR) as shown in Table 1. And the data of type and quantity of fossil fuel consumption in electricity generation are categorized by type of power producer (EGAT, IPP and SPP) as shown in Table 3.

VSPP is the renewable power plant such as biogas, biomass, hydropower, wind power and solar power which install the capacity equal or less than 10 MW and is considered as LC/MR power plant. However, VSPP power plants are non-firm and can supply only a small quantity of electricity to the national grid compared to other power plants. In year 2010, the quantity of electricity was generated by VSPP power plants, was supplied to the distribution system of PEA was 1,155.10 GWh 3 (0.72% of the total electricity was generated in 2010).

Thus, this study does not include quantity of electricity that was generated and supplied by VSPP in the calculation. The total quantity of electricity was transmitted to the national grid (only Non LC/MR) in the years 2008 – 2010 was 424,913.67 GWh.

Table 1 Quantity of electricity generated and transmitted to the national grid

Generation System	Grid Generation (GWh)				
	EGAT	IPP	SPP	Total	%
2010					
Total	78,517.70	67,775.98	13,897.27	160,190.96	100.00
Non LC/MR	73,185.41	67,775.98	11,642.33	152,603.73	95.26
LC/MR[8]	5,332.30	0.00	2,254.94	7,587.23	4.74
Thermal	27,289.03	15,408.42	2,162.89	44,860.34	
Combined-Cycle	38,338.71	52,367.56	8,655.76	99,362.04	
Gas Turbine	276.30	0.00	823.67	1,099.97	

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[8] *LC/MR power plants include hydropower and renewable energy (including biomass, solar and geothermal power)*

Generation System	**Grid Generation (GWh)**				
	EGAT	**IPP**	**SPP**	**Total**	**%**
Diesel Engine	3.98	0.00	0.00	3.98	
Hydropower	5,325.20	0.00	23.64	5,348.84	
Renewable Energy	7.10	0.00	2,231.30	2,238.40	
Electricity Import	7,277.39	0.00	0.00	7,277.39	
2009					
Total	66,488.10	64,840.72	13,971.37	145,300.19	100.00
Non LC/MR	59,541.66	64,840.72	11,811.42	136,193.80	93.73
LC/MR	6,946.44	0.00	2,159.95	9,106.39	6.27
Thermal	23,463.69	12,388.03	2,225.63	38,077.35	
Combined-Cycle	33,164.46	52,452.69	8,752.19	94,369.35	
Gas Turbine	309.63	0.00	833.60	1,143.23	
Diesel Engine	1.44	0.00	0.00	1.44	
Hydropower	6,941.74	0.00	23.97	6,965.71	
Renewable Energy	4.70	0.00	2,135.98	2,140.68	
Electricity Import	2,602.43	0.00	0.00	2,602.43	
2008					
Total	63,719.02	67,420.14	14,092.83	145,232.00	100.00
Non LC/MR	56,791.19	67,420.14	11,904.81	136,116.14	93.72
LC/MR	6,927.83	0.00	2,188.03	9,115.86	6.28
Thermal	26,778.89	14,398.34	1,996.83	43,174.06	
Combined-Cycle	26,449.20	53,021.80	9,029.90	88,500.90	
Gas Turbine	659.33	0.00	878.07	1,537.41	
Diesel Engine	2.30	0.00	0.00	2.30	
Hydropower	6,926.02	0.00	28.77	6,954.79	
Renewable Energy	1.81	0.00	2,159.26	2,161.07	
Electricity Import	2,901.47	0.00	0.00	2,901.47	
2007					
Total	67,704.95	62,233.44	14,426.00	144,364.39	100.00
Non LC/MR	59,765.33	62,233.44	11,982.99	133,981.76	92.81
LC/MR	7,939.62	0.00	2,443.02	10,382.64	7.19
Thermal	30,265.00	17,453.59	2,168.76	49,887.35	
Combined-Cycle	24,124.09	44,779.85	8,935.60	77,839.54	
Gas Turbine	884.20	0.00	878.63	1,762.83	
Diesel Engine	1.17	0.00	0.00	1.17	
Hydropower	7,937.20	0.00	21.70	7,958.90	
Renewable Energy	2.42	0.00	2,421.32	2,423.73	
Electricity Import	4,490.87	0.00	0.00	4,490.87	
2006					
Total	70,409.11	55,360.65	13,652.19	139,421.94	100.00
Non LC/MR	62,480.23	55,360.65	11,619.95	129,460.82	92.86
LC/MR	7,928.88	0.00	2,032.23	9,961.12	7.14
Thermal	31,685.00	14,299.43	2,319.08	48,303.51	
Combined-Cycle	24,560.84	41,061.21	8,370.38	73,992.43	
Gas Turbine	1,069.67	0.00	930.50	2,000.16	
Diesel Engine	1.20	0.00	0.00	1.20	
Hydropower	7,926.59	0.00	44.79	7,971.38	
Renewable Energy	2.29	0.00	1,987.44	1,989.74	
Electricity Import	5,163.53	0.00	0.00	5,163.53	
Average 5 most recent years for which data is available					**6.32**

