Project design document form
(Version 11.0)

Complete this form in accordance with the instructions attached at the end of this form.

BASIC INFORMATION	
Title of the project activity	Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor in Malaysia
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	Version 21.3
Completion date of the PDD	29/01/2020
Project participants	KUB-Berjaya Enviro Sdn. Bhd. (KBE)
Host Party	Malaysia
Applied methodologies and standardized baselines	• Selected methodology: ACM0001 “Flaring or use of landfill gas” – Version 18.0 • Selected standardized baseline(s): Not applicable
Sectoral scopes	Sectoral scope 13 - Waste handling and disposal
Estimated amount of annual average GHG emission reductions	276,630 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

KUB-Berjaya Enviro Sdn. Bhd. (KBE) is the developer responsible for the construction, operation, management and maintenance of the Bukit Tagar sanitary landfill and its facilities. This sanitary landfill is located at Bukit Tagar, Mukim Sg. Tinggi, Hulu Selangor District in the State of Selangor. KBE is expected to conclude a concession agreement with the Malaysian Government in 2008 to operate and maintain this landfill for the next 30 years.

The Bukit Tagar sanitary landfill occupies a 700 acres footprint and is surrounded by a buffer zone of 1000 hectares of palm oil plantations. The landfill has been in operation since 1 April 2005 and the waste received is expected to increase yearly from 3,000 tpd up to 6,600 tpd over the 40 years designed lifespan[1]. To date, the landfill received on average of 2,300 tons of municipal solid waste (MSW) per day from Kuala Lumpur City and the Selayang District in the State of Selangor.

The landfill is being developed in phases. The detail information on the phases is presented as below:

Cell	Status	Duration of filing	Amount of waste disposed (t)
Advance cell	Closed	Apr 2005 – Nov 2007	1,429,323.47
Phase 1	Closed	Nov 2007 – Dec 2011	3,730,406.57
Phase 2	Closed	Aug 2010 – Dec 2017	6,243,457.40
Phase 3	Operation	Jan 2018 - On-going	1,511,024.17 (Latest June 2019)

These phases are included in this project that is to be developed by year 2023. The landfill site consists of multi-phases (landfill cells) for MSW landfilling to cater for the continuous incoming waste received. Development of new phases (cells) (up to 17 phases according to landfill design) is necessary when the current cells have reached its designed capacity. All other phases will be developed when necessary.

Landfill gas consisting of mainly methane (CH_4) is generated due to the anaerobic degradation of solid waste in Bukit Tagar sanitary landfill. Currently, landfill gas (consisting Greenhouse Gases (GHGs) such as CH_4) is passively vented from the Bukit Tagar Sanitary landfill to the atmosphere. There are no regulations or specific requirement by the Malaysian Government requiring the collection, flaring and/or utilization of landfill gas.

The landfill cells are designed according to standards required for fully engineered sanitary landfill (Level 4 under United States Environmental Protection Agency (USEPA) standard). A complete cell lining system (see Figure 1 overleaf for detail) is applied with compacted clay, High Density Poly Ethylene (HDPE) liners, geo-textile and fabric membranes, gravel and clay layers to ensure separation of waste from the ground and proper drainage of leachate. The liner system is applied to create an impermeable leachate and gas flow barrier to protect the land of being contaminated.

[1] Detailed Environmental Impact Assessment (DEIA) for proposed Bukit Tagar Landfill, Sungai Tinggi, Hulu Selangor, Selangor Darul Ehsan dated June 2004

Recognising the potential of capturing and utilising landfill gas, KBE hereby propose a project that entails the collection and utilization of landfill gas for power generation as well as flaring the excess gas (as opposed to direct emission of landfill gas to the atmosphere). The renewable power generated from the landfill gas, will be sold to the grid, leading to further reduction of GHGs emission.

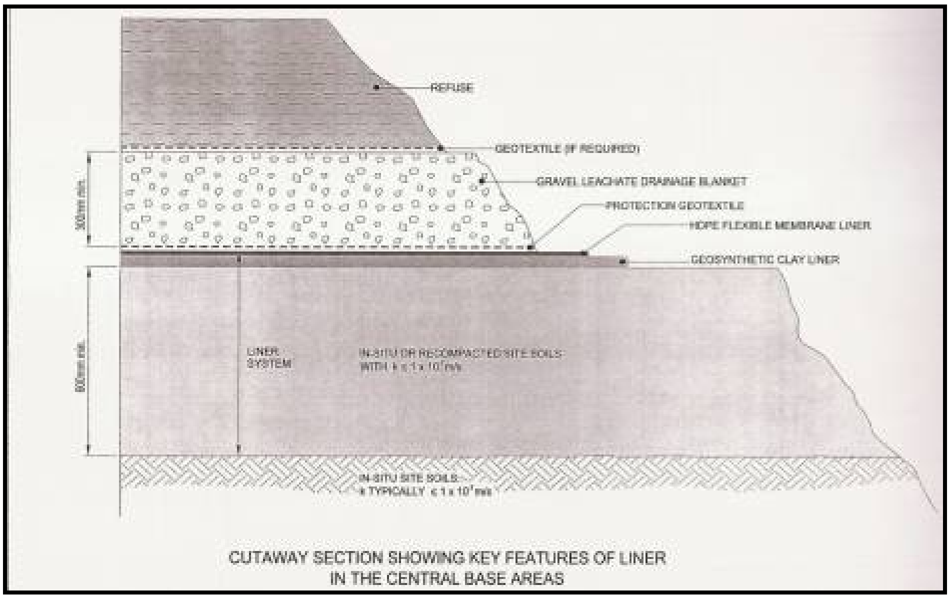


Figure 1: Cross section of Bukit Tagar Sanitary Landfill Liner System

(Source: KUB-Berjaya Environ Sdn Bhd, 2008)

The project will involve the following gas piping works:

- Installation of vertical HDPE gas extraction pipes (perforated) at regular interval period;
- Connection of vertical pipes by horizontal HDPE pipes; and
- Complete sealing of existing passive venting pipes;

With the implementation of the landfill gas recovery system, the daily operation of the landfill will not be affected. The working face (where waste is actually disposed daily) of the landfill will be kept to minimal. Under regular landfill operations, waste will be compacted and daily earth cover will be applied to maintain the hygiene and prevent odour.

Leachate management and treatment at Bukit Tagar is an important aspect for landfill gas extraction. With proper leachate drainage system already in place, leachate interference to the landfill gas extraction is not foreseen to be a problem. The collected leachate is treated extensively through a series of treatment processes in the following order:

- Anaerobic holding ponds for leachate storage and aging;
- Aerobic treatment using sequential batch reactor lagoons provides main biological treatment;
- Dissolved air flotation (DAF) tank for removal of suspended solids and colloidal particles;
- Sequence of reed beds to absorb residues in the treated leachate and maximize the treatment standard; and
- Finally irrigated to natural vegetation within the project sites rather than discharges to nearby rivers.

Apart from reducing CH_4 (as a GHG with Global Warming Potential (GWP) valid for the commitment period), the implementation of this landfill gas recovery and utilization project will also reduce the effects of air pollution on surrounding environments and minimize the risks of an explosion due to the concentration of accumulated landfill gas. This project is in line with the "Zero discharge" policy of KBE in striving to develop Bukit Tagar Sanitary Landfill into the role model of modern sanitary landfill in Malaysia. The generation of renewable energy from the captured landfill gas will inevitably contribute to the nation's renewable energy drive. This project is also in line with the Malaysian National Energy Policy where it specifically supports the following strategies laid out in the Ninth Malaysian Plan[2]:

- *"(iii) Reducing high dependence of petroleum products by increasing the use of alternative fuels"*
- *"(iv) Promoting greater use of renewable energy for power generation and by industries"*

On economic implications of the project, the implementation of the project will lead to an increase in employment opportunities and contribute to the local economy, especially in the form of foreign investment for local technological support and contractors.

On the social aspects, the improvement of the local environment due to the reduction of harmful landfill gases otherwise released to the atmosphere will improve the working environment for the workers on-site as well as for the health of surrounding community. All the above positive impacts will contribute to the overall sustainable development of Malaysia.

In year 2019, one (1) high temperature enclosed flares with maximum capacity of 2,500 Nm^3/hr each are in operation while the remaining portion of the gas captured was sent to a unit of 1.2MW Gas Engine (Gas Engine No.1), two (2) units of 1.56MW Gas Engines (Gas Engine No.2 and No.3) and three (3) units of 2MW Gas Engine (Gas Engine No.4, No. 5 and No. 6) to generate electricity. The electricity produced by the gas engines is exported to the grid.

Relevant dates for the project activities are as tabulated below:

Bukit Tagar Project	Construction Start	Commissioned	Status
Second flaring system (Flare No. 2)	22/01/2010	07/08/2010	Continued to operate
Gas Engine No.1	03/01/2011 (delivery to site)	01/06/2011	Continued to operate
Gas Engine No.2	06/08/2012 (Signed-off Delivery Order)	06/12/2013[3]	Continued to operate
Gas Engine No.3	06/08/2012 (Signed-off Delivery Order)	06/12/2013[4]	Continued to operate
Gas Engine No.4	26/12/2014 (Signed-off Delivery Order)	26/10/2015[5]	Continued to operate
Gas Engine No.5 & 6	05/03/2018 (Signed-off Delivery Order)	10/05/2019[6]	Continued to operate

[2] Pusat Tenaga Malaysia. (2006). Malaysia CDM Information Handbook. Pg 31.

[3] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 06/12/2013.

[4] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 06/12/2013.

[5] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 15/12/2015

[6] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 10/05/2019

The project activity, as opposed to the current situation, can be illustrated in the schematic below:

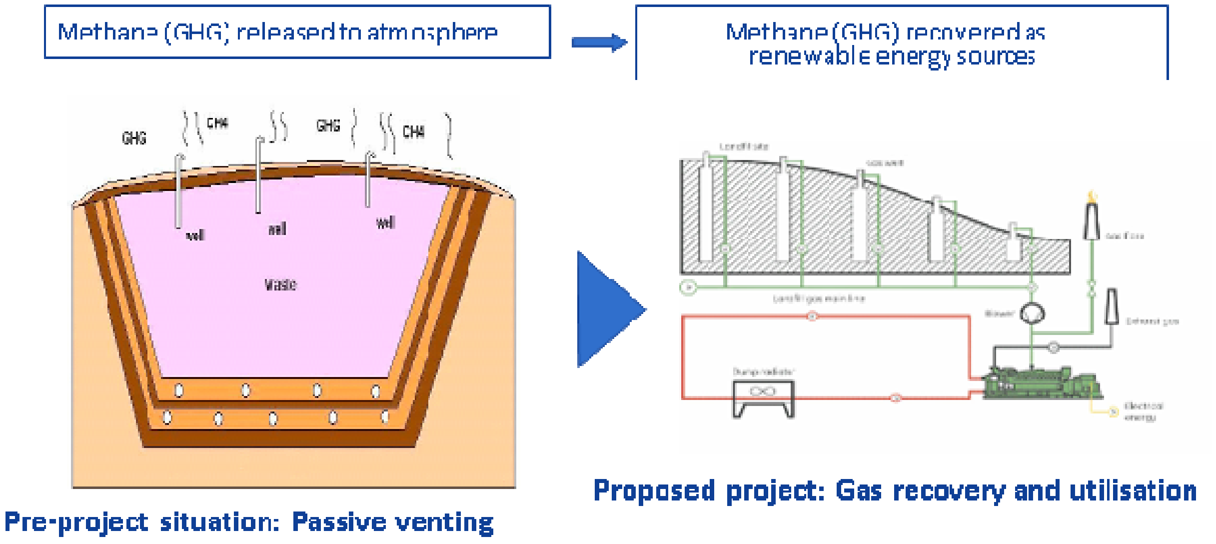


Figure 2: Proposed landfill gas recovery and utilisation

Source: Own Illustration & Jenbacher Catalouge (http://www.ge-energy.com)

An assessment of how this project will comply with the Malaysian National Criteria for Clean Development Mechanism (CDM) projects was done. The summarized results are presented below:

Comparison of Project with the Malaysia National CDM Criteria

National CDM Criteria in Malaysia	Conditions for this Project
Criterion 1: Contribute to sustainable development in Malaysia	• Improve local environment (air quality, reduce health risk) • Supports renewable energy policy
Criterion 2: Must involve Annex 1 (developed countries) parties	Technology: Gas Con/Q2 A/S (Denmark), Gas Engine Manufacturer – MWM & MTU (Germany)
Criterion 3: Must involve technology transfer or improvement of technology	Transfer of technology from overseas & improvement of technology from existing venting
Criterion 4: Must fulfill International CDM conditions	LFG recovery is voluntary and this project fulfills all conditions outlined by the CDM Executive Board
Criterion 5: Ability of Project Developer to undertake project	KBE is a local incorporated company, Jointed Venture by two public listed companies in the KLSE (Malaysian Stock Market)

A.2. Location of project activity

The project location (landfill) is situated in the State of Selangor, Malaysia at Mukim Sg. Tinggi, District of Hulu Selangor, approximately 5 km West of the Bukit Tagar Interchange along the North-South Expressway and 40 km from central Kuala Lumpur. The landfill is easily accessible by expressway and a dedicated Bukit Tagar interchange has been developed for the access from the North-South Expressway. The landfill is situated in a leased agricultural land, surrounded by hectares of oil palm plantations and rubber trees.

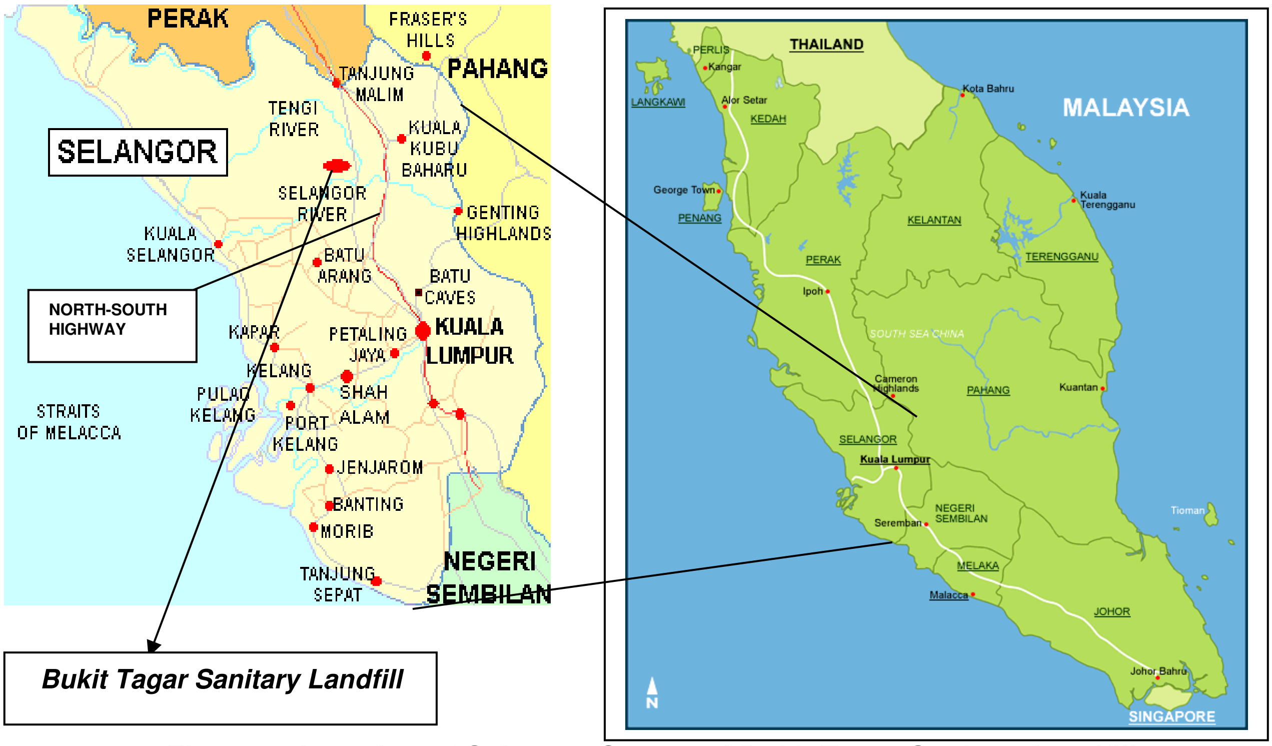


Figure 3: Location of Selangor State and Bukit Tagar Sanitary Landfill

The specific geographical coordinates of the Bukit Tagar Landfill is as below:

Latitude	Longitude	Description
3^{0} 30’ 168”	101^{0} 28’ 428”	North
3^{0} 29’ 07”	101^{0} 28’ 452”	South
3^{0} 29’ 46”	101^{0} 28’ 20”	West
3^{0} 29’ 69”	101^{0} 29’ 268”	East

A.3. Technologies/measures

Overall, the landfill gas technology and design will be sourced from developed countries since it is not readily available locally. The technology has been implemented and proven in Europe. The technology has commissioned at Seelong Landfill (another CDM project that has been registered by CDM Executive Board) in the State of Johor, Malaysia.

The gas extraction (collection) system to be applied included a containerised landfill gas pumping and control unit, supplied by a series of new vertical landfill gas wells. The system is designed based on a modular concept whereby expansion of the extraction system can be done in stages as the landfill develops. Two imported gas blowers with a total maximum capacity of approximately 2500 m^3/hr are used.

The landfill gas recovered will be utilised to generate electricity as follows:

Connection and Sell to TNB National Grid

The first gas engine (installed capacity of 1.2MW) was commissioned in 2011, the second and third gas engines (installed capacity of 1.56MW each) were commissioned in 2013 and the fourth gas engine (installed capacity of 2MW) were commissioned in 2015. The fifth and sixth gas engines (installed capacity of 2MW each) were commissioned in May 2019.

Upon commencement of the extraction of LFG in Phase 2 and with the additional gas expected, KBE intends to generate an additional of approximately 4MW and upload to the grid by year 2019, making the total grid upload capacity from the site to approximately 9.5MW.

There are three existing diesel generator sets at the Bukit Tagar site with the following capacity and efficiency:

- 100 kW – 85%
- 120 kW – 85%
- 750 kW – 85%

These engines were put in place before the grid power was available. With grid power available, the generators have been used as back-up generators in the landfill operation where the remaining operational lifetime is expected to be more than 15years.

Upon the implementation of power generation from landfill gas, the power required to operate the project activities will be sourced internally from the gas engines and backed up by grid power.

There is another diesel generator which will be used as backup for project activities during the power failure of the grid. The specification for the backup diesel generator is described as below:

Name	Perkins
Series	2500
Generator Output	500 kVA
Output Voltage	415 V

A high accuracy gas analyser and data logging system were installed to monitor the flow, gas composition and temperature of the gas extraction system. The gas analyser was imported.

Overall, technological transfer is expected from this project to both KBE as well as the local office of the technological provider in Malaysia. The successful transfer will also ensure the system can be monitored and sustained in future.

Details of the components are further described below:

Wells and Piping

Well heads are completed with well piping, constructed by drilling and inserting a gravel filter material surrounding a HDPE perforated filter pipe. The dimension of the chosen filter pipe will allow various types of pumping equipment to be installed in case leachate problems are detected.

The Advance Phase has been closed, vertical wells were installed for gas extraction. The gas extraction for advance cell planned to be stopped in extraction in 2018. On the other hand, horizontal wells were installed for Phase 1 and 2. This design is considered more efficient than the vertical wells for installation at operating landfills that are still currently being operated (for example Phase 2 in Bukit Tagar).

Each of the well heads is equipped with a measuring and regulating string consisting of a measuring point and a regulating valve. The measuring point is used to sample gas quality with a portable gas analyzer. In addition, the measuring string allows the use of a portable gas velocity instrument, giving the possibility of obtaining the yield of each well independently. The production of gas in each well can then be optimized by regulating the flow on the well control valve.

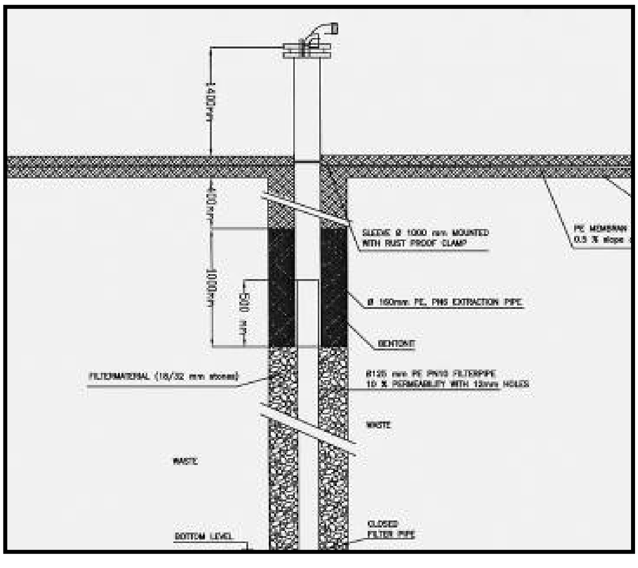


Figure 4: Schematic drawing of a "telescopic" vertical extraction well

(Source: Gas Con A/S / Q2 Engineering Sdn Bhd)

LFG Blower / Flare

The landfill gas booster blower installed is known as a twin lobe roots blower. Its total capacity amounts to a maximum of 2,500Nm^3/h and is capable of delivering a differential pressure of 250 mbar as well as being suitable for vacuum duty. The blowers are coupled to allow the use of one burner while the other is being serviced, thus maximizing the utilization time of the total system.

One (1) enclosed flares with a destruction ratio of at least 99% and a retention time of more than 0.3 second at temperatures exceeding 1000°C are installed at the landfill to destruct the landfill gas that is not consumed by the gas engine generator. The flare is delivered together with pumping units on skids to be placed in the open air. The excess gas will be burned in enclosed type of flares fitted onto the pumping system. The flare will have the ability to burn the total capacity to prevent emission if a grid failure or any other event that will force the engines to be turned off.

Figure 5: High temperature enclosed methane flare
(Source: KUB-Berjaya Enviro Sdn Bhd, 2012)

Gas Treatment
Primary pre-treatment of gas represents the first stage in reducing the number of contaminants in the landfill gas and typically employs simple physical process operations. The main contaminants removed or reduced are condensate and particulates. The removal of these contaminants will prolong the lifetime of the gas engines. These technologies have been in use for many years and are now a relatively standard element of active landfill gas management plants. The same also applies to the Biogas Filter System which is capable of a 2,000m^3 per hour flow rate to be installed in on-site of the gas vents.

Gas Engine Energy Power Plants
The gas is transformed into electricity by combustion gas engines. Its design and stationary engine concept ensure excellent component durability and a service life of 60,000 operating hours before the first major overhaul, depending on the types and specifications of gas engines used.

Power generated will be for sale to the national grid. This will involve applying for necessary license and reaching agreement with Tenaga National Berhad (TNB) – the largest electricity utility in Malaysia.

Figure 6: Gas Engine 2 & 3
(Source: KUB-Berjaya Enviro Sdn Bhd., 2016)

Gas Analyzer and Data Logging System

The gas analyzing system, a multi-functional environmental monitoring equipment can monitor up to 14 different measurement and data logging channels. Data from the logging system is presented on a local screen and stored in a local PC-unit with a possibility for external communication via GSM. Data can be downloaded directly from the in-built data logger to an external PC or transmitted via GSM modem. The system will be equipped with probes for accurate measurement of methane, carbon dioxide, oxygen, atmospheric pressure, LFG-line pressure and/or velocity. Temperature sensors on the gas side will also record, report and display values relating to flare operation. Monitoring of the correct functioning of the flaring system will be provided by the continuous logging system which examine the operational parameters of the flares. The details of the gas analyzers will be discussed in the monitoring section below.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Malaysia (host)	KUB-Berjaya Enviro Sdn. Bhd. (KBE) (Private)	No

A.5. Public funding of project activity

This project will be fully funded by KBE (Non-Annex 1 private entity) and will not involve any public funding or Official Development Assistance (ODA) diversion.

A.6. History of project activity

This project is not included as a component project activity (CPA) in a registered CDM programme of Activities (PoA). However, it is registered as a CDM project activity and is now undergoing the process of request for renewal of crediting period.

This project is not a project activity that has been deregistered.

A.7. Debundling

Not applicable

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

This project will apply the following approved methodology (ACM):

This project will apply the following approved methodology (ACM):

- ACM0001: *"Flaring or use of landfill gas – Version 18.0"*

The methodology also draws upon the following applicable tools in the case of this project:

- "Emissions from solid waste disposal sites" (*Version 07.0*)*;*
- "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*);
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (*Version 02*)
- "Project emissions from flaring" (*Version 02.0.0*);
- "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*); and
- "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" (*Version 03.0.1*).

Other tools to which the selected methodology refers to are not applied due to the following reasons:

- "Combined tool to identify the baseline scenario and demonstrate additionality" (*Version 06.0*)
  - "Simplified procedures to identify the baseline scenario and demonstrate additionality" in ACM0001 are applied when identifying the baseline scenario and demonstrating additionality
- "Determining the baseline efficiency of thermal or electric energy generation systems" (*Version 02.0*)
  - Not applicable because the project envisages no heat generation
- "Tool to determine the remaining lifetime of equipment" (*Version 01*)
  - Not applicable because LFG is not used in the equipment that was already in operation prior to the implementation of the project activity
- "Project and leakage emissions from transportation of freight" (*Version 01.1.0*)
  - Not applicable because the project envisages no transportation of compressed/liquefied LFG

The applied tools to which "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*) refer are as follow:

- "Tool to calculate the emission factor for an electricity system" (*Version 5.0*)
  Latest available national data published by Green Tech Centre (GTC) CDM Secretariat 2014 was calculated using version 04.0 of the tool.

B.2. Applicability of methodologies and standardized baselines

ACM0001 (*Version 18.0*), a consolidated approved methodology for landfill gas projects is most applicable and appropriate to this project which involves recovering and utilisation of landfill gas.

The applicability of this methodology is relevant to this project since the baseline scenario is the total atmospheric release of LFG (as described in A.3 above) and the project activity includes the situation where the captured gas is flared as well as used to produce energy (electricity).

According to the "Simplified procedures to identify the baseline scenario and demonstrate additionality" in ACM0001, the baseline scenario for LFG is assumed to be the atmospheric release of the LFG and electricity generation in existing grid-connected power plants.

In addition, the applicability under the methodology and relevant tools mentioned are also met as demonstrated below:

Table 1: Applicability of the methodology and relevant tools in the Bukit Tagar project

Methodology / Tool	Applicability	This Project (Bukit Tagar)
ACM0001 "Flaring or use of landfill gas" (*Version 18.0*)	a) Install a new LFG capture system in a new or existing SWDS where no LFG capture system was installed prior to the implementation of the project activity; or	Yes, the project involves the installation of new LFG capture systems in an existing SWDS where no LFG capture system was installed prior to the implementation of the project activity.
	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.	Not applicable, as the project involves the installation of new LFG capture systems.
	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	Yes. The project involves using the captured LFG to generate electricity besides flaring of LFG.

Methodology / Tool	Applicability	This Project (Bukit Tagar)
	network; iv. Supplying compressed/liquefied LFG to consumers using trucks;	
ACM0001 "Flaring or use of landfill gas" (*Version 18.0)*	d) Do not reduce the amount of organic waste that would be recycled in the absence of the project activity.	The project does not reduce the amount of organic waste that would be recycled in the absence of the project activity.
	Applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is: a) Atmospheric release of the LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons; 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 would be generated using fossil fuels in equipment located within the project boundary. c) In the case of LFG supplied to the end-user(s) through natural gas distribution network, trucks or the dedicated pipeline, the baseline scenario is assumed to be displacement of natural gas	a) Yes, the most plausible baseline scenario is atmospheric release of the LFG. b) Yes, the electricity would be generated in the grid. c) No, LFG is not supplied to the end user(s) through natural gas distribution network.
	Not applicable in combination with other approved methodologies.	The project does not involve a combination of other approved methodologies and only applies ACM0001 "Flaring or use of landfill gas" (*Version 18.0*).
	Not applicable 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 the implementation of the project activity.	The management of the SWDS in the project activity is not deliberately changed during the crediting period in order to increase methane generation compared to the situation prior to the implementation of the project activity.

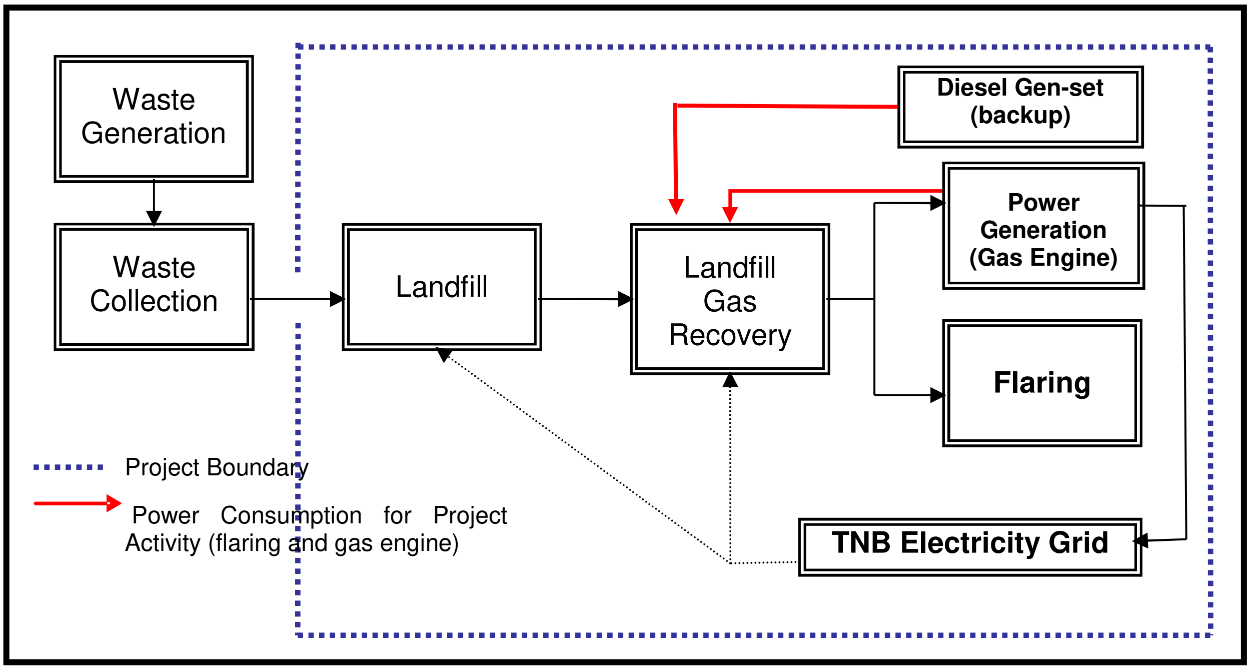
Methodology / Tool	Applicability	This Project (Bukit Tagar)
"Emissions from solid waste disposal sites" (*Version 07.0*)	Application A: The CDM project activity mitigates methane emissions from a specific existing SWDS. Application B: The CDM project activity avoids or involves the disposal of waste at a SWDS.	Application A: Yes, the CDM project activity mitigates methane emissions from a specific existing SWDS by capturing and flaring or combusting the methane. The methane is generated from waste disposed in the past.
"Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*)	Satisfy one out of the three scenarios to the sources of electricity consumption: a) Scenario A: Electricity consumption from the grid b) Scenario B: Electricity consumption from (an) off-grid fossil fuel fired captive power plant(s) c) Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s)	Yes, the project satisfies scenario A. The electricity is purchased from the grid only and no captive power plant is installed at the site of electricity consumption.
	Applicable if one out of the following three project scenarios applies to the recipient of the electricity generated: a) Scenario I: Electricity is supplied to the grid; b) Scenario II: Electricity is supplied to consumers/electricity consuming facilities; or c) Scenario III: Electricity is supplied to the grid and consumers/electricity consuming facilities.	Yes, the project satisfies scenario I. The electricity is supplied to the grid.
	Not applicable in cases where captive renewable power generation technologies are installed to provide electricity in the project activity, in the baseline scenario or to sources of leakage.	The project does not involve the installation of captive renewable power generation technologies in the project activity, in the baseline scenario or to sources of leakage.
"Project emissions from flaring" (*Version 02.0.0*)	Applicable to enclosed or open flares.	Yes, this project involves enclosed flares.
	Applicable to the flaring of flammable greenhouse gases where methane is the component with the highest concentration in the flammable residual gas.	Yes, the project activity flares LFG as flammable greenhouse gases and methane is the component with the highest concentration in the flammable residual gas.
	Applicable to the flaring of flammable greenhouse gases where the source of the residual gas is coal mine methane or a gas from a biogenic source (e.g. biogas, landfill gas or wastewater treatment gas).	Yes, the project involves the flaring of flammable greenhouse gases where the source of the residual gas is from a biogenic source, i.e. landfill gas.

Methodology / Tool	Applicability	This Project (Bukit Tagar)
"Project emissions from flaring" (*Version 02.0.0*)	Not applicable to the use of auxiliary fuels.	The project does not involve the use of auxiliary fuels.
	For the case of an enclosed flare, there shall be operating specifications provided by the manufacturer of the flare.	Yes, there are operating specifications provided by the manufacturer of the flare.
"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*)	Flow and composition of residual or flared gases or exhaust gases are measured for the determination of baseline or project emissions.	Yes, the flow and composition of flared gases are measured for the determination of baseline or project emissions.
	CO_2 is not the particular and only gas of interest.	CO_2 is not the particular and only gas of interest.
	The underlying methodology should specify: a) The gaseous stream the tool should be applied to; b) For which greenhouse gases the mass flow should be determined; c) In which time intervals the flow of the gaseous stream should be measured; and d) Situations where the simplification offered for calculating the molecular mass of the gaseous stream (equations (3) or (17)) is not valid (such as the gaseous stream is predominantly composed of a gas other than N_2).	Yes, the underlying methodology has specified all the 4 criteria in the following section under calculations.
"Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" (*Version 03.0.1*)	Applicable for projects which intend to renew the crediting period to assess the continued validity of the baseline and to update the baseline at the renewal of a crediting period, as required by paragraph 49 (a) of the modalities and procedures of the Clean Development Mechanism.	Yes, the project intends to renew the crediting period and therefore, refers to the tool to assess the continued validity of the baseline and to update the baseline at the renewal of a crediting period whenever applicable.
"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (*Version 2*)	Consumption of fossil fuel by the proposed CDM project activity, used in cases where CO_2 emissions from fossil fuel combustion are calculated based on the quantity of fuel combusted and its properties	Yes. The diesel generator sets will only be used as back up during power failure of grid.
"Tool to calculate the emission	Applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity	Yes, the tool is applied by the national grid to estimate the OM, BM and/or CM when

Methodology / Tool	Applicability	This Project (Bukit Tagar)
factor for an electricity system" (*Version 5.0*)	that is where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid.	calculating baseline emissions for a project activity that substitutes grid electricity.
	Not applicable if the project electricity system is located partially or totally in an Annex I country.	The project electricity system is not located in any Annex I countries.

B.3. Project boundary, sources and greenhouse gases (GHGs)

The project boundary is illustrated below:



Note: Diesel generator which will be used as backup for project activities during the power failure of the grid is added into the chart

Figure 7: Project Boundary of Bukit Tagar CDM Project

Table 2: Source of GHGs Included in the Project

	Source	GHGs	Included?	Justification/Explanation
Baseline scenario	Emissions from decomposition of waste at the SWDS site	CH_4	Yes	Landfill gas released to the atmosphere.
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from SWDS. This is conservative.
		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.
	Emissions from electricity generation	CO_2	Yes	Power generation is included in the project activity.
		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	Not applicable. Heat generation is not included in the project activity.
		CH_4	No	Not applicable. Heat generation is not included in the project activity.
		N_2O	No	Not applicable. Heat generation is not included in the project activity.
	Emissions from the use of natural gas	CO_2	No	Not applicable. Supply of LFG through a natural gas distribution network or using trucks is excluded in the project activity.
		CH_4	No	Not applicable. Supply of LFG through a natural gas distribution network or using trucks is excluded in the project activity.
		N_2O	No	Not applicable. Supply of LFG through a natural gas distribution network or using trucks is excluded 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	Applicable.
		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	Electricity consumed by project activity.
		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 flaring	CO_2	No	Emissions are considered negligible.
		CH_4	Yes	Emissions of methane can be important source of project emissions.
		N_2O	No	Emissions are considered negligible.
	Emissions from distribution of LFG using trucks	CO_2	No	Not applicable. The project does not involve transportation of compressed/liquefied LFG using trucks.
		CH_4	No	Not applicable. The project does not involve transportation of compressed/liquefied LFG using trucks.
		N_2O	No	Not applicable. The project does not involve transportation of compressed/liquefied LFG using trucks.

B.4. Establishment and description of baseline scenario

According to "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" (*Version 03.0.1, EB 66, Annex 47*); the following sub-steps are used to assess the continued validity of the current baseline:

Step 1: Assess the validity of the current baseline for the next crediting period

Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies

The most ***plausible baseline scenario*** (business-as-usual) identified for this project is assumed to be the atmospheric release of the LFG and electricity generation in existing grid-connected power plants, according to the "Simplified procedures to identify the baseline scenario and demonstrate additionality" in ACM0001. The current baseline complies with all relevant mandatory national and/or sectoral policies, which are applicable at the time of requesting renewal of the crediting period. There is no mandatory legal requirement to collect, recover and utilize gases generated from landfills in Malaysia. This has been further confirmed with the Department of National Solid Waste Management, Malaysia[7]. Therefore, the current baseline does not need to be updated and can proceed to Step 1.2.

Step 1.2: Assess the impact of circumstances

The most ***plausible baseline scenario*** (business-as-usual) identified for this project is assumed to be the atmospheric release of the LFG and electricity generation in existing grid-connected power plants, according to the "Simplified procedures to identify the baseline scenario and demonstrate additionality" in ACM0001. No changes in market characteristics that is related with or/and has any impacts to landfills, new fuels or raw materials, electricity or fuel prices are found, which means that the current baseline does not need to be updated. The conditions used to determine the baseline emissions in the previous crediting period are still valid and therefore, can proceed to Step 1.3.

Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested

This sub-step is not applicable because the baseline scenario identified at the validation of the project activity was not the continuation of use of the current equipment(s) without any investment and, the projects proponents or third party (or parties) would not undertake an investment later due, for example, to the end of the technical lifetime of the equipment(s) before the end of the crediting period or the availability of a new technology. Therefore, the current baseline does not need to be updated and can proceed to Step 1.4.

Step 1.4: Assessment of the validity of the data and parameters

Data and parameters that are determined at the start of the crediting period and not monitored during the crediting period that need to be updated are Global Warming Potential (GWP_{CH4}) and Grid Emission Factor ($EF_{EL,k,y}$). The updates are shown in Step 2.2 below.

[7] Personal communication with Department of National Solid Waste Management, Malaysia on 05/01/2016.

Step 2: Update the current baseline and the data and parameters

Step 2.1: Update the current baseline

The current baseline emissions for the renewal of crediting period is updated based on the latest approved version of the methodology and tools applicable to the project activity. The values are shown in **Section B.5.4**.

Step 2.2: Update the data and parameters

Data and parameters that are determined at the start of the crediting period and not monitored during the crediting period that need to be updated are as follow:

GWP_{CH4} (Global Warming Potential (GWP) of methane) – With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report, for the second commitment period of the Kyoto Protocol, the global warming potentials used by Parties to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of the greenhouse gases listed in Annex A to the Kyoto Protocol shall be those listed in the column entitled "Global Warming Potential for Given Time Horizon" in Table 2.14 of the errata to the contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, based on the effects of greenhouse gases over a 100-year time horizon, i.e. 25 tCO_2/tCH_4.

$EF_{EL,k,y}$ (Grid Emission Factor) – $EF_{grid,CM,y}$ 2014 was calculated based on the "Tool to calculate the emission factor for an electricity system", Version 04.0. Operating margin (OM) and build margin (BM) emission factors were included to calculate the combined margin (CM) emission factor.

For second crediting period, W_{OM} = 0.25 and W_{BM} = 0.75 was used in the calculation according to the "Tool to calculate the emission factor for an electricity system", version 05.0, paragraph 84 (b). The value recalculated using latest available information which is 2014 data[8] is 0.7146 tCO_2/MWh. EF_{grid} of 0.7146 was applied in the calculation starting from 28 August 2016 (2nd crediting period) onwards. The detail description on the calculation is presented in section B.6.

B.5. Demonstration of additionality

According to ACM0001, version 18.0, Step 1 of the latest version of "Combined tool to identify the baseline scenario and demonstrate additionality (Version 06)" was used to identify all realistic and credible baseline alternatives for this project.

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

Not applicable to the proposed CDM Project Activity

[8] Latest available data (2014) obtained from Green Tech Centre (GTC) CDM Secretariat.

Step 1. Identification of alternative scenarios

The realistic and credible alternatives scenarios to the proposed CDM Project Activity were identified following the recommendations of the "Combined Tool for the demonstration and assessment of additionality" and ACM0001, version 18.0 methodology

Step 1a. Define alternative scenarios to the proposed CDM project activity:

According to the methodology ACM0001, version 18.0, the following baseline alternatives shall be taken into consideration.

For the destruction of LFG alternative(s) include:

(a) LFG 1: The project activity implemented without being registered as a CDM project activity (i.e. capture and flaring or use of LFG);
This scenario is considered as the Project not undertaken as a CDM project activity in that the recovered LFG is used for power generation, with excess being flared. This alternative is financially infeasible on its own and would not be undertaken in the absence of CDM. This scenario involves significant investment and additional costs of landfill operations. This alternative will be further detailed in step 3 (investment analysis).

(b) LFG 2: Atmospheric release of the LFG or capture of LFG in a managed SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;
Prior to the implementation of the Project, LFG was directly released to the atmosphere. This is the prevailing practice in the host country. It is considered as the continuation of the current practice and thus regarded as a possible baseline scenario.

(c) LFG 3: Atmospheric release of the LFG or capture of LFG in an unmanaged SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;
The project activity is capturing of LFG in a managed sanitary landfill "Level 4", therefore LFG 3 is not credible and realistic baseline scenarios.

(d) LFG 4: LFG generation is partially avoided because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;
The organic fraction of the solid waste has not been recycled prior to the project implementation; therefore LFG 4 is not credible and realistic baseline scenarios.

(e) LFG 5: LFG generation is partially avoided because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;
The organic fraction of the solid waste has not been treated aerobically prior to the project implementation; therefore, LFG 5 is not credible and realistic baseline scenarios.

(f) LFG 6: LFG generation is partially avoided because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS
The organic fraction of the solid waste has not been incinerated prior to the project implementation; therefore LFG 6 is not credible and realistic baseline scenarios.

For electricity generation, alternative(s) include:

(i) E1: Electricity generation from LFG, undertaken without being registered as CDM project activity;
Implementation of project is deemed possible and in compliance with mandatory laws and regulations of Malaysia. This option is considered as a plausible alternative and will be analysed thoroughly by pursuing steps of the additionality analysis.

(ii) E2: Electricity generation in existing or new renewable or fossil fuel based captive power plant(s);
There is no demand for captive power plant off-site and there is no need for a new captive power plant on-site. Furthermore, there is no economical attractive renewable energy resource like wind, solar, geothermal, etc in the area where the proposed project is developed. Therefore, the alternative E2 is not a credible and realistic scenario to the baseline.

(iii) E3: Electricity generation in existing and/or new grid-connected power plants.
This alternative is in compliance with mandatory laws and regulations in Malaysia, which make it a realistic and credible alternative. This also represents the continuation of the current situation.

It is noted that the project does not involve thermal energy generation or supply of LFG to a natural gas distribution network. Thus, all the alternatives relate to heat generation or natural gas supply are not considered herein.

Outcome from step 1a

Alternatives	Destruction of LFG	Electricity generation
The project undertaken without being registered as CDM project activity;	LFG1	E1
Atmospheric release of the LFG or capture of LFG in a managed SWDS and Electricity generation in existing and/or new grid-connected power plants	LFG2	E3

Step 1b. Consistency with mandatory applicable laws and regulations:

<u>Landfill Gas Management</u>

Most relevant laws related to this project (landfill & landfill gas management) in Malaysia would include:

Federal (National) Laws

- The Solid Waste and Public Cleansing Management Act 2007 (Act 672);
- Environmental Quality Act 1974 (Act 127) and subsidiary legislations;

State and Local Laws

- Local Government Act 1976 (171) and subsidiary legislations;
- Street, Drainage and Building Act 1974 (Act 133) and subsidiary legislations;

The Solid Waste and Public Cleansing Management Act 2007 were passed by the Malaysia Government in August 2007. A new Department of National Solid Waste Management and a Solid

Waste Management Corporation have been set up to implement this law. This law provides a comprehensive regulatory framework for managing solid waste from generation to treatment and disposal. However, in the main act, no specific requirement for landfill gas management is included.