Sources: Electricity Statistic Annual Report 2006 – 2010, Electricity Generating Authority of Thailand.

Low-cost/must-run resources represent only 6.32% of total grid emission in Thailand; hence the simple OM method can be applied.

The simple OM method option B (Ex ante option) is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emission factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average (2008 - 2010), based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emission factor during the crediting period.

STEP 4 Calculate the operating margin emission factor according to the selected method

The simple OM emission factor is calculated as the generation-weighted average CO2 emissions per unit net electricity generation (tCO2/MWh) of all generating power plants serving the system, not including low-cost / must-run power plants / units. It will be calculated according to Option B, i.e. based on the net electricity generation of all power plants serving the system and the fuel types and CO2 emission factor of each power unit. As fuel consumption data for each power plant in Thailand is not available, Option B (Ex ante option) is selected. Hence, the simple OM emission factor is calculated as follows step below:

If The simple OM method Option B (Ex ante option) is chosen, $EF_{grid,OMsimple,y}$ is determined as the formula below:

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_y} \tag{1}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO2 emission factor in year y (t CO2/MWh)

$FC_{i,y}$ = Amount of fuel type i consumed in the project electricity system in year y (mass or volume unit)

$NCV_{i,y}$ = Net calorific value (energy content) of fuel type i in year y (GJ/mass or volume unit)

$EF_{CO2,i,y}$ = CO2 emission factor of fuel type i in year y (t CO2/GJ)

EG_y = Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must-run power plants/units, in year y (MWh)

i = All fuel types combusted in power sources in the project electricity system in year y

y = The relevant year as per the data vintage chosen in Step 3

The following fuel consumption and Net Calorific Value data is taken from Electricity Power in Thailand Annual Report 2010 by DEDE Department Ministry of Energy, Thailand, Available on website: http://www.dede.go.th

Data available for carbon emission factor of fossil fuel type $EF_{CO2,i,y}$: 2006 IPCC Guidelines for National Greenhouse Gas Inventories lower limit values:

Table 2 Net Calorific Value and CO_2 emission per unit of each type of fossil fuel

Fuel type	Unit	NCV (MJ/Unit)	CO_2 Emission (tCO2/TJ)	CO_2 Emission (kgCO2/Unit)
Natural Gas	scf	1.02	54.30	0.0554
Lignite	ton	10470	90.90	951.7230
Bituminous	ton	26,370.00	89.50	2,360.1150
Bunker	liter	39.77	75.50	3.0026
Diesel	liter	36.42	72.60	2.6441