The Environmental Quality Act 1974 is the main legislation governing the environmental management in Malaysia. Environmental impact assessment is required for establishing a landfill. However, under these regulations, no specific requirement is set for landfill gas management.

The Local Government Act 1976 & Street, Drainage and Building Act 1974 empowers the local authorities (municipalities) to set up and manage solid waste management within their own jurisdiction. Under the law, no specific requirement is set for landfill gas management.

Reviewing the above, there are no mandatory legal requirement to collect, recover and utilise gases generated from landfills in Malaysia. Landfill gas venting is considered to be part of a "Level 4" sanitary landfill in Malaysia under a guideline (not enforceable) published[9]. However, the collection, extraction and utilisation have not been mentioned or required. This has also been further confirmed with the Department of National Solid Waste Management Malaysia[10].

All alternatives listed in ***outcome step 1a*** are in compliance with the relevant mandatory applicable legal and regulatory requirements of Malaysia and will be further assessed in following steps.

Baseline Fuel for Electricity Supply

Generation of electricity supply in Malaysia is subjected to the following regulations[11]:

Energy Commission Act 2001 - This law was pass to fulfil the need to regulate an increasingly energy industry. In January 2002, the Energy Commission also empowered to regulate, enforce and promote all matters related to the electricity and gas supply industry within the scope of the legislation provided by the Electricity Supply Act 1990, Gas Supply Act 1993, Electricity Supply Regulations 1994, Gas Supply Regulations 1997 and Licensee Supply Regulations 1990.

The Energy Commission regulates all matters relating to the electricity supply industry and to protect any person from dangers arising from the generation, production, transmission, distribution, supply and use of electricity as provided under the electricity supply laws.

In Malaysia, an electricity demand can be met by either connecting to the TNB national grid or by generating own electricity by means of on-site or off-site fossil fuel-based power plant. However, a license is required from the Energy Commission for such installation. There are no restrictions of the baseline fuel to be used. Fossil (e.g. diesel) or renewable (e.g. landfill gas) can be utilized to generate power.

[9] "Technical Requirements for Safe Closure of Landfill Sites. (4) Gas Ventilation Facility – Gas ventilation facility should be provided and the venting pipes should be installed at 50m intervals. The purpose of the venting pipes is to allow the landfill gas to be released into the atmosphere and thus preventing gas explosion. This facility will also assist the acceleration on the landfill stabilisation by enhancing the waste decomposition process." *Source: Japanese International Corporation Agency & Ministry of Housing and Local Government Malaysia. 2004. "The Study on the safe closure and rehabilitation of landfill sites in Malaysia, Volume 3 - II - 6)"*

[10] Personal communication with Department of National Solid Waste Management, Malaysia on 07/01/2016.

[11] Energy Commission Malaysia Website. http://www.st.gov.my/. (Accessed 2 August 2008).

The relevant energy policies in Malaysia[12] are:

- National Energy Policy 1979 – Set the overall energy policy with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy.
- National Depletion Policy 1980 – Introduced to safeguard the exploitation of natural oil reserves because of the rapid increase in the production of crude oil.
- Four Fuel Diversification Policy 1981 – Designed to prevent over-dependence on oil as the main energy resource, its aim was to ensure reliability and security of the energy supply by focusing on four primary energy resources: oil, gas, hydropower and coal.
- Fifth Fuel Policy – In the Eighth Malaysian Plan (2001 – 2005), Renewable Energy was announced as the fifth fuel in the energy supply mix. Renewable Energy is being targeted to be a significant contributor to the country's total electricity supply. With this objective in mind, greater efforts are being undertaken to encourage the utilization of renewable resources, such as biomass, biogas, solar and mini-hydro, for energy generation.
- The Ninth Malaysia Plan (2006-2010) strengthens the initiatives for energy efficiency and renewable energy put forth in the Eighth Malaysia Plan that focused on better utilisation of energy resources. An emphasis to further reduce the dependency on petroleum provides for more efforts to integrate alternative fuels.

The Government of Malaysia also encouraged renewable energy through the introduction of the Small Renewable Energy Programme (SREP) since 2001. The SREP offers some financial incentives to power producers. However, such development is still based on voluntary basis i.e. consumers are not mandated under law to develop renewable energy-based power supply.

The Ministry of Energy, Green Technology and Water in April 2010 has approved the National Renewable energy Policy and Action Plan which is a holistic roadmap for RE growth in the country. Under this policy, the Feed-In Tariff (FiT) System which provides a premium tariff up to a specified period to RE developers was introduced. The Renewable Energy Act 2011 was enforced on 1st December 2011 to provide for the establishment and implementation of a special tariff system to catalyse the generation of renewable energy and to provide for related matters. The implementation of FiT and development of renewable energy in general are carried out by the Sustainable Energy Development Authority Malaysia (SEDA Malaysia).

Considering the regulations and policies above, all alternatives listed in ***outcome step 1a*** for electricity supply (baseline fuel) are in compliance with the relevant mandatory applicable legal and regulatory requirements of Malaysia and will be further assessed in barrier analysis.

Outcome from step 1b

The alternatives to be taken into considerations is the same as outcome from step 1a.

Step 2. Barrier analysis

The barrier analysis step is not considered in the demonstration of additionality because there are more than one alternative remaining and one of the alternatives is the project without CDM. The proposed CDM project activity is unlikely to be the most financially attractive after the sensitivity analysis in step 3. None of the baseline alternatives face barriers apart from what is discussed in the Investment Analysis to the extent that they would prevent the alternatives' implementation.

[12] Energy Information Bereau, Malaysia Energy Centre Website. http://eib.ptm.org.my/. (Accessed 2 August 2008).

Step 3. Investment analysis

This step determines whether the proposed project activity is economically or financially less attractive than at least one other alternative, identified in Step 1, without the revenue from the sale of certified emission reductions (CERs). The following sub-steps are used to conduct the investment analysis:

Benchmark Analysis was applied in this PDD to assess and demonstrate the additionality of the proposed Project. Internal Rate of Return (IRR) is deemed most suitable financial indicator for the Project and is compared to a benchmark value. In this analysis, project IRR is applied.

Determination of "Benchmark"

Several possible benchmarks were considered:

Base Lending Rate

In December 2007 (upon signing of term sheet with CER buyer for this project – date of real action), the Base Lending Rate (BLR) for Commercial Banks in Malaysia was 6.72% and the average lending rate was 6.29%. This is illustrated in the table below.

Interest Rates: Banking institutions (in percent per annum)

Average rates at end-period	**Commercial Banks**						
	Period (in months)					**Base Lending Rate**	**Average Lending Rate**
	1	**3**	**6**	**9**	**12**		
2007 Dec	3.08	3.15	3.29	3.38	3.70	6.72	6.29

Source: Monthly Statistical Bulletin December 2007, Central Bank of Malaysia

Project IRR Benchmark for Renewable Energy Projects

Although there is no official published figure available for this, several published sources by reputable organizations (Board of Engineers and Study commissioned by the Ministry of Energy, Water and Communication/Malaysian Energy Centre) can be referred to. These are further elaborated below:

An article published by the Board of Engineer in year 2005 can be referred to. The main figures are summarized below:

Research Survey: Comparison of Responses from Various Stakeholders on Investment (Project IRR) in Renewable Energy Generation

	Renewable Energy Developers (Non-millers)	**Bankers**
Project IRR (%)	12-15	15-18
Loan Tenure (years)	10-15	10

Source: Article Renewable Energy: The Failure of the Malaysian 5th Fuel Policy, Ingeniur Magazine, published by Board of Engineer Malaysia (2005).

To finance a renewable energy project that is viable, the Malaysian Bankers and private business owners viewed that they will be comfortable with a project IRR of not less than 15%. On the other hand, it can be noted that typical Malaysian Renewable Energy Developers will be comfortable with a project IRR of not less than 12% while financier such as bankers demand a higher return mainly attributed to the risk and uncertainties of the projects.

Landfill gas projects that provide energy in the form of electricity is rather new to Malaysia and their deployment is still rater limited. The uncertainties over the application of new technology and the supplies of wastes compared to conventional energy investments (coal power plant) add additional level of risk to the investment and these risks must be considered when applying a benchmark IRR for this project.

Another report, named "Study on Clean Development Mechanism Potential in the Waste Sectors in Malaysia", Renewable Energy & Energy Efficiency Component (Sub-Component III: CDM Action Plan) published by Ministry of Energy, Water and Communications, Malaysia Energy Centre and Danish International Development Assistance (DANIDA) stated that the benchmark for CDM for project is set at financial IRR of 15% in Malaysia. This is comparable to the 12-15% IRR indicated by the Board of Engineer articles.

In view of the few rates mentioned, the benchmark rate of IRR for the project is deemed at least have to be more than the BLR of 6.72% and with the risk of the application of the new technology and likelihood of other risks that might not be foreseen, the **project IRR of 12%** (Source: Article Renewable Energy: The Failure of the Malaysian 5th Fuel Policy, Ingeniur Magazine, published by Board of Engineer Malaysia) is **deemed appropriate to be selected as the benchmark for this project.** 12% Project IRR benchmark presents the lower bound of the range indicated by the Board of Engineer article. This is a conservative approach.

Calculation and comparison of financial indicators

The table below represents the main parameters and assumptions used in the IRR calculation for the Project.

Parameters/Assumptions	**Value**
Revenues (excluding CER revenues)	
- Sale of electricity to grid from 2012 (1MW)	RM 1,497,960/yr
- Sale of electricity to grid from 2013 -2015 (4MW)	RM 6,622,560/yr
- Sale of electricity to grid from 2016 - 2018 (5.5MW[13])	RM 12,144,119/yr
- Sale of electricity to grid from 2019 (9.5MW)	RM 14,454,000/yr
- Sale of electricity to grid from 2020 – 2028 (9.5MW)	RM 25,418,016/yr
Total capital outlay up to year 2028	RM 99,456,936
Interest rate for long term bank loan	8% p.a.
Average electricity tariff	
- For sale to the grid from 2011 onwards (1MW)	0.19/kWh
- For sale to the grid from 2013 onwards (4MW)	0.21/kWh
- For sale to the grid from 2016 - 2018 (2MW)	0.4669/kWh

[13] According to the Feed-in Approval, the declared annual availability for GE no.1 (installed capacity of 1.2MW) is 7,446MWh per year, for GE no.2&3 (total installed capacity of 3.12MW) is 22,338MWh per year and for GE no.4 (installed capacity of 2MW) is 9,855MWh per year. Assuming 90% availability of GEs, the delivery capacity rating for the GEs is 5.69MW. In addition, after taking into account of the energy consumed for project activity of 0.09MW, the total amount of energy generated from the GEs is 5.12MW which is less than the amount of 5.5MW used in the financial analysis calculation. Therefore, the value of 5.5MW used is conservative.

- For sale to the grid from 2019 – 2028 (5.5MW)	0.447/kWh
Average operations and maintenance costs	RM 2,754,766/yr
Project lifespan	21 years
Project payback period (with CERs)	10 years
Project payback period (without CERs)	>21 years
Project NPV at discount rate of 8% for 10 years (without CERs)	(20,847,329)
Project NPV at discount rate of 8% for 21 years (without CERs)	9,007,330
Project NPV at discount rate of 8% for 10 years (with CERs)	(3,588,041)
Project NPV at discount rate of 8% for 21 years (with CERs)	26,445,307
Project IRR for 10 years (without CERs)	**-15.7%**
Project IRR for 21 years (without CERs)	**10.6%**
Benchmark Project IRR	**12.0%**
Project IRR for 10 years (with CERs)	**2.2%**
Project IRR for 21 years (with CERs)	**18.8%**

The table above shows the financial analysis for the project activity. As shown, the project IRR for the project in 21 years without CDM is estimated to be 10.6%, below benchmark of 12%. The low project IRR indicates that the project is financially unattractive and not viable without CDM. With the CDM revenue, project IRR is significantly improved and exceeds the lending rates of commercial banks (6.29% to 6.72%) and benchmark IRR. Therefore, the proposed project with the CDM revenue can be considered as financially viable to the investors.

Sensitivity analysis

A sensitivity analysis based on the following scenarios are established and analysed to examine whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions. The critical assumptions include:

(1) Changes in electricity tariff (sell to grid), -10% and +10% (without CDM)
(2) Changes in electricity sold to grid[14], -10% and +10% (without CDM)
(3) Changes in the total investment costs (capital outlay), -10% and +10% (without CDM)
(4) Changes in total operating & maintenance (O&M) costs, -10% and +10% (without CDM)

These parameters were selected as being the most likely to fluctuate over time due to external factors.

Financial analyses were performed by altering each of these parameters by 10% (average plausible range) and assessing the impact on the project IRR for each scenario (without CDM), see table below.

[14] Amended production hour to electricity sold to grid for better representation.

<table>
<tr><th colspan="2" rowspan="3">Description</th><th colspan="2">Project IRR 10 and 21 years (without CDM)</th></tr>
<tr><th colspan="2">Scenario</th></tr>
<tr><th>-10%</th><th>+10%</th></tr>
<tr><td rowspan="2">Electricity tariff (sell to grid)</td><td>10 years</td><td>-19.9%</td><td>-11.9%</td></tr>
<tr><td>21 years</td><td>7.7%</td><td>13.1%</td></tr>
<tr><td colspan="4">It is unlikely that the electricity tariff for renewable energy will be further decreased 10% due to government's policy to increase RE share in electricity supply. Likely to be increased 10% as the interest of government to increase RE may motivate this move. The tariff effective period was fixed for 16 years; thus, the tariff increases or decrease is impossible as it is already fixed under the approval. In fact, the trend of FiT rate is going downwards as seen in actual approved tariffs for biogas</td></tr>
<tr><td rowspan="2">Electricity sold to grid[15]</td><td>10 years</td><td>-18.7%</td><td>-11.9%</td></tr>
<tr><td>21 years</td><td>8.4%</td><td>13.1%</td></tr>
<tr><td colspan="4">The amount of electricity sold to grid depends on the operating hours of the gas engine. The likelihood of the decrease in electricity sold to grid of another 10% is possible considering the possible breakdown, the needs for regular maintenance and the consistency of gas supply may affect the electricity sold to grid. It is unlikely the generation capacity exceeds the approved capacity stated in the feed-in tariff approval. In addition, it is also not possible for the gas engine to operation at 100% capacity (24 hours, 365 days) in one year without stoppage for maintenance.</td></tr>
<tr><td rowspan="2">Total capital outlay</td><td>10 years</td><td>-12.4%</td><td>-18.6%</td></tr>
<tr><td>21 years</td><td>12.4%</td><td>9.0%</td></tr>
<tr><td colspan="4">The capital outlay of the project cannot decrease 10% as the actual prices of the equipment is applied and tabulated in financial analysis. It is likely that the capital outlay of the project might increase 10% in future as prices of some of the equipment for future purchase may increase over time due to inflation as well as increasing demand of equipment.</td></tr>
<tr><td rowspan="2">Total O&M costs</td><td>10 years</td><td>-14.8%</td><td>-16.6%</td></tr>
<tr><td>21 years</td><td>11.1%</td><td>10.0%</td></tr>
<tr><td colspan="4">It is likely that the O&M might decrease to this level as the company might be able to optimize the process, proper maintenance and thus reducing the overall O&M cost. It is very likely that the O&M might increase to this level as cost of material and services is likely to increase over time in line with the inflation. Furthermore, raw materials prices are increasing and thus the spare parts and replacement parts of the plant will surely be increased in parallel.</td></tr>
</table>

Further sensitivity analysis by different parameters until the project IRR meets the identified project IRR benchmark (12.0%) was estimated and tabulated as below:

Parameters	Increase/ decrease of percentage in order to meet the 12% benchmark (without CDM)
Electricity tariff (sell to grid)	+5.6%
Electricity sold to grid	+5.6%
Total capital outlay	-7.7%
Total O&M costs	-28.0%

[15] Amended production hour to electricity sold to grid for better representation. The results remain same for increase in production hours or actual electricity sold to grid as it is directly correlated.

The results obtained above are not realistic, the description is as below:

Electricity tariff (sell to grid) – It is not likely to be increased to this level (+5.6%) as the cost of energy at this price already exceeds the production cost of conventional energy production. The main utility (Tenaga National Berhad) would be resistant to enter into any purchase agreement at this price. There is no obligatory requirement for TNB to purchase electricity from renewable sources.

Electricity sold to grid – The amount of electricity sold to grid depends on the operating hours of the gas engine. There are only 24 hours a day (8,760 hours a year). Hence, it is not logical that production hours could go beyond the 8,760 hours, i.e. +5.6% to 9,251 hours.

Total capital outlay – It is very unlikely to decrease to this level (-7.7%) because the prices of some of the equipment and installation have been determined and agreed upon and quotation prices of other equipment and installation have also been obtained. Furthermore, it is very unlikely for the capital outlay to decrease up to -7.7% without any changes in the scope and equipment.

Total O&M cost – It is impossible for not having O&M cost as the plant will go into deterioration if there is no O&M cost furthermore with a decrease in 28% in the cost.

Conclusion for Step 2d – Sensitivity Analysis

As it is shown in the various scenarios above, the project IRR can only achieve the project benchmark of 12% with "unrealistic" scenarios. With the variation of 10%, which is likely to occur, the project IRR is still remains lower than the benchmark (12.0%). This further confirms that the project is unlikely to be financially attractive and feasible without CDM financing.

Outcome for Step 3

Based on the analysis shown above, LFG 2 (atmospheric release of LFG) and E6 (existing and/or new grid-connected power plants) are the only remaining credible and plausible scenarios, and have been identified as the baseline scenario.

Step 4. Common practice analysis

Step 4a. The proposed CDM project activity(s) applies measure(s) that are listed in the definitions section above:

The proposed activity applies a measure that is listed in the definitions section of the Combined tool to identify the baseline scenario and demonstrate additionality, version 06.0, the Project is not the First-of-its-kind and which involves methane destruction (example: landfill gas flaring) and applies the measure that is listed in the definitions section in the tool. Therefore, proceed to Step 4 a, and the followed four steps are applied.

Sub-step 4a (1)
The proposed project activity has an installed electricity generation capacity of 10.4MW. The applicable output range of +/-50% yields 5.2MW~15.6MW.

Sub-step 4a (2)

The applicable geographical area is the entire host country, Malaysia. In Malaysia, municipal solid waste is typically handled by the local government under public cleansing activities. Waste are collected and transported to disposal sites. Open dumps and landfills are the most common disposal method for solid waste. As reported by National Solid Waste Management Department (JPSPN), in 2015, there are approximately 297 operating and closed landfills throughout the country[16] of which 162 considered as operating landfills (excluding closed landfills). The landfills which are inactive or not operational are not taken into consideration for this calculation

Most of these landfills are not engineered and do not have gas venting or collection systems[17]. In 2007, a new Solid Waste Management and Public Cleansing Act was gazetted to empower the federal government of Malaysia to take over the solid waste management in Peninsula Malaysia in the coming future. Under the new legislation, there are no obligations for landfill operators to recover and utilize landfill gas.

The following table shows the list of projects in Malaysia retrieved from UNFCCC website at the time of submitting the revised PDD to the DOE for verification:

Table 3: CDM status of LFG recovery projects in Malaysia

Projects	Method	Reference	Status
Krubong Melaka LFG Collection & Energy Recovery CDM Project	ACM0001 ver. 2	0323	Registered on 29/09/2006
Landfill Gas utilization at Seelong Sanitary Landfill, Malaysia	ACM0001 ver. 4	0927	Registered on 02/05/07
Kuantan Jabor-Jerangau Integrated Landfill Management	ACM0001 ver. 5	1652	Registered on 11/08/08
Taman Beringin Integrated Landfill Management Project, Kuala Lumpur, Malaysia	ACM0001 ver. 8	1925	Registered on 03/09/09
Jeram landfill gas recovery project	ACM0001 ver. 11	6673	Registered on 13/07/12
Bionersis LFG Project Malaysia (Penang)	ACM0001 ver. 11	4316	Registered on 24/07/12
Magenko IYO Alam Sekitar Bercham Landfill Gas to Energy Project in Ipoh, Malaysia	ACM0001 ver. 13	6812	Registered on 08/11/12
Ayer Hitam landfill gas recovery project	ACM0001 ver. 11	5797	Rejected
Batu Pahat Kampung Kelichap Integrated Landfill Management	ACM0001 ver. 9	NA	Under Validation
Utilization of Landfill Gas from Municipal Solid Waste in Kuching, Malaysia	AMS-III.G. ver. 6	NA	Under Validation
Batu Empat & Rimba Terjun Bundled Landfill Gas Management Project, Malaysia	AMS-III.G. ver. 6	NA	Under Validation

16 http://www.data.gov.my/data/ms_MY/dataset/statistik-bil-insinirator-tapak-pelupusan-sisa-pepejal-yg-beroperasi-dan-yg-ditamatkan-operasi-2015

17 Ministry of Energy, Water and Communication/Malaysia Energy Centre/DANIDA. (2004). Study on the Clean Development Mechanism Potential in the Waste Sector.

Projects	Method	Reference	Status
Ulu Tualang & Bukit Palong Bundled Landfill Gas Management Project, Malaysia	AMS-III.G. ver. 6	NA	Under Validation
Ladang CEP Landfill Gas Management Project, Malaysia	AMS-III.G. ver. 6	NA	Under Validation
Pajam Landfill Gas Management Project, Malaysia	AMS-III.G. ver. 6	NA	Under Validation

From the above-mentioned 162 sites, a total of 14 projects are being developed under the Clean Development Mechanism (See table 7), they are either Registered CDM project activities and/or undergoing validation.

Therefore, N_{all} = 162 – 14 = 148.

Sub-step 4a (3)

Apart from several CDM-registered projects, there is only one landfill gas recovery activity (TPS Air Hitam Sanitary Landfill) that is similar to the proposed project activity which was not a CDM project originally. The project was funded and implemented as a demonstration project as a renewable energy demonstration initiative under a "Small Renewable Energy Programme" under the Energy Commission of Malaysia. The project was operated by Jana Landfill Sdn Bhd, a subsidiary of Tenaga Energy Services (a subsidiary of the national utility TNB) under the largest electricity supplier in Malaysia and Worldwide Landfill Sdn Bhd. since November 2003. The project, however, is rejected[18].

As all these projects were already excluded as part of Sub-step 4a (2), then the rest are considered to apply different technologies to the Project. Hence, N_{diff} = 148.

Sub-step 4a (4)

Calculate factor $F=1-N_{diff}/N_{all}$. The proposed project activity is regarded as common practice within a sector in the applicable geographical area if both the following conditions are fulfilled:
(a) The factor F is greater than 0.2; and
(b) $N_{all}-N_{diff}$ is greater than 3.

The factor F is calculated as 1 – (148/148), which is 0.

From the above, neither of these two conditions applies to the proposed CDM Project Activity. Hence, the conditions of sub-step4a (4) are met and the project is additional.

Step 4b. The proposed CDM project activity(s) does not apply any of the measures that are listed in the definitions section above:

As demonstrated, similar activities are not widely observed and commonly carried out in Malaysia, when we discard the other CDM projects, there is no other activities are currently delivering the

[18] https://cdm.unfccc.int/Projects/DB/RINA1329296417.81/view

same output as the proposed project activity, it can be concluded the project is not a common practice in Malaysia.

Outcome of Step 4:

From the common practice analysis, it is concluded that either no gas management or passive venting method are common practices in landfills in Malaysia. Landfill gas projects that are similar are all implemented with consideration of CDM.

The proposed project activity is not regarded as "common practice". In conclusion, with steps 4a and 4b satisfied, this **project activity is additional**.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

The following equation based on ACM0001 (*Version 18.0*) was used to calculate the baseline emissions on a particular year *y*:

$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$ *(Equation 1 of ACM0001)*

Where:

BE_y	Baseline emissions in year *y* (t CO_2e/yr)
$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
$BE_{EC,y}$	Baseline emissions associated with electricity generation in year *y* (t CO_2/yr)
$BE_{HG,y}$	Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
$BE_{NG,y}$	Baseline emissions associated with natural gas use in year *y* (t CO_2/yr)

The project does not involve heat generation and natural gas use and hence, $BE_{HG,y}$ and $BE_{NG,y}$ = 0. The following revised equation was used to calculate the baseline emissions on a particular year *y*:

$BE_y = BE_{CH4,y} + BE_{EC,y}$ *(Revised equation 1 of ACM0001)*

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

The following equation based on ACM0001 (*Version 18.0*) was used to calculate the baseline emissions of methane from the SWDS in year *y*:

$BE_{CH4,y} = [(1 – OX_{top\_layer}) \times F_{CH4,PJ,y} – F_{CH4,BL,y}] \times GWP_{CH4}$ *(Equation 2 of ACM0001)*

Where:

$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year *y* (t CO_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)[19]

[19] $OX_{top-layer}$ is the fraction of the methane in the LFG that would oxidize in the top layer of the SWDS in the absence of the project activity. Under the project activity, this effect is reduced as a part of the LFG is captured and does not pass through the top layer of the SWDS. This oxidation effect is also accounted for in the methodological tool "Emissions from solid waste disposal sites". In addition to this effect, the installation of a LFG capture system under the project activity may result in the suction of additional air into the SWDS. In

$F_{CH4,PJ,y}$	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$	Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr)
GWP_{CH4}	Global warming potential of CH_4 (t CO_2e/t CH_4)

According to ACM0001 (*Version 18.0*), the default values applicable are for the following data and parameters:

- OX_{top_layer} = 0.1
- GWP_{CH4} = 25 t CO_2e/t CH_4 (With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report)

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

Ex-post estimation

The following equation for ex-post estimation based on ACM0001 (*Version 18.0*) is used to calculate the amount of methane in the LFG which is flared and/or used in the project activity in year *y*:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$$ *(Equation 3 of ACM0001)*

Where:

$F_{CH4,PJ,y}$	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,flared,y}$	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,EL,y}$	Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/yr)
$F_{CH4,HG,y}$	Amount of methane in the LFG which is used for heat generation in year *y* (t CH_4/yr)
$F_{CH4,NG,y}$	Amount of methane in the LFG which is sent to the natural gas distribution network and/or to the trucks in year *y* (t CH_4/yr)

The project does not involve heat generation and natural gas use and hence, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ = 0. The following revised equation is used to calculate the baseline emissions on a particular year *y*:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y}$$ *(Revised equation 3 of ACM0001)*

(1.1.1) Amount of methane in the LFG which is destroyed by flaring in year *y* ($F_{CH4,flared,y}$)

The following equation based on ACM0001 (*Version 18.0*) was used to calculate the amount of

some cases, such as with a high suction pressure, the air may decrease the amount of methane that is generated under the project activity. However, in most circumstances where the LFG is captured and used this effect was considered to be very small, as the operators of the SWDS have in most cases an incentive to main a high methane concentration in the LFG. For this reason, this effect is neglected as a conservative assumption.

methane in the LFG which is destroyed by flaring in year *y*:

$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - (PE_{flare,y} / GWP_{CH4})$ *(Equation 4 of ACM0001)*

Where:

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

According to ACM0001 (*Version 18.0*), the default value applicable is for the following data and parameter:

- GWP_{CH4} = 25 t CO_2e/t CH_4 (With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report)

(1.1.1.1) Amount of methane in the LFG which is sent to the flare in year *y* ($F_{CH4,sent\_flare,y}$)

$F_{CH4,sent\_flare,y}$ is determined using the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*). $F_{CH4,sent\_flare,y}$ is determined on a dry basis.

The following table based on Table 2 of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to determine the measurement option applicable for this project activity:

Option	Flow of gaseous stream	Volumetric fraction
B	Volume flow – wet basis	Dry basis

<u>Absolute humidity of the gaseous stream</u>

The absolute humidity is a parameter required for Option B. It is determined by assuming the gaseous stream is dry or saturated in a simplified conservative approach (Option 2).

It is conservative to assume that the gaseous stream is saturated and so, $m_{H2O,t,db}$ is assumed to be equal to the saturation absolute humidity ($m_{H2O,t,db,sat}$). The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the saturation absolute humidity in time interval *t* on a dry basis:
$m_{H2O,t,db,Sat} = (p_{H2O,t,Sat} \times MM_{H2O}) / [(P_t - P_{H2O,t,Sat}) \times MM_{t,db}]$

(Equation 4 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream")

Where:

$m_{H2O,t,db,Sat}$	Saturation absolute humidity in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$p_{H2O,t,Sat}$	Saturation pressure of H_2O at temperature T_t in time interval *t* (Pa)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)
P_t	Absolute pressure of the gaseous stream in time interval *t* (Pa)
$MM_{t,db}$	Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a

gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2Okg/kmol H_2O

<u>Molecular mass of the gaseous stream in a time interval *t* on a dry basis ($MM_{t,db}$)</u>

The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the molecular mass of the gaseous stream in a time interval *t* on a dry basis:

$$MM_{t,db} = \sum_{k} (v_{k,t,db} \times MM_k)$$

(Equation 3 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream")

Where:

$MM_{t,db}$	Molecular mass of the gaseous stream in a time interval *t* on a dry basis (kg dry gas/kmol dry gas)
$v_{k,t,db}$	Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (m^3 gas k/m^3 dry gas)
MM_k	Molecular mass of gas *k* (kg/kmol)
k	All gases, except H_2O, contained in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs). See available simplification below

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_k = as per the table below:

Compound	Structure	Molecular mass (kg/kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04
Oxygen	O_2	32.00

<u>Mass flow of methane gas CH_4 in the gaseous stream in minute *m* ($F_{CH4,m}$)</u>

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the mass flow of methane gas CH_4 in the gaseous stream in minute *m*:

$$F_{CH4,m} = V_{m,db} \times v_{CH4,m,db} \times \rho_{CH4,m}$$

(Equation 5 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream")

$$\rho_{CH4,m} = (P_m \times MM_{CH4}) / R_u \times T_m$$

(Equation 6 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream")

Where:

$F_{CH4,m}$	Mass flow of methane gas CH_4 in the gaseous stream in minute *m* (kg gas/h)
$v_{m,db}$	Volumetric flow of the gaseous stream in minute *m* on a dry basis (m^3 dry gas/h)
$v_{CH4,m,db}$	Volumetric fraction of methane gas CH_4 in the gaseous stream in minute *m* on a dry basis (m^3 CH_4/m^3 dry gas)
$\rho_{CH4,m}$	Density of methane gas CH_4 in the gaseous stream in minute *m* (kg CH_4/m^3 CH_4)
P_m	Absolute pressure of the gaseous stream in minute *m* (Pa)
MM_{CH4}	Molecular mass of methane gas CH_4 (kg/kmol)
R_u	Universal ideal gases constant (Pa.m^3/kmol.K)
T_m	Temperature of the gaseous stream in minute *m* (K)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default values applicable are for the following data and parameters:

- MM_{CH4} = 16.04 kg/kmol
- R_u = 8,314 Pa.m^3/kmol.K

$F_{CH4,m}$ is then used to determine the amount of methane in the LFG which is sent to the flare in year *y* ($F_{CH4,sent\_flare,y}$).

Volumetric flow of the gaseous stream in time interval *t* on a dry basis ($v_{t,db}$)

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the volumetric flow of the gaseous stream in time interval *t* on a dry basis:

$$v_{t,db} = v_{t,wb} / (1 + v_{H2O,t,db})$$

(Equation 7 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$v_{t,db}$	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m^3 dry gas/h)
$v_{t,wb}$	Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m^3 wet gas/h)
$v_{H2O,t,db}$	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O/m^3 dry gas)

Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis ($v_{H2O,t,db}$)

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis:

$$v_{H2O,t,db} = (m_{H2O,t,db} \times MM_{t,db}) / MM_{H2O}$$

(Equation 8 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$v_{H2O,t,db}$	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m^3 H_2O/m^3 dry gas)
$m_{H2O,t,db}$	Absolute humidity in the gaseous stream in time interval *t* on a dry basis (kg H_2O/kg dry gas)
$MM_{t,db}$	Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2O/kmol H_2O

The calculations of absolute humidity in the gaseous stream in time interval *t* on a dry basis ($m_{H2O,t,db}$) and molecular mass of the gaseous stream in time interval *t* on a dry basis ($MM_{t,db}$) are as shown respectively in *Equation 4* and *Equation 3* of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) above.

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

$PE_{flare,y}$ is determined using the methodological tool "Project emissions from flaring" (*Version 02.0.0*). LFG is flared through more than one flare, and hence, $PE_{flare,y}$ is the sum of the emissions for each flare determined separately.

$PE_{flare,y}$ calculation procedure is given in the following steps:

- Step 1: Determination of the methane mass flow of the residual gas
- Step 2: Determination of the flare efficiency
- Step 3: Calculation of project emissions from flaring

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

$F_{CH4,m}$, mass flow of methane in the residual gaseous stream in the minute *m* is determined using the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*). $F_{CH4,m}$ is determined on a dry basis.

According to the methodological tool "Project emissions from flaring" (*Version 02.0.0, EB 68, Annex 15*), the following is applicable for this project:

- 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 (equations (3) and (17) in the tool). Equation 17 is not applicable for this project; and
- The time interval *t* for which mass flow should be calculated is every minute *m*.

The following table based on Table 2 of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to determine the measurement

option applicable for this project activity:

Option	Flow of gaseous stream	Volumetric fraction
B	Volume flow – wet basis	Dry basis

Absolute humidity of the gaseous stream

The absolute humidity is a parameter required for Option B. It is determined by assuming the gaseous stream is dry or saturated in a simplified conservative approach (Option 2).

It is conservative to assume that the gaseous stream is saturated and so, $m_{H2O,t,db}$ is assumed to be equal to the saturation absolute humidity ($m_{H2O,t,db,sat}$). The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the saturation absolute humidity in time interval *t* on a dry basis (*t* = minute, *m*):

$$m_{H2O,m,db,Sat} = (p_{H2O,m,Sat} \times MM_{H2O}) / [(P_m - P_{H2O,m,Sat}) \times MM_{m,db}]$$

(Equation 4 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$m_{H2O,m,db,Sat}$	Saturation absolute humidity in minute *m* on a dry basis (kg H_2O/kg dry gas)
$p_{H2O,m,Sat}$	Saturation pressure of H_2O at temperature T_m in minute *m* (Pa)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)
P_m	Absolute pressure of the gaseous stream in minute *m* (Pa)
$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2O/kmol H_2O

Molecular mass of the gaseous stream in minute *m* on a dry basis ($MM_{m,db}$)

The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the molecular mass of the gaseous stream in minute *m* on a dry basis:

$$MM_{m,db} = \sum_k (v_{k,m,db} \times MM_k)$$

(Equation 3 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)
$v_{k,m,db}$	Volumetric fraction of gas *k* in the gaseous stream in minute *m* on a dry basis (m^3 gas k/m^3 dry gas)

MM_k	Molecular mass of gas *k* (kg/kmol)
k	All gases, except H_2O, contained in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs). See available simplification below

For this project activity, k = CO_2, CH_4 and O_2.

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_k = as per the table below:

Compound	Structure	Molecular mass (kg/kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04
Oxygen	O_2	32.00

<u>Mass flow of methane gas CH_4 in the gaseous stream in minute *m* ($F_{CH4,m}$)</u>

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the mass flow of methane gas CH_4 in the gaseous stream in minute *m*:

$$F_{CH4,m} = v_{m,db} \times v_{CH4,m,db} \times \rho_{CH4,m}$$

(Equation 5 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

$$\rho_{CH4,m} = (P_m \times MM_{CH4}) / R_u \times T_m$$

(Equation 6 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$F_{CH4,m}$	Mass flow of methane gas CH_4 in the gaseous stream in minute *m* (kg gas/h)
$v_{m,db}$	Volumetric flow of the gaseous stream in minute *m* on a dry basis (m^3 dry gas/h)
$v_{CH4,m,db}$	Volumetric fraction of methane gas CH_4 in the gaseous stream in minute *m* on a dry basis (m^3 CH_4/m^3 dry gas)
$\rho_{CH4,m}$	Density of methane gas CH_4 in the gaseous stream in minute *m* (kg CH_4/m^3 CH_4)
P_m	Absolute pressure of the gaseous stream in minute *m* (Pa)
MM_{CH4}	Molecular mass of methane gas CH_4 (kg/kmol)
R_u	Universal ideal gases constant (Pa.m^3/kmol.K)
T_m	Temperature of the gaseous stream in minute *m* (K)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default values applicable are for the following data and parameters:

- MM_{CH4} = 16.04 kg/kmol

- R_u = 8,314 Pa.m^3/kmol.K

$F_{CH4,m}$ is then used to determine the mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$).

Volumetric flow of the gaseous stream in minute *m* on a dry basis ($v_{m,db}$)

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the volumetric flow of the gaseous stream in minute *m* on a dry basis:

$$v_{m,db} = v_{m,wb} / (1 + v_{H2O,m,db})$$

(Equation 7 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$v_{m,db}$	Volumetric flow of the gaseous stream in minute *m* on a dry basis (m^3 dry gas/h)
$v_{m,wb}$	Volumetric flow of the gaseous stream in minute *m* on a wet basis (m^3 wet gas/h)
$v_{H2O,m,db}$	Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis (m^3 H_2O/m^3 dry gas)

Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis ($v_{H2O,m,db}$)

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis:

$$v_{H2O,m,db} = (m_{H2O,m,db} \times MM_{m,db}) / MM_{H2O}$$

(Equation 8 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$v_{H2O,m,db}$	Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis (m^3 H_2O/m^3 dry gas)
$m_{H2O,m,db}$	Absolute humidity in the gaseous stream in minute *m* on a dry basis (kg H_2O/kg dry gas)
$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2O/kmol H_2O

The calculations of absolute humidity in the gaseous stream in minute *m* on a dry basis ($m_{H2O,m,db}$)

and molecular mass of the gaseous stream in minute *m* on a dry basis ($MM_{m,db}$) are as shown respectively in *Equation 4* and *Equation 3* of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) above.

Step 2: Determination of the flare efficiency

For this project, enclosed flares are used.

According to the methodological tool "Project emissions from flaring" (*Version 02.0.0*), Option A is applicable for the project activity:

Option A: Apply a default value for flare efficiency

The flares are not defined as low height flares.

According to the methodological tool "Project emissions from flaring" (*Version 02.0.0, EB 68, Annex 15*), 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:

- 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
- The flame is detected in minute *m* ($Flame_m$).

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

Step 3: Calculation of project emissions from flaring

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

The following equation based on the methodological tool "Project emissions from flaring" (*Version 02.0.0*) is used to calculate the project emissions from flaring of the residual gas in year *y*:

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

(Equation 15 of "Project emissions from flaring" tool)

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 (t CO_2e/t CH_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*

According to the methodological tool "Project emissions from flaring" (*Version 02.0.0*), the default values applicable are for the following data and parameters:

- GWP_{CH4} = 25 t CO_2e/t CH_4 (With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report)

(1.1.2) Amount of methane in the LFG which is used for electricity generation in year *y* ($F_{CH4,EL,y}$)

$F_{CH4,EL,y}$ is determined using the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) and monitoring the working hours of the power plant(s). This is taken into account by monitoring the hours that the equipment utilizing the LFG is operating in year *y* ($Op_{j,h,y}$).

According to ACM0001 (*Version 18.0*), the following is applicable for this project:

- The gaseous stream the tool shall be applied to the LFG delivery pipeline to each item of electricity generation equipment *j*. $F_{CH4,EL,y}$ is then calculated as the sum of mass flows to each item of electricity generation equipment *j*;
- CH_4 is the greenhouse gas for which the 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). Equation 17 is not applicable for this project;
- The mass flow should be calculated on an hourly basis for each hour *h* in year *y*; and
- 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.

The following table based on Table 2 of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to determine the measurement option applicable for this project activity:

Option	Flow of gaseous stream	Volumetric fraction
B	Volume flow – wet basis	Dry basis

<u>Absolute humidity of the gaseous stream</u>

The absolute humidity is a parameter required for Option B. It is determined by assuming the gaseous stream is dry or saturated in a simplified conservative approach (Option 2).

It is conservative to assume that the gaseous stream is saturated and so, $m_{H2O,t,db}$ is assumed to be equal to the saturation absolute humidity ($m_{H2O,t,db,sat}$). The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the saturation absolute humidity in time interval *t* on a dry basis (*t* = minute, *m*):

$$m_{H2O,m,db,Sat} = (p_{H2O,m,Sat} \times MM_{H2O}) / [(P_m - P_{H2O,m,Sat}) \times MM_{m,db}]$$

(Equation 4 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$m_{H2O,m,db,Sat}$	Saturation absolute humidity in minute *m* on a dry basis (kg H_2O/kg dry gas)
$p_{H2O,m,Sat}$	Saturation pressure of H_2O at temperature T_m in minute *m* (Pa)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)
P_m	Absolute pressure of the gaseous stream in minute *m* (Pa)
$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2O/kmol H_2O

<u>Molecular mass of the gaseous stream in minute *m* on a dry basis ($MM_{m,db}$)</u>

The following equation based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the molecular mass of the gaseous stream in minute *m* on a dry basis:

$$MM_{m,db} = \sum_{k} (v_{k,m,db} \times MM_k)$$

(Equation 3 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)
$v_{k,m,db}$	Volumetric fraction of gas *k* in the gaseous stream in minute *m* on a dry basis (m^3 gas k/m^3 dry gas)
MM_k	Molecular mass of gas *k* (kg/kmol)
k	All gases, except H_2O, contained in the gaseous stream (e.g. N_2, CO_2, O_2, CO, H_2, CH_4, N_2O, NO, NO_2, SO_2, SF_6 and PFCs). See available simplification below

For this project activity, *k* = CO_2, CH_4 and O_2.

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_k = as per the table below:

Compound	Structure	Molecular mass (kg/kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04
Oxygen	O_2	32.00

Mass flow of methane gas CH_4 in the gaseous stream in minute *m* ($F_{CH4,m}$)

The following equation for Option B based on the methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (*Version 03.0*) is used to calculate the mass flow of methane gas CH_4 in the gaseous stream in minute *m*:

$$F_{CH4,m} = v_{m,db} \times v_{CH4,m,db} \times \rho_{CH4,m}$$

(Equation 5 of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” tool)

$$\rho_{CH4,m} = (P_m \times MM_{CH4}) / R_u \times T_m$$

(Equation 6 of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” tool)

Where:

$F_{CH4,m}$	Mass flow of methane gas CH_4 in the gaseous stream in minute *m* (kg gas/h)
$v_{m,db}$	Volumetric flow of the gaseous stream in minute *m* on a dry basis (m^3 dry gas/h)
$v_{CH4,m,db}$	Volumetric fraction of methane gas CH_4 in the gaseous stream in minute *m* on a dry basis (m^3 CH_4/m^3 dry gas)
$\rho_{CH4,m}$	Density of methane gas CH_4 in the gaseous stream in minute *m* (kg CH_4/m^3 CH_4)
P_m	Absolute pressure of the gaseous stream in minute *m* (Pa)
MM_{CH4}	Molecular mass of methane gas CH_4 (kg/kmol)
R_u	Universal ideal gases constant (Pa.m^3/kmol.K)
T_m	Temperature of the gaseous stream in minute *m* (K)

According to the methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (*Version 03.0*), the default values applicable are for the following data and parameters:

- MM_{CH4} = 16.04 kg/kmol
- R_u = 8,314 Pa.m^3/kmol.K

$F_{CH4,m}$ is then used to determine the amount of methane in the LFG which is used for electricity generation in year *y* ($F_{CH4,EL,y}$).

Volumetric flow of the gaseous stream in minute *m* on a dry basis ($v_{m,db}$)

The following equation for Option B based on the methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (*Version 03.0*) is used to calculate the volumetric flow of the gaseous stream in minute *m* on a dry basis:

$$v_{m,db} = v_{m,wb} / (1 + v_{H2O,m,db})$$

(Equation 7 of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” tool)

Where:

$v_{m,db}$	Volumetric flow of the gaseous stream in minute *m* on a dry basis (m^3 dry gas/h)
$v_{m,wb}$	Volumetric flow of the gaseous stream in minute *m* on a wet basis (m^3 wet

	gas/h)
$v_{H2O,m,db}$	Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis (m^3 H_2O/m^3 dry gas)

Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis ($v_{H2O,m,db}$)

The following equation for Option B based on the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) is used to calculate the volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis:

$$v_{H2O,m,db} = (m_{H2O,m,db} \times MM_{m,db}) / MM_{H2O}$$

(Equation 8 of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" tool)

Where:

$v_{H2O,m,db}$	Volumetric fraction of H_2O in the gaseous stream in minute *m* on a dry basis (m^3 H_2O/m^3 dry gas)
$m_{H2O,m,db}$	Absolute humidity in the gaseous stream in minute *m* on a dry basis (kg H_2O/kg dry gas)
$MM_{m,db}$	Molecular mass of the gaseous stream in minute *m* on a dry basis (kg dry gas/kmol dry gas)
MM_{H2O}	Molecular mass of H_2O (kg H_2O/kmol H_2O)

According to the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*), the default value applicable is for the following data and parameter:

- MM_{H2O} = 18.0152 kg H_2O/kmol H_2O

The calculations of absolute humidity in the gaseous stream in minute *m* on a dry basis ($m_{H2O,m,db}$) and molecular mass of the gaseous stream in minute *m* on a dry basis ($MM_{m,db}$) are as shown respectively in *Equation 4* and *Equation 3* of the methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*) above.