Table 3 Amount of fossil fuel consumed by power plants

Fuel type	unit	fuel Consumption			
		EGAT	IPP	SPP	Total
2010					
Natural Gas	scf	430,662,249,446	491,131,955,423	151,290,468,150	1,073,084,673,019
Lignite	ton	16,043,174	-	-	16,043,174
Bituminous	ton	-	3,646,898	1,855,262	5,502,160
Bunker	liter	140,084,467	87,347,782	5,797,497	233,229,746
Diesel	liter	11,865,427	10,853,795	1,307,336	24,026,558
2009					
Natural Gas	scf	369,146,214,392	459,228,417,361	140,550,086,056	968,924,717,809
Lignite	ton	15,818,265	-	-	15,818,265
Bituminous	ton	-	3,645,721	1,840,527	5,486,248
Bunker	liter	111,039,065	38,180,874	8,797,506	158,017,445
Diesel	liter	12,140,891	-	1,685,046	13,825,937
2008					
Natural Gas	scf	340,739,529,461	490,866,999,785	145,410,364,035	977,016,893,281
Lignite	ton	16,407,465	-	-	16,407,465
Bituminous	ton	-	3,711,791	1,866,776	5,578,567
Bunker	liter	247,441,682	93,212,260	9,555,452	350,209,394
Diesel	liter	6,792,039	43,698,832	1,451,087	51,941,958

Sources: Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

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Table 4 Quantity of CO_2 emission was emitted from electricity generation in the years 2008 - 2010

Fuel type	Fuel Consumption		CO_2 Emission ($kgCO_2$/Unit)	CO_2 Emission ($kgCO_2$)
	Unit	volume		
2010				
Total				88,452,088
Natural Gas	scf	1,073,084,673,019	0.055386	59,433,868
Lignite	ton	16,043,174	951.7230	15,268,658
Bituminous	ton	5,502,160	2360.1150	12,985,730
Bunker	liter	233,229,746	3.002635	700,304
Diesel	liter	24,026,558	2.644092	63,528

2009				
Total				82,178,673
Natural Gas	scf	968,924,717,809	0.055386	53,664,864
Lignite	ton	15,818,265	951.723	15,054,607
Bituminous	ton	5,486,248	2360.115	12,948,176
Bunker	liter	158,017,445	3.002635	474,469
Diesel	liter	13,825,937	2.644092	36,557
2008				
Total				84,083,369
Natural Gas	scf	977,016,893,281	0.055386	54,113,058
Lignite	ton	16,407,465	951.723	15,615,362
Bituminous	ton	5,578,567	2360.115	13,166,060
Bunker	liter	350,209,394	3.002635	1,051,551
Diesel	liter	51,941,958	2.644092	137,339

Sources: Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

Table 5 Operating Margin Emission Factor (Ex ante option)

Year	CO$_2$ Emission (tCO$_2$)	Grid Consumption (GWh)	OM Emission Factor (tCO$_2$/MWh)
2010	88,452,088	152,603.73	0.5796
2009	82,178,673	136,193.80	0.6034
2008	84,083,369	136,116.14	0.6177
Summary	**254,714,130**	**424,913.67**	**0.5994**

The operating margin (OM) $EF_{grid,OMsimple,y}$ is 0.5994 tCO$_2$/MWh as the calculation was shown in detail above.

STEP 5 Calculate the build margin (BM) emission factor

The group of power units is used for calculating the build margin (BM) emission factor which can be determined following with the option 1 (ex ante) and condition (b) ^{B}:

"(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEGtotal, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the gird most recently and that comprise 20% AEGtotal (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) (SET≥20%) and determine their annual electricity generation (AEGSET≥20%, in MWh)"

The group of power units that supply electricity to the grid most recently (sorted by the Commercial Operation Date (COD) which is the date when the power unit starts to supply electricity to the grid) and their annual quantity of electricity generation comprise larger than or equal to 20% of total annual electricity generation (in year 2010) are shown in Table 6. And fuel consumption of these power units are shown in Table 7.