Ex-ante estimation

The following equation for ex-ante estimation based on ACM0001 (*Version 18.0*) was used to calculate the amount of methane in the LFG which is flared and/or used in the project activity in year *y*:

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4} \quad \text{(Equation 5 of ACM0001)}$$

Where:

$F_{CH4,PJ,y}$	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
η_{PJ}	Efficiency of the LFG capture system that will be installed in the project activity
$BE_{CH4,SWDS,y}$	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (t CO_2e/yr)
GWP_{CH4}	Global warming potential of CH_4 (t CO_2e/t CH_4)

According to ACM0001 (*Version 18.0*), the default value applicable is for the following data and parameter:

- GWP_{CH4} = 25 t CO_2e/t CH_4 (With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report)

(1.1.3) Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* ($BE_{CH4,SWDS,y}$)

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites" (*Version 07.*0).

According to paragraph 3 of the methodological tool "Emissions from solid waste disposal sites" (*Version 07.0*), Application A is applicable for the project activity:

Application A: The CDM project activity mitigates methane emissions from a specific existing SWDS. Methane emissions are mitigated by capturing and flaring or combusting the methane (e.g. "ACM0001: Flaring or use of landfill gas"). The methane is generated from waste disposed in the past, including prior to the start of the CDM project activity. In these cases, the tool is only applied for an ex-ante estimation of emissions in the project design document (CDM-PDD). The emissions will then be monitored during the crediting period using the applicable approaches in the relevant methodologies (e.g. measuring the amount of methane captured from the SWDS).

Since the project is not eligible as Application B, "Simplified procedure to determine methane emissions from the SWDS" as per paragraph 11 of methodological tool "Emissions from solid waste disposal sites" (*Version 07.0*) is not applicable.

The amount of methane generated from disposal of waste at the SWDS is calculated based on a first order decay (FOD) model[20]. The basis selected are yearly calculations, i.e. $BE_{CH4,SWDS,y}$ using equation 1 and consecutive years, i.e. *x*.

According to ACM0001 (*Version 18.0*), the following are applicable for this project:

- f_y in the tool is 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 ACM0001;
- *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 is obtained from previous studies.

The following equation based on the methodological tool "Emissions from solid waste disposal sites" (*Version 07.0*) was used to calculate the baseline methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y*:

$$BE_{CH4,SWDS,y} = \varphi_y \times (1 - f_y) \times GWP_{CH4} \times (1 - OX) \times 16/12 \times F \times DOC_{f,y} \times MCF_y \times \sum_{x=1}^{y} \sum_{j} [W_{j,x} \times DOC_j \times e^{-k_j \times (y-x)} \times (1 - e^{-k_j})]$$

(Equation 1 of "Emissions from solid waste disposal sites" tool)

[20] As an approximation, methane generation in the SWDS is described as a function of time according to a first order decay process with rapid, moderate and slow degrading organic fractions distinguished.

Where:

$BE_{CH4,SWDS,y}$	Baseline methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y* (t CO_2e/yr)
φ_y	Model correction factor to account for model uncertainties for year *y*
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*
GWP_{CH4}	Global warming potential of CH_4 (t CO_2e/t CH_4)
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
F	Fraction of methane in the SWDS 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 SWDS in the year *x* (t)
DOC_j	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
k	Decay rate for the waste type *j* (1 / yr)
j	Type of residual waste or types of waste in the MSW
x	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (*x* = 1) to year *y* (*x* = *y*)
y	Year of the crediting period for which methane emissions are calculated (*y* is a consecutive period of 12 months)

Referring to methodological tool “Emissions from solid waste disposal sites” (*Version 07.0*):

- Option 1 (use a default value) is chosen to determine the model correction factor (φ_y)

According to methodological tool “Emissions from solid waste disposal sites” (*Version 07.0*), the default values applicable are for the following data and parameters:

- φ_y = 0.75 (default value for the model correction factor under application A, humid/wet conditions)
- f_y = 0 because no methane captured at the SWDS and flared, combusted or used in another manner in the BL scenario

- GWP_{CH4} = 25 t CO_2e/t CH_4 (With reference to decision 4/CMP7 and paragraph 66 of the EB 69 Meeting Report)

- OX = 0.1

- F = 0.5

- $DOC_{f,y}$ = $DOC_{f,default}$ for Application A, i.e. 0.5

- MCF_y = $MCF_{default}$ for Application A, i.e. 1.0 for anaerobic managed solid waste disposal site

- DOC_j as per the table below:

Waste type *j*	DOC_j (% wet waste)
Wood and wood products	43
Pulp, paper and cardboard (other than sludge)	40
Food, food waste, beverages and tobacco (other than sludge)	15
Textiles	24
Nappies	24
Garden, yard and park waste	20
Glass, plastic, metal, other inert waste	0

- k_j as per the table below:

Waste type *j*		Tropical (MAT > 20°C)
		Wet (MAP > 1,000 mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.07
	Wood, wood products and straw	0.035
Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.40

(1.2) Amount of methane in the LFG that would be flared in the baseline in year *y* ($F_{CH4,BL,y}$)

The following table based on Table 3 of ACM0001 (*Version 18.0*) was used to determine the amount of methane in the LFG that would be flared in the baseline in year *y*:

Situation at the start of the project activity	Requirement to destroy methane	Existing LFG capture and destruction system
Case 1	No	No

Hence, in this situation, $F_{CH4,BL,y}$ = 0 (Equation 6 of ACM0001).

(2) Baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$)

$BE_{EC,y}$ is determined using the methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (*Version 02.0*).

According to the methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (*Version 02.0*), Scenario A is applicable for the project activity:

Scenario A: Electricity consumption from the grid. The electricity is purchased from the grid only, and either no captive power plant(s) is/are installed at the site of electricity consumption or, if any captive power plant exists on site, it is either not operating or it is not physically able to provide electricity to the of electricity consumer.

According to ACM0001 (*Version 18.0*), the following are applicable for this project:

- 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* ($EG_{PJ,y}$).

The following generic equation based on the methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*) was used to calculate the baseline emissions associated with electricity generation in year *y*:

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

(Equation 2 of "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" *tool)*

Where:

$BE_{EC,y}$	Baseline emissions from electricity consumption in year *y* (t CO_2/yr)
$EC_{BL,k,y}$	Quantity of electricity that would be consumed by the baseline electricity consumption source *k* in year *y* (MWh/yr)
$EF_{EL,k,y}$	Emission factor for electricity generation for source *k* in year *y* (t CO_2/MWh)
$TDL_{k,y}$	Average technical transmission and distribution losses for providing electricity to source *k* in year *y*
k	Sources of electricity consumption in the baseline

Emission factor for electricity generation for source *k* in year *y* ($EF_{EL,k,y}$)

In the registered revised PDD Ver 19.0 dated 02/09/2016, the 2013 emission factor of 0.742 tCO_2/MWh was calculated using "Tool to calculate the emission factor for an electricity system", version 04.0.

For this renewal crediting period, the emission factor is calculated using:

- Latest national data: The published data by Green Tech Centre (GTC) CDM Secretariat 2014; and
- Latest calculation tool: The Version 05.0 of "Tool to calculate the emission factor for an electricity system" valid from 27/11/2015 onward.
    - The emission factor published by GTC in 2014 applied the weighting factors of both OM and BM emission as 0.5 using version 04.0 of the tool, which are not applicable for the renewal crediting period. As a result, the emission factor of 2014 is recalculated using W_{OM} = 0.25 and W_{BM} = 0.75 according to the "Tool to calculate the emission factor for an electricity system", version 05.0, paragraph 84 (b). The detail calculation of CM is described in step 6 below.

The baseline emission factor *(EFy)* is calculated as a Combined Margin (CM) consists of Operating Margin (OM) and the Build Margin *(BM)* factors, according to the following three steps:

1. Calculation of the Simple Operating Margin
2. Calculation of the Simple Adjusted Operating Margin
3. Calculation of Build Margin

In accordance to the above-mentioned tool, the following six steps were applied:

Step 1. Identify the relevant electric power system

There are 3 electricity grid systems in Malaysia – namely the Peninsular Malaysia national grid operated by the Tenaga Nasional Berhad (TNB, largest national utility company in Malaysia), the Sarawak State grid operated by Sarawak Energy Corporation and Sabah State grid operated by Sabah Electricity Supply Berhad (SESB). The electricity supply to the Bukit Tagar today is imported from the national grid of Peninsular Malaysia.

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

This step is optional. Off-grid power plants is not included in the calculation

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

The methodology to calculate the Operating Margin is based on one of the following methods:

- Simple OM, or
- Simple adjusted OM, or
- Dispatch Data Analysis OM, or
- Average OM.

This study used both the Simple OM and Simple adjusted OM method to determine the baselines for Malaysia.

The analysis of the baselines was then carried out using Simple OM and Simple Adjusted OM because the low-cost/must run resources in Peninsular Malaysia constitute less than 50%.

Step 4. Calculate the operating margin emission factor according to the selected method.

<u>Simple OM</u>

The Simple OM is calculated as the generation-weighted emissions per electricity unit of all generating units serving the system, excluding low-operating cost and must-run power plants. It may be calculated with two options:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit, or

Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

Option A - Calculation based on average efficiency and electricity generation of each plant is selected to calculate the operating margin emission factor

Under this option, the simple OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

The $EF_{grid,OMsimple,y}$ is calculated based on the following formula:

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

(Equation 3 of "Tool to calculate the emission factor for an electricity system"*)*

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m	All power units serving the grid in year y except low-cost/must-run power units
y	The relevant year as per the data vintage chosen in Step 3. (Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option)

The emission factors of each power unit m are determined using the following option:

Option A1 - If for a power unit m data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_{m,y}}$$

(Equation 4 of "Tool to calculate the emission factor for an electricity system"*)*

Where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
$FC_{i,m,y}$	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)
$EF_{CO2,i,y}$	CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)
$EG_{m,y}$	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)
m	All power units serving the grid in year y except low-cost/must-run power units
i	All fuel types combusted in power unit m in year y

Option A2 - If for a power unit *m* only data on electricity generation and the fuel types used is available, the emission factor should be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as follows:

$$EF_{EL,m,y} = \frac{EF_{co2,m,i,y} \times 3.6}{\eta_{m,y}}$$

(Equation 5 of "Tool to calculate the emission factor for an electricity system"*)*

Where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
$EF_{CO2,m,i,y}$	Average CO2 emission factor of fuel type i used in power unit m in year y (t CO_2/GJ)
$\eta_{m,y}$	Average net energy conversion efficiency of power unit m in year y (ratio)
m	All power units serving the grid in year y except low-cost/must-run power units
i	All fuel types combusted in power unit m in year y

Where several fuel types are used in the power unit, use the fuel type with the lowest CO_2 emission factor for $EF_{CO2,m,i,y}$.

Option A1 is selected for the calculation. The Simple OM is calculated using the data of all operational fossil fuel fired power plants generating electricity to the grid for the year 2014.

The calculations of OM were based on specific individual plant specific data as provided by the Energy Commission. Based on data availability and reliability, the conservative method was adopted to estimate the fuel consumption of electricity generating plants.

The operating margin for 2014 is tabulated as below:

Table 4: Operating Margin for Peninsular Malaysia, 2014[21]

Grid System	Operating Margin (tCO_2/MWh)
Peninsular Malaysia	0.6532

Simple Adjusted OM

The Simple Adjusted OM. emission factor ($EF_{OM,simple\ adjusted,y}$) is a variation on the previous method, where the power sources (including imports) are separated in low-cost/must-run power sources (k) and other power sources (/). As with the simple OM, it can be calculated as follows:

$$EF_{grid,OM-adj,y} = (1-\lambda_y) \times \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} + \lambda_y \times \frac{\sum_k EG_{k,y} \times EF_{EL,k,y}}{\sum_k EG_{k,y}}$$

(Equation 10 of “Tool to calculate the emission factor for an electricity system”*)*

Where $EG_{j,y}$. and $EG_{k,y}$ are analogous to the variables described for the simple OM method and where $EF_{EL,j,y}$. and $EF_{ELk,y}$. should be determined as the simple OM method above. The indices *j* and *k* are subsets of all power sources *m* supplying electricity to the grid in year y, where power plants *k;* which are either low-cost or are must-run and j refers to the remaining power plants/unit.

The parameter λ_y is defined as follows:

[21] Latest available data (2014) obtained from Green Tech Centre (GTC) CDM Secretariat.

$$\lambda_y(\%) = \frac{Number\ of\ hours\ \text{low} - \text{cost/must} - \text{run}\ are\ on\ the\ margin\ in\ year\ y}{8760\ hours\ per\ year}$$

(Equation 11 of "Tool to calculate the emission factor for an electricity system"*)*

There are two approaches to determine lambda (λ_y):

Approach 1. Use default values of lambda from Table 1 Appendix 3 based on the share of electricity generation from low-cost/must-run in total generation derived using 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production. Approach 1 can only be applied if the LASL is not less than one-third of the HASL in a project electricity/ grid system demonstrated based on the yearly data for the years used to determine the OM emission factor.

Approach 2. Lambda (λ_y) should be determined by applying the step wise procedure provided in Appendix 4.

Approach 2 is selected to determine lambda (λ_y).

Step i) Plot a Load Duration Curve. Collect chronological load data (typically in MW) for each hour of a year, and sort load data from highest to lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Organize Data by Generating Sources. Collect data for, and calculate total annual generation (in MWh) from low-cost/must-run resources (i.e. *"*$\sum_k GEN_{k,y}$*).*

Step iii) Fill Load Duration Curve. Plot a horizontal line across load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from low-cost/must-run resources (i.e. *"*$\sum_k GEN_{k,y}$*)*

Step iv) Determine the Number of hours per year for which low-cost/must-run sources are on the margin. First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run resources are on the margin. If the lines do not intersect, then one may conclude that low-cost/must-run sources do not appear on the margin and λ_y is equal to zero. Lambda (λ_y) is the calculated number of hours divided by 8760.

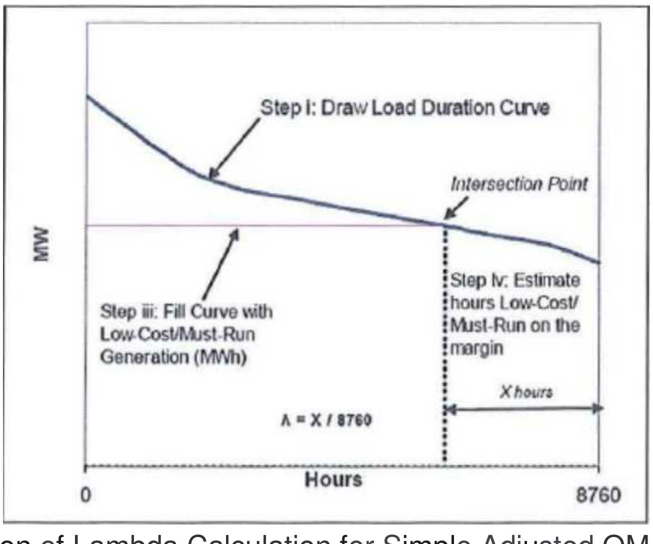
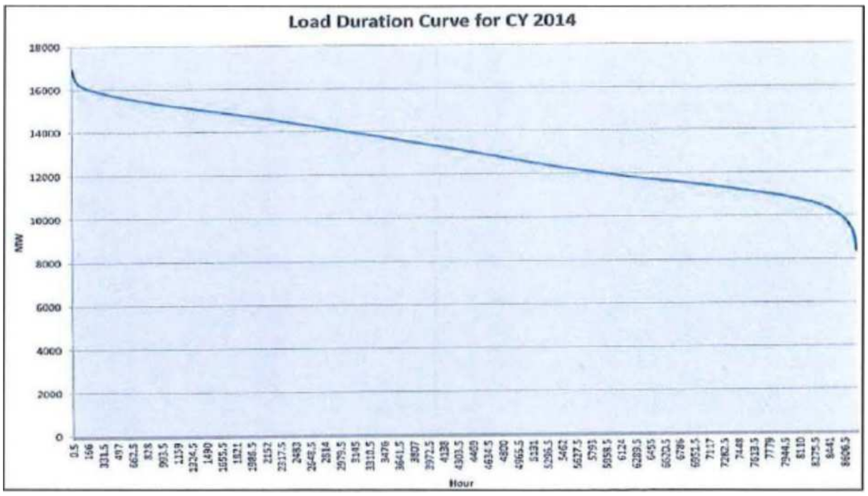


Illustration of Lambda Calculation for Simple Adjusted OM Method

The Lambda (λ_y) calculation for the Simple Adjusted OM is to determine whether the low-cost/must-run resources (Hydro) are operating at margin. The lambda calculation shows that there is no intersection of the horizontal line plotted (low-cost/must-run resources) in step (iii) and the load duration curve plotted in step (i) for Peninsular Malaysia grid.

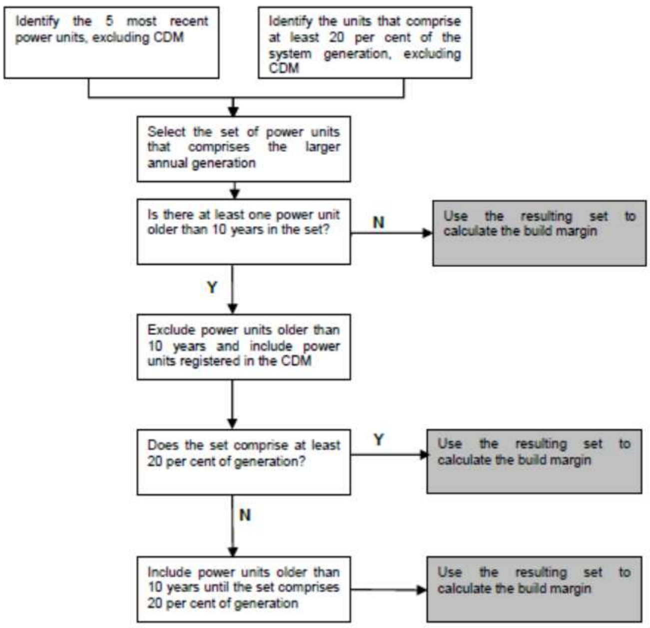
These results indicate that the low-cost/must-run resources are not operating at margin at any hours in a year for Peninsula Malaysia grid. Hence the value of lambda is zero. When calculating the Simple Adjusted OM, it was found that the results were similar to those for the Simple OM. This is due to the fact that low-cost/must-run sources constitute less than 50% of the total grid generation, and it can be demonstrated by the Simple OM that the low-cost/must-run sources do not operate on margin.



Load Duration Curve and Low-Cost/Must-Run Resources (Hydro) - Peninsular Malaysia for 2014 (Source – Tenaga National Berhad)

Step 5. Calculate the build margin (BM) emission factor

The sample group of powers unit's m used to calculate the build margin should be determined as per the following procedure:



Procedure to determine the sample group of powers units' m used to calculate the build margin

(g) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently (SET 5-units) and determine their annual electricity generation (AEG SET-5-units, in MWh);

(h) Determine the annual electricity generation of the project electricity system, excluding power units registered as COM project activities (AEG total, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG total (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 (AEG SET≥20%, in MWh);

(i) From SET 5-units and SET≥20% select the set of power units that comprises the larger annual electricity generation (SET sample); Identify the date when the power units in SET sample started to supply electricity to the grid. If none of the power units in SET sample started to supply electricity to the grid more than 10 years ago, then use SET sample to calculate the build margin. In this case ignore step (d), (e) and (f).

Otherwise:

(j) Exclude from SET sample the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set (SET sample CDM) the annual electricity generation (AEG SET-sample-COM, in MWh);

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. AEG SET-sample CDM ≥ 0.2 x AEG total), then use the sample group SET sample-COM to calculate the build margin. Ignore steps (e) and (f).

Otherwise:

(k) Include in the sample group SET sample-COM the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

(l) The sample group of power units m used to calculate the build margin is the resulting set (SET sample-CDM->10yrs).

In terms of vintage of data, project participants can choose between one of the following two options: These include:

Option 1: For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. This option does not require monitoring the emission factor during the crediting period.

Option 2: For the second crediting period, the build margin emissions factor shall be calculated ex ante, as described in Option 1 above.

Option 1 was selected for the calculation – For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. The calculations of build margin are based on the weighted average emissions of the 5 most recently installed power plants in Peninsular Malaysia.

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

(Equation 15 of "Tool to calculate the emission factor for an electricity system"*)*

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emissions factor in year *y* (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m	Power units included in the build margin
y	Most recent historical year for which power generation data is available

Table 5: Build Margin for Peninsular Malaysia, 2014[22]

Region	tCO_2/MWh
Peninsula Malaysia	0.735

Step 6. Calculate the combined margin (CM) emissions factor

The combined margin emissions factor is calculated as follows:

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

(Equation 16 of "Tool to calculate the emission factor for an electricity system"*)*

Where:

$EF_{grid,CM,y}$	Combined margin CO_2 emissions factor in year y (tCO_2/MWh)
$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year (tCO_2/MWh)
W_{OM}	Weighting of operating margin emissions factor (%)
W_{BM}	Weighting of built margin emissions factor (%)

However, the above-mentioned report (2014) applied the weighting factors of both OM and BM emission are 0.5, which is not applicable for the renewal crediting period.

According to the Version 05.0 of "Tool to calculate the emission factor for an electricity system" For the following default values are used in the renewal crediting period:

W_{OM} = 0.25 and W_{BM} = 0.75.

[22] Latest available data (2014) obtained from Green Tech Centre (GTC) CDM Secretariat

The renewal crediting period, the CM emissions factor is derived as follows:

Table 6: Combined Margin for Peninsular Malaysia, 2014

Simple Operating Margin (A) tCO_2/MWh	Build Margin (B) tCO_2/MWh	Combined Margin (A*0.25) + (B*0.75) tCO_2/MWh
0.6532	0.735	0.7146

Project Emissions

The following equation based on ACM0001 (*Version 18.0*) was used to calculate the project emissions on a particular year *y*:

$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y}$ *(Equation 22 of ACM0001)*

Where:

PE_y	Project emissions in year *y* (t CO_2e/yr)
$PE_{EC,y}$	Emissions from consumption of electricity due to the project activity in year *y* (t CO_2/yr)
$PE_{FC,y}$	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year *y* (t CO_2/yr)
$PE_{DT,y}$	Emissions from the distribution of compressed/liquefied LFG using trucks, in year *y* (t CO_2/yr)

The project does not involve consumption from the distribution of compressed/liquefied LFG and hence, $PE_{DT,y} = 0$.

The following revised equation was used to calculate the project emissions on a particular year *y*:

$PE_y = PE_{EC,y} + PE_{FC,y}$ *(Revised equation 22 of ACM0001)*

(1) Emissions from consumption of electricity due to the project activity in year *y* ($PE_{EC,y}$)

$PE_{EC,y}$ is determined using the methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*).

According to the methodological tool "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (*Version 02.0*), Scenario A is applicable for the project activity:

Scenario A: Electricity consumption from the grid. The electricity is purchased from the grid only, and either no captive power plant(s) is/are installed at the site of electricity consumption or, if any captive power plant exists on site, it is either not operating or it is not physically able to provide electricity to the of electricity consumer.

According to ACM0001 (*Version 18.0*), the following are applicable for this project:

- $EC_{PJ,k,y}$ 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). For this project activity, $F_{CH4,BL,y} = 0$.

The following generic equation based on the methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (*Version 02.0*) was used to calculate the project emissions associated with electricity generation in year *y*:

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

(Equation 1 of “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” *tool)*

Where:

$PE_{EC,y}$	Project emissions from electricity consumption in year *y* (t CO_2/yr)
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source *j* in year *y* (MWh/yr)
$EF_{EL,j,y}$	Emission factor for electricity generation for source *j* in year *y* (tCO_2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*
j	Sources of electricity consumption in the project

<u>Emission factor for electricity generation for source *k* in year *y* ($EF_{EL,j,y}$)</u>

According to the methodological tool “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” (*Version 02.0*), Option A1 is applicable for the project activity:

Option A1: Calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the “Tool to calculate the emission factor for an electricity system” ($EF_{EL,j,y} = EF_{grid,CM,y}$).

For this project activity, the value of $EF_{EL,j,y}$ is obtained from the latest release of grid emission factor 2014 by Green Tech Centre (GTC) CDM Secretariat. The grid emission factor 2014 was calculated based on the methodological tool “Tool to calculate the emission factor for an electricity system” (*Version 4.0*), which was then recalculated for this project activity using Version 05.0 of the tool.

(2) Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation in year *y* ($PE_{FC,y}$)

For $PE_{FC,y}$, for this project, is the emission from diesel backup generators. In ex-ante emission calculation, the diesel consumption is considered zero, because the diesel generator installed at the site is used only in emergency case when no electricity import from the national grid.
The fuel consumption will be monitored during the actual implementation.

$PE_{FC,j,y} = \sum FC_{i,j,y} \times COEF_{i,y}$

(Equation 1 of Tool *to calculate project or leakage CO_2 emissions from fossil fuel combustion)*

Where:

$PE_{FC,j,y}$	CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr)
$FC_{i,j,y}$	Quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr)
$COEF_{i,y}$	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)

Option B is selected to calculate $COEF_{i,y}$, 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:

$COEF_{i,y} = NCV_{,i,y} \times EF_{CO2,I,y}$

(Equation 4 of Tool *to calculate project or leakage CO_2 emissions from fossil fuel combustion)*

Where:

$COEF_{i,y}$	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
$NCV_{,i,y}$	Weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,I,y}$	Weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)

Leakage

No leakage effects are accounted for under this methodology.

Emission reductions

The following equation based on ACM0001 (*Version 18.0*) was used to calculate the emission reductions on a particular year *y*:

$ER_y = BE_y – PE_y$ *(Equation 25 of ACM0001)*

Where:

ER_y	Emission reductions in year y (t CO2e/yr)
BE_y	Baseline emissions in year y (t CO2e/yr)
PE_y	Project emissions in year y (t CO2/yr)

B.6.2. Data and parameters fixed ex ante

The applicable data and parameters which are not monitored in this project include:

ACM0001: “Flaring or use of landfill gas” (Version 18.0)

Data / Parameter	OX_{top_layer}
Unit	Dimensionless
Description	Fraction of methane that would be oxidized in the top layer of the SWDS in the baseline
Source of data	Consistent with how oxidation is accounted for in the methodological tool “Emissions from solid waste disposal sites”
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global warming potential of CH4
Source of data	IPCC
Value(s) applied	25
Choice of data or Measurement methods and procedures	Shall be updated according to any future COP/MOP decisions
Purpose of data	Baseline emission calculation
Additional comment	25 for the second commitment period. 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	-
Value(s) applied	90%
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	Technical specifications of the LFG capture system to be installed (if available) or a default value of 90%

"Emissions from solid waste disposal sites" (Version 07.0)

Data / Parameter	$\varphi_{default}$
Unit	-
Description	Default value for the model correction factor to account for model uncertainties
Source of data	-
Value(s) applied	0.75
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emission calculation
Additional comment	$\Phi_y = \varphi_{default}$. 0.75 for Application A, humid/wet conditions

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	Based on an extensive review of published literature on this subject, including the "IPCC 2006 Guidelines for National Greenhouse Gas Inventories"
Value(s) applied	0.1
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emission calculation
Additional comment	NA

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	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	**$DOC_{f,default}$**
Unit	Weight fraction
Description	Default value for the 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	-
Purpose of data	Baseline emission calculation
Additional comment	$DOC_{f,y} = DOC_{f,default}$.

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	-
Purpose of data	Baseline emission calculation
Additional comment	$MCF_y = MCF_{default}$.

<table>
<tr><td>Data / Parameter</td><td>DOC_j</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Fraction of degradable organic carbon in the waste type j (weight fraction)</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Value(s) applied</td><td>The following values for the different waste types j are applied:

Default values for DOC_j
<table>
<tr><th>Waste type j</th><th>DOC_j (% wet waste)</th></tr>
<tr><td>Wood and wood products</td><td>43</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td></tr>
<tr><td>Textiles</td><td>24</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td></tr>
</table></td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

<table>
<tr><td>Data / Parameter</td><td>k_j</td></tr>
<tr><td>Unit</td><td>1/yr</td></tr>
<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>The following values for the different waste types j are applied:

Default values for k_j
<table>
<tr><td colspan="2" rowspan="2">Waste type j</td><td>Tropical (MAT > 20°C)</td></tr>
<tr><td>Wet (MAP > 1,000 mm)</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.40</td></tr>
</table>

Note: MAT – mean annual temperature, MAP – mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

"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 and maintenance schedule
Source of data	Flare manufacturer
Value(s) applied	Minimum and maximum operating temperature = 0 to 1,200 °C Minimum and maximum inlet flow rate = 0 – 2,500 Nm^3/h
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

"Baseline, project and/ or leakage emissions from electricity consumption and monitoring of electricity generation" (Version 02.0)

Data / Parameter	$TDL_{k,y}$
Unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *k* in year *y*
Source of data	Tenaga Nasional Berhad (TNB) Annual Report 2016[23] in page 61
Value(s) applied	7.74%
Choice of data or Measurement methods and procedures	Average calculated from year 2014 – 2016 2014 – 8.15% 2015 – 7.68% 2016 – 7.39%
Purpose of data	Project emissions calculation and baseline emissions
Additional comment	For the project emission calculation, TDL of 7.74% is applied from 2017 onwards. 7.74% is calculated from the average of TDL from year 2014-2016, the % of the average TDL calculated is higher if compare to TDL in year 2016. This can be concluded that the TDL 7.74% apply for project emission from 2017 onwards is considered conservative approach.

[23] https://www.tnb.com.my/assets/annual_report/TNB_Annual_Report_2016.pdf

“Tool to calculate the emission factor for an electricity system” (Version 05.0)

Data / Parameter	$EF_{grid,OM,y}$
Unit	tCO_2/MWh
Description	Operating margin emission factor for the grid in year *y*
Source of data	2014 Grid connected baseline for Peninsular Malaysia by Green Tech Centre (GTC) CDM Secretariat
Value(s) applied	0.6532 tCO_2/MWh
Choice of data or Measurement methods and procedures	The $EF_{grid,OM,y}$ was calculated and published by Green Tech Centre (GTC) CDM Secretariat in 2014 using version 04.0 of the tool. For 2nd crediting period, the emission factor of 2014 is recalculated using W_{OM} = 0.25 according to the “Tool to calculate the emission factor for an electricity system”, version 05.0, paragraph 84 (b).
Purpose of data	Calculation of Combined margin emissions factor $EF_{grid,CM,y}$
Additional comment	-

Data / Parameter	$EF_{grid,BM,y}$
Unit	tCO_2/MWh
Description	Build margin emission factor for the grid in year *y*
Source of data	2014 Grid connected baseline for Peninsular Malaysia by Green Tech Centre (GTC) CDM Secretariat
Value(s) applied	0.7350 tCO_2/MWh
Choice of data or Measurement methods and procedures	The $EF_{grid,BM,y}$ was calculated and published by Green Tech Centre (GTC) CDM Secretariat in 2014 using version 04.0 of the tool. For 2nd crediting period, the emission factor of 2014 is recalculated using W_{BM} = 0.75 according to the “Tool to calculate the emission factor for an electricity system”, version 05.0, paragraph 84 (b).
Purpose of data	Calculation of Combined margin emissions factor $EF_{grid,CM,y}$
Additional comment	-

Data / Parameter	$EF_{grid,CM,y}$
Unit	tCO_2/MWh
Description	Combined margin emission factor for the grid in year *y*
Source of data	2014 Grid connected baseline for Peninsular Malaysia by Green Tech Centre (GTC) CDM Secretariat
Value(s) applied	0.7146 tCO_2/MWh
Choice of data or Measurement methods and procedures	The $EF_{grid,CM,y}$ is calculated using published data by Green Tech Centre (GTC) CDM Secretariat in 2014 using version 04.0 of the tool. For 2nd crediting period, the emission factor of 2014 is recalculated according to the “Tool to calculate the emission factor for an electricity system”, version 05.0
Purpose of data	Baseline and project emissions calculation
Additional comment	-

"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0)

Data / Parameter	**MM_{H2O}**
Unit	kg/kmol
Description	Molecular mass of H_2O
Source of data	Methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*)
Value(s) applied	18.0152
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	**R_u**
Unit	Pa.m^3 /kmol.K
Description	Universal ideal gases constant
Source of data	Methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*)
Value(s) applied	8,314
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	**MM_{CO2}**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas CO_2
Source of data	Methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (*Version 03.0*)
Value(s) applied	44.01
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	**MM_{CH4}**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas CH_4
Source of data	Methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (*Version 03.0*)
Value(s) applied	16.04
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	**MM_{O2}**
Unit	kg/kmol
Description	Molecular mass of gas O_2
Source of data	Methodological tool “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (*Version 03.0*)
Value(s) applied	32.00
Choice of data or Measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

B.6.3. Ex ante calculation of emission reductions

Ex-ante calculations of emission reductions are implemented in accordance to the equations shown in **Section B.6.1** above.

Total baseline emissions

$BE_y = BE_{CH4,y} + BE_{EC,y}$ *(Revised equation 1 of ACM0001)*

Crediting Year	Baseline emissions of methane from SWDS (tCO_2e)	Baseline emissions from power generation (tCO_2e)	Total BE (tCO_2e)
28/08/2016 – 31/12/2016	80,972	11,092	92,064
01/01/2017 – 31/12/2017	236,410	33,385	269,795
01/01/2018 – 31/12/2018	228,904	33,385	262,289
01/01/2019 – 31/12/2019	232,539	36,723	269,263
01/01/2020 – 31/12/2020	235,226	40,062	275,288
01/01/2021 – 31/12/2021	243,389	40,062	283,451
01/01/2022 – 31/12/2022	250,323	40,062	290,385
01/01/2023 – 27/08/2023	171,660	26,708	198,368

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

$BE_{CH4,y} = [(1 – OX_{top\_layer}) \times F_{CH4,PJ,y} – F_{CH4,BL,y}] \times GWP_{CH4}$ *(Equation 2 of ACM0001)*

Crediting Year	OX_{top_layer}	$F_{CH4,PJ,y}$	$F_{CH4,BL,y}$	GWP_{CH4}	$BE_{CH4,y}$
28/08/2016 – 31/12/2016	0.1	3,599	0	25	80,972
01/01/2017 – 31/12/2017	0.1	10,507	0	25	236,410
01/01/2018 – 31/12/2018	0.1	10,174	0	25	228,904
01/01/2019 – 31/12/2019	0.1	10,335	0	25	232,539
01/01/2020 – 31/12/2020	0.1	10,454	0	25	235,226
01/01/2021 – 31/12/2021	0.1	10,817	0	25	243,389
01/01/2022 – 31/12/2022	0.1	11,125	0	25	250,323
01/01/2023 – 27/08/2023	0.1	7,629	0	25	171,660

As per ACM0001, $F_{CH4,PJ,y}$ is estimated as follow:

$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$ *(Equation 5 of ACM0001)*

Crediting Year	η_{PJ}	$BE_{CH4,SWDS,y}$ captured (tCO_2e)	GWP_{CH4}	$F_{CH4,PJ,y}$
28/08/2016 – 31/12/2016	0.90	99,966	25	3,599
01/01/2017 – 31/12/2017	0.90	291,864	25	10,507
01/01/2018 – 31/12/2018	0.90	282,598	25	10,174
01/01/2019 – 31/12/2019	0.90	287,086	25	10,335
01/01/2020 – 31/12/2020	0.90	290,402	25	10,454
01/01/2021 – 31/12/2021	0.90	300,480	25	10,817
01/01/2022 – 31/12/2022	0.90	309,040	25	11,125
01/01/2023 – 27/08/2023	0.90	211,926	25	7,629

$BE_{CH4,SWDS,y} = \varphi_y \times (1 - f_y) \times GWP_{CH4} \times (1 - OX) \times 16/12 \times F \times DOC_{f,y} \times MCF_y \times \sum \sum [W_{j,x} \times DOC_j \times e^{-kj \times (y-x)} \times (1 - e^{-kj})]$

(Equation 1 of "Emissions from solid waste disposal sites" tool)

The amount of solid waste type *j* disposed in the SWDS in the year *x* is tabulated as below:

Year	Type of waste						Total (t)
	Food waste	Paper / cardboard	Textiles	Wood	Garden and park waste	Nappies	
2016	468,141	182,672	21,019	43,484	26,767	37,490	779,573
2017	457,577	178,549	20,545	42,503	26,163	36,644	761,981
2018	476,596	185,971	21,399	44,269	27,250	38,167	793,652
2019	500,426	195,269	22,469	46,483	28,613	40,075	833,335
2020	525,447	205,033	23,592	48,807	30,043	42,079	875,002
2021	551,719	215,284	24,772	51,247	31,546	44,183	918,752
2022	579,305	226,049	26,011	53,809	33,123	46,392	964,689
2023	608,271	237,351	27,311	56,500	34,779	48,712	1,012,924

Crediting Year	$BE_{CH4,SWDS,y}$ captured (tCO_2e)
28/08/2016 – 31/12/2016	99,966
01/01/2017 – 31/12/2017	291,864
01/01/2018 – 31/12/2018	282,598
01/01/2019 – 31/12/2019	287,086
01/01/2020 – 31/12/2020	290,402
01/01/2021 – 31/12/2021	300,480
01/01/2022 – 31/12/2022	309,040
01/01/2023 – 27/08/2023	211,926

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

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

(Equation 2 of "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" *tool)*

The value of $EF_{EL,k,y}$ (for 2014 is 0.7146 tCO_2/MWh) is recalculated from the latest release of grid emission factor published by Green Tech Centre (GTC) CDM Secretariat, based on the methodological tool "Tool to calculate the emission factor for an electricity system" (*Version 5.0*). The Transmission and Distribution Loses ($TDL_{k,y}$) value applied in this project is 7.74%. This value is calculated from the average of TDL from 2014-2016 obtained from TNB 2016 annual report[24].

In addition, according to ACM0001, $EC_{BL,k,y}$ is equivalent to the net amount of electricity generated using LFG in year *y* ($EG_{PJ,y}$). $EF_{EL,k,y} = EF_{grid,CM,y}$ and therefore,

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

(Revised equation 2 of "Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" *tool)*

The baseline emissions associated with electricity generation ($BE_{EC,y}$) are as follow:

Crediting Year	Estimated power generation from LFG (MWh)	CoEF of grid power (tCO_2eq/MWh)	$TDL_{,k,y}$	Ex-ante emissions (tCO_2e) from power generation
28/08/2016 – 31/12/2016	14,454	0.7146	0.0739	11,092
01/01/2017 – 31/12/2017	43,362	0.7146	0.0774	33,385
01/01/2018 – 31/12/2018	43,362	0.7146	0.0774	33,385
01/01/2019 – 31/12/2019	47,698	0.7146	0.0774	36,723
01/01/2020 – 31/12/2020	52,034	0.7146	0.0774	40,062
01/01/2021 – 31/12/2021	52,034	0.7146	0.0774	40,062
01/01/2022 – 31/12/2022	52,034	0.7146	0.0774	40,062
01/01/2023 – 27/08/2023	34,690	0.7146	0.0774	26,708

[24] https://www.tnb.com.my/assets/annual_report/TNB_Annual_Report_2016.pdf

Total project emissions

$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y}$ *(Equation 22 of ACM0001)*

The project does not involve consumption from the distribution of compressed/liquefied LFG and hence, $PE_{DT,y} = 0$.

The following revised equation was used to calculate the project emissions on a particular year *y*:

$PE_y = PE_{EC,y} + PE_{FC,y}$ *(Revised equation 22 of ACM0001)*

Crediting Year	Project emissions (tCO_2e) from power consumption	Project emissions (tCO_2e) from fossil fuel consumption	Total PE (tCO_2e)
28/08/2016 – 31/12/2016	182	0	182
01/01/2017 – 31/12/2017	510	0	510
01/01/2018 – 31/12/2018	510	0	510
01/01/2019 – 31/12/2019	619	0	619
01/01/2020 – 31/12/2020	729	0	729
01/01/2021 – 31/12/2021	729	0	729
01/01/2022 – 31/12/2022	729	0	729
01/01/2023 – 27/08/2023	486	0	486

Notes:
Flare 1 has stop operating from 03/01/2017 onwards, as a result, there is no power consumption of electricity from the grid from 03/01/2017 onwards.

Project emissions from consumption of electricity due to the project activity ($PE_{EC,y}$)

A table showing the estimated average annual power consumption for the flaring and power generation system is as below:

Estimated average annual power consumption for the flaring and power generation system		
Flare 1	50	MWh
Flare 2	37	MWh
1.2MW GE	113	MWh
3.12MW GE (2013 onwards)	239	MWh
Gas Supply System 1 (GSS 1) (2013 onwards)	55	MWh
2MW GE (2016 onwards)	160	MWh
GSS 2 (2016 onwards)	57	MWh
4MW GE (2019 onwards)	206	MWh
GSS 3 (2019 onwards)	79	MWh

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

(Equation 1 of “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” *tool)*

The value of $EF_{EL,k,y}$ (0.7146 tCO_2/MWh for 2014) is recalculated from the latest release of grid emission factor published by Green Tech Centre (GTC) CDM Secretariat, based on the methodological tool “Tool to calculate the emission factor for an electricity system” (*Version 5.0*). The Transmission and Distribution Loses ($TDL_{k,y}$) value applied in this project is 7.74%. This value is calculated from the average of TDL from 2014-2016 obtained from TNB 2016 annual report.

The project emissions from consumption of electricity due to the project activity ($PE_{EC,y}$) are as follow:

Crediting Year	Electricity consumption (MWh)	CoEF	TDL	$PE_{EC,y}$ (tCO_2e)
28/08/2016 – 31/12/2016	237	0.7146	0.0739	182
01/01/2017 – 31/12/2017	662	0.7146	0.0774	510
01/01/2018 – 31/12/2018	662	0.7146	0.0774	510
01/01/2019 – 31/12/2019	804	0.7146	0.0774	619
01/01/2020 – 31/12/2020	947	0.7146	0.0774	729
01/01/2021 – 31/12/2021	947	0.7146	0.0774	729
01/01/2022 – 31/12/2022	947	0.7146	0.0774	729
01/01/2023 – 27/08/2023	631	0.7146	0.0774	486

Project emissions from consumption of fossil fuels due to the project activity ($PE_{FC,y}$)

$PE_{FC,y}$, for this project is the emission from diesel backup generators. In ex-ante emission calculation, the diesel consumption is considered zero, because the diesel generator installed at the site is used only in emergency case when there is no electricity import from the national grid. The fuel consumption will be monitored during the actual implementation.

During the actual implementation, to calculate ex-ante $PE_{FC,y}$, the *“Tool to calculate project or leakage CO2 emissions from fossil fuel combustion” (Version 2)* will be used.

Leakage

According to ACM0001 (*Version 18.0*), no leakage effects need to be accounted for in this project.

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

Year	Baseline emissions (tCO_2e)	Project emissions (tCO_2e)	Leakage (tCO_2e)	Emission reductions (tCO_2e)
28/08/2016 – 31/12/2016	92,064	182	0	91,882
01/01/2017 – 31/12/2017	269,795	510	0	269,285
01/01/2018 – 31/12/2018	262,289	510	0	261,779
01/01/2019 – 31/12/2019	269,263	619	0	268,643
01/01/2020 – 31/12/2020	275,288	729	0	274,559
01/01/2021 – 31/12/2021	283,451	729	0	282,722
01/01/2022 – 31/12/2022	290,385	729	0	289,656
01/01/2023 – 27/08/2023	198,368	486	0	197,882
Total	**1,940,901**	**4,493**	0	**1,936,408**
Total number of crediting years	**7**			
Annual average over the crediting period	**277,272**	**642**	**0**	**276,630**

Note: According to CDM Project Standard for Project Activities, version 2.0, Section 8.3.5, Paragraph 241 (a) (i) (a), the CERs estimated (2019 – 2023) above for the increase capacity of 4MW gas engines is only claimed up to 20% (additional 1.1 MW) of the upload capacity stated in original registered PDD (5.5MW).