Table 6 Quantity of electricity was generated by the most recently built powers plants

Power Unit	Grid Generation (GWh)	COD
1. North Bangkok Power Plant (Unit 01)	1,584.22	19 Nov 10
2. Bangpakong Power Plant (Unit 05)	4,643.22	16 Sep 09
3. Phu Kieaw Bio Power Project 2	79.46	15 Sep 09
4. Dan Chang Bio Power Project 2	76.75	15 Sep 09
5. South Bangkok Popwer Plant (Unit 03)	4,431.92	1 Mar 09
6. Chana Power Plant (Unit 01)	5,090.02	15 Jul 08
7. Ratchaburi Power Company Limited (RPCL) (Unit 1&2)	7,124.72	1 Jul 08
8. Gulf Power Generation Co., Ltd. (Unit 1&2)	9,903.93	1 Mar 08
Summary	**32,934.24**	
Percentage as of 2010 Grid Generation (160,190.96 GWh)	**20.56**	

Sources: Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

Table 7 Fuel consumptions of the most recently built power plants as listed in Table 6

Fuel type	Fuel Consumption		CO_2 Emission ($kgCO_2$/Unit)	CO_2 Emission ($kgCO_2$)
	Unit	volume		
Total				
Natural Gas	scf	251,512,881,819	0.0554	13,930,292
Lignite	ton	-	951.7230	-
Bituminous	ton	-	2360.1150	-
Bunker	liter	-	3.0026	-
Diesel	liter	1,179,772	2.6441	3,119

Sources: Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

Table 8 Calculation of the build margin emission factor

Year	CO_2 Emission (tCO_2)	Grid Consumption (GWh)	BM Emission Factor (tCO_2/MWh)
2010	13,933,412	32,934.24	**0.4231**

Sources: Electricity Statistic Annual Report 2010, Electricity Generating Authority of Thailand

As shown in Table 6, the annual quantity of electricity generation that generated by the most recently built power units which comprise 32,934.25 GWh (20.56% of the total electricity generated in year 2010 which is 160,190.96 GWh).

As shown in Table 7, the CO2 emission of the most recently built power units is emitted from fossil fuel consumption which comprise 20,991,690 tonCO2.

As shown in table 8, the BM emission factor that calculated by the equation (1), is 0.4231 tCO2/MWh.

STEP 6 Calculate the combined margin emission factor

The combined margin emission factor CM is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM} \tag{2}$$

Where:

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year y (tCO_2/MWh)

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (tCO_2/MWh)

w_{OM} = Weighting of operating margin emission factor (%)

w_{BM} = Weighting of build margin emission factor (%)

The weighting of OM emission factor and BM emission factor for calculate CM emission factor is catergorized by type of CDM project, as shown in table 9

Table 9 Weighting of operating and build margin emission factor for general CDM projects

CDM Project type	W_{OM}	W_{BM}
General Project	**0.5**	**0.5**

The CM emission factors that were calculated by the equation (4) follow with the methodological "Tool to calculate the emission factor for an electricity system" version 03.0.0 are shown in Table 10. The CM emission factor of general CDM project is 0.5113 tCO_2/MWh.

Table 10 Calculation of combined margin emission factor

CDM Project type	Emission Factot (tCO_2/MWh)		
	$EF_{grid,OM}$	$EF_{grid,BM}$	$EF_{grid,CM}$
General Project	**0.5994**	**0.4231**	**0.5113**

Appendix 5: Further background information on monitoring plan

Details of the monitoring plan are set out in a monitoring manual

Appendix 6: Summary of post registration changes

The post registration changes made to the version 16 of this project design document dated 7th of January 2014 since some of the parameters not monitored during the monitoring period.

Revised Section	Revision made
The document header	Revision to the document formatting by CDM Executive Board and UNFCCC logo removal
B.6.1. Explanation of methodological choices	Revision to remove wet basis gaseous stream calculations of the tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" Version 02.0.0 and the CO_2 emission coefficient $COEF_{i,y}$ determination by using Option A of the tool "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" Version 02
B.6.2.Data and parameters fixed ex ante	Revision to remove data and parameters is not used: NCV_{CH4}
B.7.1. Data and parameters to be monitored	Revision to removal data and parameters stated in the GS PDD are not used and monitored : $C_{H2O,t,db,n}$, $P_{H2O,t,sat}$, $V_{t,wb}$, $V_{i,t,wb}$, $V_{k,t,db}$, $V_{k,t,wb}$.

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the project design document form for CDM project activities" (EB 66, Annex 8).
03	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		