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

The applicable data and parameters which are monitored in this project include:

ACM0001: "Flaring or use of landfill gas – Version 18.0"

Data / Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Source of data	Different sources of data available: (a) Original design of the landfill; (b) Technical specifications for the management of the SWDS; or (c) Local or national regulations.
Value(s) applied	Local or national regulations
Measurement methods and procedures	Refer to the original design of the landfill to monitor any practice to increase methane generation during the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity will be justified by referring to technical or regulatory specifications.
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	-
Additional comment	-

Data / Parameter	$Op_{j,h}$
Unit	-
Description	Operation of the equipment that consumes the LFG
Source of data	Project participant
Value(s) applied	On or Off for flare temperature and gas engine
Measurement methods and procedures	For each equipment unit using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: • Temperature – Determine the location for temperature measurements and minimum operational temperature based on manufacturer's specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD; • Flame – Flame detection system is used to ensure that the equipment is in operation; • Products generated. Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnaces. This option is not applicable to brick kilns Flare temperature will be selected for the monitoring. Gas engine operation hour will be used for cross checking. $Op_{j,h}$ = 0 when: • One of more temperature measurements are missing or below the minimum threshold in hour *h* (instantaneous measurements are made at least every minute); or • Flame is not detected continuously in hour *h* (instantaneous measurements are made at least every minute). • No products are generated in the hour h. • If gas engine not in operation. Otherwise, $Op_{j,h}$ = 1.
Monitoring frequency	Hour
QA/QC procedures	The operation of the equipment that consume the LFG will be monitored using temperature. The parameter will be measured continuously using temperature transmitter. The transmitter sensor is installed at the middle top of the enclosed flare stack. Minimum operational temperature in the exhaust gas of the enclosed flare is 500°C. The exhaust gas from the enclosed flares is expected to be in the range of 800-1,200°C. Temperatures above 500°C indicate that the flare is operated in a reliable way where the default value of destruction efficiency of 90% is valid. Temperature transmitter shall be tested, calibrated and maintained regularly. The detail information on the temperature is described under $T_{EG,m}$.

	The other method to cross check with the temperature is the operation of gas engines. The operating hour for gas engines is based on actual documented operating hours from site.
Purpose of data	Baseline emissions calculation
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	23,883MWh/year (Based on approved Monitoring Report No.9)
Measurement methods and procedures	Net electricity generation by the project activity using LFG is monitored. The amount of electricity generated is recorded by installed electricity meters (EL4, EL9, EL10, EL14 and EL15). (Figure 10).
Monitoring frequency	Continuous
QA/QC procedures	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 electricity distribution company. As a quality control procedure, the amount of electricity actually uploaded to grid will be measured by other electricity meters (EL5, EL11 and EL16) and compared with the net amount derived from above. Lower value of the amount will be taken as the net amount for emission reductions calculations. EL13 (Amount of electricity uploaded to grid from Gas Engine No. 4) no longer in used as the amount of electricity actually uploaded to grid for Gas Engine No.4, Gas Engine No.5 and Gas Engine No.6 will be monitored by EL16. The comparison is tabulated as below: **Electricity Meter** **Installed on-site** / **Owned by Grid Operator** EL4 / EL5 EL9 and EL10 / EL11 EL12, EL14 and EL15 / EL16 In the case of temporary situation where EL16 malfunctions leading to no readings captured, the power generated and uploaded to grid for Gas Engine No.4, Gas Engine No.5 and Gas Engine No.6 will use the reading captured by EL12, EL14 and EL15. The recorded reading shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6). The lower bound of 95% confidence interval with reference to the above-mentioned guideline will be applied. An additional 10% will be deducted to the lower bound of the interval boundaries calculated to account for transmission and distribution losses, according to paragraph 231 b)(ii) of "CDM Project Standard for CDM project activities" (Version 02.0).

	According to CDM Project Standard for Project Activities, version 2.0, Section 8.3.5, Paragraph 241 (a) (i) (a), the CERs estimated (2019 – 2023) above for the increase capacity of 4MW gas engines is only claimed up to 20% (additional 1.1 MW) of the upload capacity stated in original registered PDD (5.5MW). The total maximum upload capacity of 6.6MW will be demonstrated using the actual electricity generated divided by the operation hour. In the case of the total actual electricity uploaded to grid is more than 6.6MW, the additional MW will be deducted from the calculation. The additional MW (from any of the GEs) will be calculated by using the actual electricity generated and upload to grid divided by the operation hour (MWh). Electricity meters (except the meter owned by the grid operator, i.e. EL5, EL11 and EL16[25]) will be checked and calibrated regularly according to manufacturer's recommendations.
Purpose of data	Baseline emissions calculation
Additional comment	This parameter is required for calculating baseline emissions associated with electricity generation ($\boldsymbol{BE_{EC,y}}$) using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". The meters EL5, EL11 and EL16[26] are owned by the grid operator and thus, they are not within the control of the project. The calibration of the meters will be based on the grid operator's requirement and standard practice.

[25] Inclusive of any other similar and corresponding meters to be installed by the grid operator in the future.

[26] Inclusive of any other similar and corresponding meters to be installed by the grid operator in the future.

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	2,171 MWh/year (Based on approved Monitoring Report No.9)
Measurement methods and procedures	The consumption of electricity ex-post will be measured by ammeters (electricity meters). The quantity of electricity consumed by project activity will be recorded by installed electricity meter EL6 which measures the total electricity consumed by the project activity (Flare 2, Gas Engine No.1, Gas Engine No.2, Gas Engine No.3, Gas Engine No.4, GSS No.1, GSS No.2 and GSS F1[27]) (Figure 10). In case of temporary situation such as the installed electricity meter (EL6) malfunctions leading to no readings captured, $EG_{EC,y}$ shall be estimated or calculated as described as below: 1. Using the back-up meter EL1 which records the actual power consumption for Flare 2 and GSS F1; 2. For Gas Engine No. 2, Gas Engine No.3, Gas Engine No.4, GSS No.1 and GSS No.2, the power consumption will be estimated using the power rating (technical specifications) of the system involved during the power generation. The power consumed will be calculated based on the operating maximum capacity for the full period, including the 10% addition to account for transmission and distribution losses, according to paragraph 231 b)(ii) of "CDM Project Standard for CDM project activities" (Version 02.0). In the case of project GHG emissions related to the consumption of electricity, the estimate shall include an addition of 10% to account for transmission and distribution losses. In the case of temporary situation where EL1 malfunctions leading to no readings captured, the power consumption for Flare 2 and GSS F1 will use the estimated historical data (Sept 2014 to Aug 2016) of 56.93 MWh per month and compared with the calculated future 24 months' data prior to the malfunction period and, whichever value that is higher will be applied for the project emissions calculation. The higher power consumption selected for the project emissions calculation shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6). The upper bound of 95% confidence interval with reference to the above-mentioned guideline will be applied. An additional 10% will be

[27] Inclusive of components in the project activity to be installed in the future.

	added to the upper bound of the interval boundaries calculated to account for transmission and distribution losses, according to paragraph 231 b)(ii) of "CDM Project Standard for CDM project activities" (Version 02.0). In the case of project GHG emissions related to the consumption of electricity, the estimate shall include an addition of 10% to account for transmission and distribution losses.
Monitoring frequency	Continuous
QA/QC procedures	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 electricity distribution company
Purpose of data	Project emissions calculation
Additional comment	This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process *t* ($PE_{EC,y}$) using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

"Emissions from solid waste disposal sites" (Version 07.0)

Data / Parameter	f_y
Unit	-
Description	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*
Source of data	Approved Monitoring Report No. 9
Value(s) applied	0.5545
Measurement methods and procedures	-
Monitoring frequency	For application A: Once for the crediting period ($f_y = f$)
QA/QC procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	This is for reporting purposes, and not applied in ER calculation

"Project emissions from flaring" (Version 02.0.0)

Data / Parameter	$T_{EG,m}$
Unit	°C
Description	Temperature in the exhaust gas of the enclosed flare in minute *m*
Source of data	Project participant
Value(s) applied	700.07°C (Annual average of Flare 1 and Flare 2 calculated based on approved Monitoring Report 09).
Measurement methods and procedures	Measure the temperature of the exhaust gas in the flare by an appropriate temperature measurement equipment. The temperature of the exhaust gas in the flares is measured by temperature transmitters The exhaust gas from the enclosed flares is expected to be in the range of 800-1,200°C. Temperatures above 500°C indicate that the flare is operated in a reliable way where the default value of destruction efficiency of 90% is valid. Minimum operational temperature in the exhaust gas of the enclosed flare is 500°C
Monitoring frequency	Once per minute
QA/QC procedures	Temperature measurement equipment is calibrated in accordance with the maintenance schedule
Purpose of data	Baseline emissions calculation
Additional comment	Any unexpected changes such as a sudden increase/drop in temperature will 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 participant
Value(s) applied	On or Off
Measurement methods and procedures	Measured using a fixed installation optical flame detector: Ultra Violet detector
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	The flame detection will be monitored and cross checked with the amount of gas sent to flare (FT2) and gas engine (FT3). If there is data for FT2 and FT3, means the flame is on. Equipment will be maintained and calibrated in accordance with manufacturer's recommendations
Purpose of data	Baseline emissions calculation
Additional comment	Applicable to all flares

“Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 03.0)

Data / Parameter	$v_{t,wb}$
Unit	m^3 wet gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a wet basis
Source of data	Onsite records of the flow meters. There is an independent flow meter to measure the gas sent to Flare 2 ($FT1_{F2}$ & $FT2_{F2}$), GSS1 ($FT3_{GSS1}$), GSS2 ($FT3_{GSS2}$), GSS3 ($FT3_{GSS3}$) and GSS F1 ($FT3_{GSSF1}$). There are two (2) sets of flow meter to measure the gas sent to Gas Engine No.4, Gas Engine No.5 and Gas Engine No. 6. 1st set of the meter will measure the total amount of gas sent to GSS2 ($FT3_{GSS2}$) and GSS3 ($FT3_{GSS3}$) before sent to respective gas engines. Another set of the meter will measure the total amount of gas sent to specific gas engine No. 4 (FT7), gas engine No. 5 (FT8) and gas engine No. 6 (FT9). In the case of temporary situation where $FT3_{GSS2}$ or $FT3_{GSS3}$ malfunctions leading to no readings captured, the flow of gas sent to gas engines will use the reading captured by respective flow meter (FT7, FT8 and FT9). The recorded reading shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6). The lower bound of 95% confidence interval with reference to the above-mentioned guideline will be applied. Alternately, the record from the daily manual log-sheet will be used to calculate the lower bound of 95% confidence interval. The lower bound of the interval boundaries calculated will be applied to the period for the constant data as a conservative approach. There are two (2) sets of flow meter ($FT1_{F2}$ & $FT2_{F2}$) to measure the gas sent to Flare 2. Flow obtained from $FT2_{F2}$ will be used for the calculation. During temporary malfunctioning of $FT2_{F2}$ or data logging system resulting in unrepresentative data, the value of $FT1_{F2}$ will be used for the calculation. According to CDM Project Standard for Project Activities, version 2.0, Section 8.3.5, Paragraph 241 (a) (i) (a), the CERs estimated (2019 – 2023) above for the increase capacity of 4MW gas engines is only claimed up to 20% (additional 1.1 MW) of the upload capacity stated in original registered PDD (5.5MW). In the case of the total actual electricity uploaded to grid is more than 6.6MW, the additional flow will be deducted from the calculation. The additional flow (from any of the flow meters) will be calculated based on the MWh calculated in $\mathbf{EG_{PJ,y}}$ by using the estimated unit amount of m^3 to produce the additional electricity generation.
Value(s) applied	31,523,707m^3/year (Based on approved Monitoring Report No.9)

Measurement methods and procedures	Instruments with recordable electronic signal (analogical or digital) is used
Monitoring frequency	Continuous if not specified in the underlying methodology
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory for all projects applying large scale methodology(ies). Calibration and frequency of calibration is according to manufacturer’s specifications
Purpose of data	Baseline emissions calculation
Additional comment	This parameter is monitored in Option B

Data / Parameter	$v_{CH4,m,db}$
Unit	m^3 gas CH_4/m^3 dry gas
Description	Volumetric fraction of greenhouse gas CH_4 in minute *m* on a dry basis
Source of data	Onsite records of the gas analyzers. In case of temporary situation such as the installed CH_4 gas analyser mal-functioned or giving unrepresentative results due to data logging problem, the V_{CH4} shall be measured manually with portable gas analyser. For any affected day, the calculation of the values measured using the portable analyser will be based on the Guidelines to calculate the fraction of methane in the landfill gas from periodical measurements (Version 01). As conservative approach, the lower bound of the 95% Confidence Interval will be applied as per guideline.
Value(s) applied	55.7% (Annual average calculated based on approved Monitoring Report No.9)
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	Continuous if not specified in the underlying methodology
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) 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	Baseline emissions calculation
Additional comment	This parameter is monitored in Option B

<table>
<tr><td>Data / Parameter</td><td>T_t</td></tr>
<tr><td>Unit</td><td>K</td></tr>
<tr><td>Description</td><td>Temperature of the gaseous stream in time interval t</td></tr>
<tr><td>Source of data</td><td>Onsite records of the temperature. In the case of temporary situation where T_t malfunctions leading to no readings captured, according to Tool to determine the mass flow of a greenhouse gas in a gaseous stream Version 03.0, data substitution procedure is as follow:
<table>
<tr><td>Duration of Missing Data</td><td>Data Substitution procedure</td></tr>
<tr><td>Less than six hours</td><td>Use the weighted average of the four hours period immediately before and four hours period immediately after the outage</td></tr>
<tr><td>Six to 24 hours</td><td>Use the upper bound of 95% confidence interval of the data spanning 24 hours prior to and 24 hours after the outage, whichever results in more conservative estimate of emission reductions</td></tr>
<tr><td>One to seven days</td><td>Use the upper bound of 95% confidence interval of the data spanning 72 hours prior to and 72 hours after the outage, whichever results in more conservative estimate of emission reductions</td></tr>
<tr><td>Greater than one week</td><td>No data may be substituted</td></tr>
</table>
</td></tr>
<tr><td>Value(s) applied</td><td>43.77°C (Annual average calculated based on approved Monitoring Report No.9)</td></tr>
<tr><td>Measurement methods and procedures</td><td>Instruments with recordable electronic signal (analogical or digital) is used</td></tr>
<tr><td>Monitoring frequency</td><td>Continuous unless differently specified in the underlying methodology</td></tr>
<tr><td>QA/QC procedures</td><td>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</td></tr>
<tr><td>Purpose of data</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comment</td><td>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 60ºC is adopted, this parameter must be monitored continuously to assure the applicability condition is met</td></tr>
</table>

<table>
<tr><td>Data / Parameter</td><td>P_t</td></tr>
<tr><td>Unit</td><td>Pa</td></tr>
<tr><td>Description</td><td>Pressure of the gaseous stream in time interval t</td></tr>
<tr><td>Source of data</td><td>Onsite records of the pressure sensors. In the case of temporary situation where P_t malfunctions leading to no readings captured, according to Tool to determine the mass flow of a greenhouse gas in a gaseous stream Version 03.0, data substitution procedure is as follow:
<table>
<tr><td>Duration of Missing Data</td><td>Data Substitution procedure</td></tr>
<tr><td>Less than six hours</td><td>Use the weighted average of the four hours period immediately before and four hours period immediately after the outage</td></tr>
<tr><td>Six to 24 hours</td><td>Use the lower bound of 95% confidence interval of the data spanning 24 hours prior to and 24 hours after the outage, whichever results in more conservative estimate of emission reductions</td></tr>
<tr><td>One to seven days</td><td>Use the lower bound of 95% confidence interval of the data spanning 72 hours prior to and 72 hours after the outage, whichever results in more conservative estimate of emission reductions</td></tr>
<tr><td>Greater than one week</td><td>No data may be substituted</td></tr>
</table></td></tr>
<tr><td>Value(s) applied</td><td>112,083Pa (Annual average calculated based on approved Monitoring Report No.9)</td></tr>
<tr><td>Measurement methods and procedures</td><td>Instruments with recordable electronic signal (analogical or digital) is used</td></tr>
<tr><td>Monitoring frequency</td><td>Continuous unless differently specified in the underlying methodology</td></tr>
<tr><td>QA/QC procedures</td><td>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</td></tr>
<tr><td>Purpose of data</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comment</td><td>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)</td></tr>
</table>

Data / Parameter	$P_{H2O,t,Sat}$
Unit	Pa
Description	Saturation pressure of H_2O at temperature T_t in time interval t
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0)
Value(s) applied	101,325 Pa
Measurement methods and procedures	This parameter is solely a function of the gaseous stream temperature T_t and can be found at reference [1] for a total pressure equal to 101,325 Pa
Monitoring frequency	-
QA/QC procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	[1] Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Borgnakke; 4º Edition 1994, John Wiley & Sons, Inc.

Data / Parameter	$v_{CO2,t,db}$
Unit	m^3 gas CO_2/m^3 dry gas
Description	Volumetric fraction of gas CO_2 in the gaseous stream in time interval t on a dry basis
Source of data	The vCO_2 shall be measured manually with portable gas analyser. A minimum sampling frequency of one sample per week to be conducted. As conservative approach, the lower bound of the 95% Confidence Interval will be applied for the data collected.
Value(s) applied	0
Measurement methods and procedures	Continuous gas analyser operating in dry-basis
Monitoring frequency	Continuous if not specified in the underlying methodology/tool
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) 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	Baseline emissions calculation
Additional comment	-

Data / Parameter	$v_{O2,t,db}$
Unit	m^3 gas O_2/m^3 dry gas
Description	Volumetric fraction of gas O_2 in the gaseous stream in time interval *t* on a dry basis
Source of data	On site measurement
Value(s) applied	0
Measurement methods and procedures	Continuous gas analyser operating in dry-basis
Monitoring frequency	Continuous if not specified in the underlying methodology/tool
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) 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	Baseline emissions calculation
Additional comment	-

Data / Parameter	Status of biogas destruction device
Unit	-
Description	Operational status of biogas destruction devices
Source of data	On-site measurement
Value(s) applied	On or off
Measurement methods and procedures	Monitoring and documenting may be undertaken by recording the energy production from methane captured or the operation of the flare by means of a flame detector to demonstrate the actual destruction of methane, unless a different method is specified in the underlying methodology/tool. Emission reductions will not accrue for periods in which the destruction device is not operational
Monitoring frequency	Continuous if not specified in the underlying methodology/tool
QA/QC procedures	The operational status will be monitored and cross checked with the amount of gas sent to flare (FT2), and also the operating hour for Gas Engines.
Purpose of data	Baseline emissions calculation
Additional comment	For flame detector devices, refer to the methodological tool “Project emissions from flaring”

"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02)

Data / Parameter	$FC_{i,j,y}$
Unit	ton/yr
Description	Quantity of fuel type i combusted in process j during the year y
Source of data	Onsite measurements
Value(s) applied	0
Measurement methods and procedures	Onsite measurement using fuel meter. The measurement from fuel meter is in litre, for the calculation, the amount of diesel in litre will be convert to tonne/year by multiply the density of diesel (kg/l).
Monitoring frequency	Continuously
QA/QC procedures	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	Project emissions calculation
Additional comment	-

Data / Parameter	$EF_{CO2,i,y}$
Unit	tCO_2/GJ
Description	Weighted average CO2 emission factor of fuel type i in year y
Source of data	Option A will be used if the value is available from the fuel supplier in invoices; Option D will be used if there is no data available from the fuel supplier.
Value(s) applied	0.0741
Measurement methods and procedures	Default (Option D was applied in the calculation) If the values are provided by fuel supplier, the measurements should be undertaken in line with national or international fuel standards. If the value is according to IPCC default value, any future revision of the IPCC Guidelines should be taken into account
Monitoring frequency	For a): The CO_2 emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For d): Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures	-
Purpose of data	Project emissions calculation
Additional comment	-

Data / Parameter	$NCV_{i,y}$
Unit	GJ/ton
Description	Weighted average net calorific value of fuel type i in year y
Source of data	Option A will be used if the value is available from the fuel supplier in invoices; Option D will be used if there is no data available from the fuel supplier.
Value(s) applied	43
Measurement methods and procedures	Default (Option D was applied in the calculation) If the values are provided by fuel supplier, the measurements should be undertaken in line with national or international fuel standards. If the value is according to IPCC default value, any future revision of the IPCC Guidelines should be taken into account
Monitoring frequency	For a): The NCV emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For d): Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures	If option A value is used for the calculation, verify if the values under a) 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) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data	Project emissions calculation
Additional comment	-

B.7.2. Sampling plan

Not applicable

B.7.3. Other elements of monitoring plan

The monitoring plan for this project includes all monitoring requirements following the procedures set by ACM0001 (version 18.0).

The main variables that need to be monitored during project activity include:

- Operation of the equipment that consumes the LFG
- Amount of electricity generated using LFG by the project activity in year *y*
- Amount of electricity consumed by the project activity in year *y*
- Temperature in the exhaust gas of the enclosed flare in minute *m*
- Flame detection of flare in the minute *m*
- Volumetric flow of the gaseous stream in time interval *t* on a wet basis

- Volumetric fraction of greenhouse gas CH_4 in minute *m* on a dry basis
- Pressure of the gaseous stream in time interval *t*
- Volumetric fraction of gas CH_4 in the gaseous stream in minute *m* on a dry basis
- Volumetric fraction of gas CO_2 in the gaseous stream in time interval *t* on a dry basis
- Volumetric fraction of gas O_2 in the gaseous stream in time interval *t* on a dry basis
- Operational status of biogas destruction devices
- Combined margin emission factor for the grid in year *y*

The monitoring measurement method and quality assurance/control description for the different parameters can be found in **Section B.7.1** above.

The overall monitoring plan can be illustrated in the figure below:

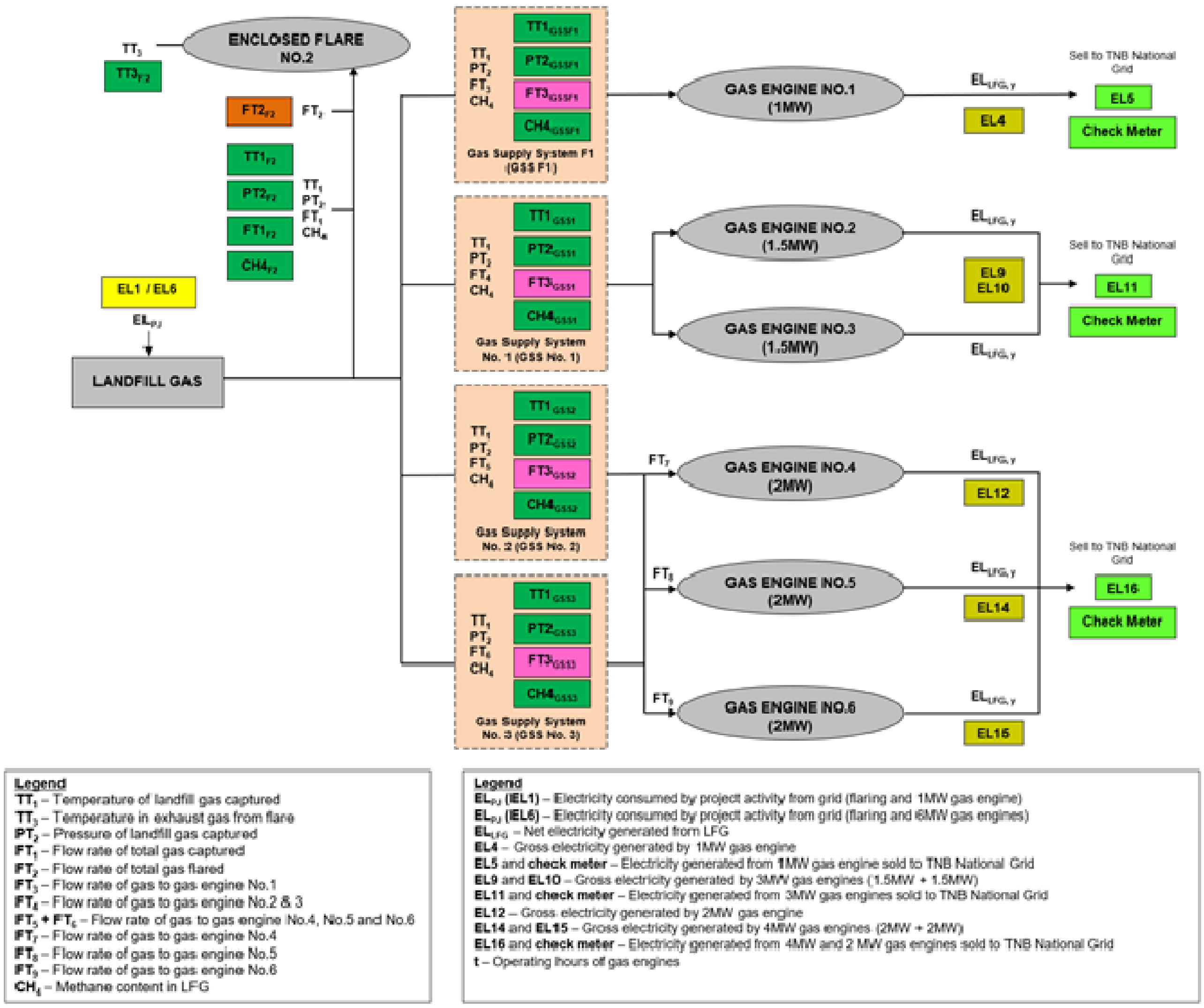


Figure 10: Monitoring Plan for Landfill Gas to Energy and Flare System at Bukit Tagar
Source: Own Illustration

Landfill gas will be capture and send to Enclosed Flare No.2, Gas Supply System F1 (GSS F1), Gas Supply System No.1 (GSS No.1), Gas Supply System No.2 (GSS No.2) and Gas Supply System No.3 (GSS No.3). Flow rate of total gas flared by Enclosed Flare No.2 is monitored by FT_2 while flow rate of gas to gas engines are monitored by FT_3 (GSS F1), FT_4 (GSS No.1) and FT_5 (GSS No.2), FT_6 (GSS No.3) respectively. Each gas engines also have their own individual meter

to record the flow supply from GSS, where FT_7 for gas engine no.4, FT_8 is for gas engine no.5, FT_9 is for gas engine no.6 respectively.

The gross electricity generated by each gas engines are monitored using EL4, EL9, EL10 and EL12, EL14 and EL15. The amount will be compared with EL5, EL11 and EL16 which are managed by Tenaga National Berhad to obtain the lower amount so that the result is conservative. As data will be captured separately in the flaring and power generation system (Flare No.2, Gas Engine No.1 and so forth), a specific subscript will be assigned to the monitoring parameters of the different equipment installed.

Relevant regulations on LFG project activities shall be monitored and updated upon renewal of each crediting period. Changes to regulations, if any will be converted to the amount of methane in the LFG which is flared in the baseline due to a requirement in year y ($F_{CH4,BL,R,y}$).

Implementation of the Monitoring Plan

The landfill gas system operator will adopt the instructions presented in the monitoring plan and ensure all activities related to the implementation of the procedures given in the guidelines for LFG plant operation and monitoring are implemented. The main responsibilities of monitoring include:

- Data reading and handling: maintaining an adequate system for collecting, recording and storing data in accordance with the protocols determined by the monitoring plan as well as checking data quality, collection and record-keeping procedures on a regular basis. This also includes making sure that all relevant electronic data is backed-up electronically for at least 2 years after the end of crediting period in case of an unanticipated loss of data. The data recording frequency and requirement are detailed in **Section B.7.1** above;

- In the case of erroneous data recorded for the monitored parameter occurred during short period, data for the affected period shall be derived based on the approach based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6*)*. A total of 10 readings before and after the constant period will be used to calculate the lower bound of 95% confidence interval with reference to the above-mentioned guideline. The lower bound of the interval boundaries calculated will be applied to the period for the constant data as a conservative approach. Alternately, if the 10 readings before and after the erroneous period is unavailable, the record from the daily manual log-sheet will be used to calculate the lower bound of 95% confidence interval. The lower bound of the interval boundaries calculated will be applied to the period for the constant data as a conservative approach.

- Reporting: preparing periodic summaries and reports that include emission reductions generated and observations regarding monitoring plan procedures;

- Training: assuring assigned personnel received adequate and regular training on project performances and the monitoring plan. Any new staff taking over the role of monitoring and reporting will be fully trained as well; and

- Quality control and quality assurance: complying with quality control and quality assurance procedures to facilitate periodical audits and verification. Any observation of matters affecting data quality will be reported to the management immediately.

Responsibility of Monitoring Plan

A dedicated CDM monitoring team will be assigned to be responsible for undertaking the monitoring as well as the quality control and assurance tasks. The following are the position and responsibility of the CDM monitoring team:

Personnel	Description of Roles in Monitoring Plan
Management Representative	• Reports to and obtain decisions from management on CDM-related matters • Chairs internal meetings on CDM matters • Signs off official correspondence for external parties
Deputy General Manager - Operation	• Reports to the management representative (MR) • Oversees entire operation of landfills (including LFG management system) • Covers responsibility of CDM Manager when he is not available
CDM Manager	• Reports to the Deputy General Manager - Operation • Oversees and coordinates the entire CDM monitoring plan • Verifies and signs off all relevant monitoring records • Ensures Quality Control / Quality Assurance (QC/QA) is carried out • Ensures all data are recorded and necessary documentations are prepared according to the requirements of CDM monitoring • Responsible in optimising the LFG extraction and utilisation system
Engineer	• Reports to the CDM Manager • Assists the CDM Manager in performing CDM monitoring works • To monitor daily operation for landfill gas operations • To assist in daily monitoring records for all CDM related equipment • To prepare daily summary record for landfill gas operation
Supervisors	• Report to the CDM Manager on CDM monitoring issues • Check and ensure that the flaring system is functional • Ensure all data recording devices are functioning and calibrated as planned (including performing QA/QC) • Check and sign the daily monitoring log sheets for CDM monitoring • Supervise general workers in maintenance work and record monitored parameters for CDM monitoring • Identify maintenance requirement and contact the supplier if maintenance and support are needed • Optimise the flare operation together with the CDM Manager • Responsible with the security of locked Programmable Logic Controller (PLC) control room. The supervisor will hold the door key for the PLC control room
General Workers	• Perform regular operational and maintenance tasks • Record necessary readings in daily monitoring log sheets and request verification from the supervisors on the log sheets • Report any fault to supervisor-in-charge or the electrical chargeman
CDM Consultant	• Provides advice on all CDM-related matters • Prepares monitoring reports for verifications • Liaises with the verifier on verification process • Conducts regular audits on CDM monitoring

Quality Control, Assurance and Maintenance Schedule

Regular maintenance of monitoring equipment is a crucial part of the quality control and assurance of the monitoring plan. A regular maintenance schedule of the different equipment is included in **Appendix 5**.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

27/5/2008 (Appointment of EPC Contractor)

C.2. Expected operational lifetime of project activity

21 years

C.3. Crediting period of project activity

C.3.1. Type of crediting period

The second 7-year crediting period (Renewable crediting period).

C.3.2. Start date of crediting period

28/08/2016 (for the second 7-year crediting period).

C.3.3. Duration of crediting period

7 years.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The project activities include the installation of landfill gas collection system (gas collection wells and blower) as well as the flaring and landfill gas electricity generation facilities. The project will recover landfill gas that is currently been released directly into the surrounding and atmosphere.

As a result, the following positive environmental impacts can be realised:

- Improvement of local air quality and reduce environmental and health risks;
- Possibility of structural damage to landfill through gas seepage (migration) minimized;
- LFG as renewable energy sources – cleaner fuel that replaces fossil fuel based grid power; and
- In line with Malaysia's National Policy on Environment and its commitment to reducing climate change.

The project activity will not create any major environmental issues. The project activity will not include any land clearance as all the installation and equipment will be mostly on-site (landfill). The system installed will minimise the emission of landfill gas and will not result in any environmental emissions which exceeds the current emissions from the landfill and its facilities.

Programme to address safety (e.g. gas leakage) issues related to the project will be in place. Exhaust fumes of the flare and gas generators will be monitored. High quality equipment and regular maintenance and monitoring of system will be taken by the landfill operator to ensure that the impacts (if any) from these processes are minimized.

D.2. Environmental impact assessment

There are no significant negative impacts resulting from this project.

Positive impacts are the improvement of air quality and the reduction of fossil fuel-based electricity usage, leading to reduction in greenhouse gas emission reduction.

No environmental impact assessment (EIA) is required for the implementation of this project. List of prescribed activities requiring EIA is attached in **Appendix 4**.

EIA is required for establishment of sanitary landfill. The EIA for Bukit Tagar Sanitary Landfill was approved in 2005.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

The stakeholder meeting described below is the stakeholder meeting conducted during the 1st Crediting Period.

A stakeholders meeting to obtain comments on the proposed project activity was held on 22nd of January 2008; 10:00am - 12:00pm at Boardroom 2, Level 3 Eastin Hotel, Petaling Jaya.

The stakeholder meeting was opened to the public and widely promoted in English and Malaysian language through the local media (see the newspaper announcement below).

METRO AHAD, AHAD, 20 JANUARI, 2008

223. NOTIS AM

JEMPUTAN MENGHADIRI MESYUARAT PIHAK BERKEPENTINGAN ATAU "STAKEHOLDERS" PADA 22 JANUARI 2008:
Tapak pelupusan sanitari Bukit Tagar untuk pengumpulan dan penggunaan gas metana

KUB-Berjaya Enviro Sdn Bhd (KBE) (Co. No: 614497-H) adalah pemaju dan penyelenggara tapak pelupusan sanitari Bukit Tagar di Hulu Selangor, Selangor, Malaysia. Tapak pelupusan sanitari ini menerima kira-kira 1,800 tan matrik sampah perbandaran sehari dari Kuala Lumpur dan Selayang.

Tapak pelupusan sanitari Bukit Tagar telah direkacipta untuk memenuhi piawaian alam sekitar yang ditetapkan Kerajaan Malaysia. Kini, walaupun semua peraturan dalam piawaian alam sekitar dipenuhi, tapak pelupusan sanitari Bukit Tagar masih melepaskan gas rumah kaca seperti metana ke atmosfera. Menyedari pentingnya usaha mengurangkan peningkatan suhu global selain potensi menggunakan gas berkenaan yang dikumpul sebagai sumber tenaga, KBE merancang untuk melabur dalam usaha memanfaatkan gas berkenaan sebagai sumber tenaga alternatif.

Dalam usaha ini, KBE merancang untuk memulakan projek di bawah Mekanisme Pembangunan Bersih atau 'Clean Development Mechanism' (CDM). CDM adalah mekanisme kewangan di bawah Protokol Kyoto di mana negara maju boleh melabur dalam projek mengurangkan pelepasan gas di negara membangun menggantikan projek mengurangkan pelepasan gas rumah kaca di negara mereka sendiri yang membabitkan kos lebih tinggi.

KBE dengan segala hormatnya, ingin menjemput pihak yang berkepentingan atau 'stakeholders' untuk menghadiri mesyuarat dan sesi penerangan mengenai projek tersebut. Tarikh dan tempat mesyuarat adalah seperti di bawah:

TARIKH : 22 Januari 2008
MASA : 10.00 pagi (diikuti dengan makan tengah hari)
TEMPAT : Bilik 2, Tingkat 3, Eastin Hotel, Petaling Jaya

Jika anda berminat untuk menghadiri mesyuarat atau untuk sebarang pertanyaan, sila hubungi **Puan Iza Bakar, (Tel: +6 03-7882 6333)**

theSun | FRIDAY JANUARY 18 2008

classified

For greater reach call Tel: 03-7784 8888 or Fax: 03-7784 44

Messages / Other Announcements

INVITATION TO STAKEHOLDER MEETING 22 January 2008:
Bukit Tagar Landfill for Gas Extraction & Utilization

KUB-Berjaya Enviro Sdn Bhd (KBE) [illegible]

[illegible]

Date : 22 January 2008
Time : 10:00am-12:00pm [illegible]
Venue : Boardroom 2, Level 3, Eastin Hotel, Petaling Jaya

Please contact **Puan Iza Bakar (Tel: +603-7882 6333)** should you are joining the meeting or require any clarification.

Figure 11: Press releases of stakeholders meeting invitation on local newspaper

In addition to public announcement, invitation by letter to a number of identified organizations and individuals relevant to the project was issued.

The meeting attendants included private companies, NGOs, government representatives, among others.

The attended institutions are listed below:

- Ministry of Natural Resources and Environment Management (the Designated National Authority for Malaysia in CDM);
- Ministry of Housing and Local Government (Department of National Solid Waste Management) – recently established federal authority to take over all solid waste management matters in Peninsula Malaysia;
- Dewan Bandaraya Kuala Lumpur – Kuala Lumpur City Hall (local authority);
- Majlis Perbandaran Selayang – Selayang City Council (local authority);
- Solid Waste Disposal Sdn. Bhd. (Transfer station operators delivering to Bukit Tagar);
- Nearby residents to the landfill;
- Nearby Palm Oil estate representatives;
- Perunding Utama Sdn. Bhd. (EIA consultant to landfill);
- ENSEARCH – Environmental NGO;
- KUB-Berjaya Enviro Sdn. Bhd. (Project developer); and
- Eco-Ideal Consulting Sdn. Bhd. (CDM consultant).

Figure 12: CDM Stakeholder Holder Meeting, 22 January 2008
Source: Own Illustration

During a project presentation, by the project representatives, different aspects of the project, such as social, environmental, economic and technical issues, were outlined to the 29 attendees. After the presentations, the audience was invited to an open session of questions and comments.

The comments are recorded in **Section E.2** below.

The 2nd stakeholder meeting was conducted on 12/04/207; 11:00AM - 12:00PM at Bukit Tagar Sanitary Landfill to obtain the comment on the proposed project.

A total number of seven (7) participants from nearby villages and estate attended the stakeholder meeting.

E.2. Summary of comments received

The questions received from the 1st stakeholder meeting is presented as below:

Figure 13: Question and Answer at CDM Stakeholder Meeting
Source: Own Illustration

Question asked by a representative of Solid Waste Disposal Sdn. Bhd.
Is Environmental Impact Assessment required for this project?
Answers: • EIA is only required in Malaysia if the proposed activity is listed as "prescribed activities" under the Environmental Quality Act. Landfill gas recovery project does not require EIA as it is not in the list. EIA was conducted for the overall landfill development and operation and was already approved in 2005. There is no regulatory requirement to capture and utilize landfill gas.

Question asked by a representative of Ministry of Natural Resources and Environment Management (NRE)
What kind of technology will be applied? Is this technology new or existing? What are the costs?
Answers: • It was explained that a proven gas recovery and utilization system from overseas will be applied to the proposed project activity. Vertical wells equipped with gas cleaning systems will be drilled to enable gas extraction and an imported gas engine will be installed for power generation purposes. Gas recovery and utilization system has been implemented all over the world but the technology is still relatively new to Malaysia. To date, there is only one project i.e. the Puchong Air Hitam Landfill gas recovery project is implemented. • Therefore, the design of the landfill gas extraction and utilization system is considered relatively new to Malaysia. • The total costs of implementation are expected to amount to around RM 10 million (on-site power utilisation only – not including grid connection).

Question asked by a representative of Kementerian Sumber Asli & Alam Sekitar – Natural Resources and Environment Management
Is there more environmentally friendly solutions other than flaring the landfill gas?
Answers: • It was explained that flaring only partially solves the environmental problems related to the release of landfill gases as this process does not generate renewable energy. • However, if all the landfill gas recovered is to be used for power generation, then the overall investment will be higher and there will be an excess of power on-site (Bukit Tagar only requires 500 kW). Generation of additional power, connection and selling addition power to grid requires economic of scale as it involves extra investment. Furthermore, Soon also highlighted the difficulties of selling power to grid, including the low tariffs, long application process time and complex agreement with the national power company TNB and so forth. • However, as the total waste accumulated increases and when the power generation potential becomes greater, then the connection to grid option will become more feasible.

Question asked by Mr. Gui Hun Chuen – Ministry of Housing and Local Government
How many tons of waste is required for such project to become feasible? When will the project commence?
• Mr. How explained that the project can start immediately since almost 1.4 million tons of wastes were disposed of at the cell where the proposed gas extraction and utilization is to be implemented. This would be sufficient to justify the investment. • Mr. Soon added that the project can only start claiming CERs after receiving letter of approval (for CDM) from the Government of Malaysia as well as the registration of the project as a CDM project with United Nations.

Question asked by Encik Zamzuri Bin Nordin – Solid Waste Disposal Sdn. Bhd.
Could you please elaborate on how the Certified Emission Reductions (CERs) are calculated?
• It was explained the concept of baseline emissions and project emissions from the landfill. He explained that emission reductions generated from the project is the difference between baseline (current emissions without project) and project emissions (emissions

during the project). The calculation is based on internationally approved methodologies. He stressed that the proposed project will not be able to capture 100% of the landfill gas. Typical collection efficiency is around 50%. • It was also mentioned that the degradation of waste resulting in methane emissions will occur over an extensive period of time and that the figures presented earlier in the meeting were solely estimates based on the approval methodology. The actual emission reductions from the project will be determined by actual measurement during the project implementation.

There were no negative comments received from the 1st stakeholder meeting.

For the 2nd stakeholder meeting, participants are aware on the operation of the landfill, there are no negative comments received from the local community. The local community very appreciated Bukit Tagar Landfill offering the job opportunity to them.

E.3. Consideration of comments received

The following are actions taken in response to the questions and comments received from the stakeholder meeting:

Questions/comments	Response and follow up action by project developer
Is EIA required?	Relevant list of prescribed activity requiring EIA in Malaysia attached to this PDD.
Technology type and cost	Details of the technology to be applied and cost implication will be included in the PDD.
More environmental friendly solutions than flaring?	In consideration of the issue raised, the project developer decided to include generating additional power for selling to the grid by including the recovery of landfill gas from the current cell (phase 1) in the PDD. A 2 MW additional electricity capacity is added to the project plan. Converting the landfill gas captured to electricity generation will contribute to the renewable energy development in Malaysia as well as contribute to the reduction of greenhouse gas emissions from fossil fuel.
Feasibility of landfill gas project	No further action required. There are sufficient wastes in placed to justify this project.
How is CERs calculated?	This was sufficiently explained at the meeting. No further actions required.

SECTION F. Approval and authorization

KEMENTERIAN SUMBER ASLI DAN ALAM SEKITAR
LOT 4G3, PRESINT 4, 62574 PUTRAJAYA
TEL: 03-8886 1111 FAX: 03-8886 1512
Web: http://www.nre.gov.my

Our Reference: NRE(S)62.120.010.001.
002/012 Jld. 7 (23)
Date: 22 January 2009

Chief Executive Director
KUB-Berjaya Enviro Sdn Bhd
No. 15, Jalan 16/11, Off Jalan Damansara
Suite 806, Block A, Pusat Dagangan Phileo Damansara
46350 Petaling Jaya
SELANGOR DARUL EHSAN
(Attention: Mr. How Lim Sek)

Fax: 03-7882 6332

Dear Sir,

Host Country's Letter of Approval for Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor, Malaysia

As the Designated National Authority (DNA) for the implementation of Clean Development Mechanism (CDM) in Malaysia, I am pleased to inform that your project proposal for Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor, Malaysia as defined in the Project Design Document is found to be in compliance with the national criteria for the CDM activities and will assist Malaysia to achieve sustainable development.

2. I hereby confirm that:

(i) Malaysia has ratified the United Nations Framework Convention on Climate Change on 13th July 1994 and Kyoto Protocol on 4th September 2002; and

(ii) Malaysia participates voluntarily in this proposed CDM activity.

3. In this regard, your project can now be submitted to the CDM Executive Board for registration as a CDM project activity.

4. As Malaysia does not support unilateral CDM project, this approval is considered void if this project is found to be a unilateral project by the CDM Executive Board.

5. This approval is valid if it is submitted to the Executive Board for registration within 6 months from the date of this letter and is independent of the time taken by the Executive Board to register the project.

ER

6. You are required to submit a written report to the DNA on the stages and progress of the project implementation at least twice a year.

Thank you.

Yours sincerely,

(DR. LIAN KOK FEI)
Conservation and Environmental Management Division
for Secretary General
Ministry of Natural Resources and Environment
As the DNA

Appendix 1. Contact information of project participants

Organization name	KUB-Berjaya Enviro Sdn. Bhd. (KBE)
Country	Malaysia
Address	No. 1, Jalan Imbi, 09-03 & 09-05, Level 9 East, Berjaya Times Square, 55100, Kuala Lumpur
Telephone	+603-2688 6333
Fax	+603-2688 6332
E-mail	mail@kbenviro.com.my
Website	http://www.kbenviro.com.my/
Contact person	How Lim Sek

Appendix 2. Affirmation regarding public funding

Not applicable. The project will be privately funded and will not involve any public funding or Official Development Assistance (ODA).

Appendix 3. Applicability of methodologies and standardized baselines

Refer to **Section B** for detail.

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

BASELINE INFORMATION

<u>Climatic Data Used to Estimate Methane Emissions</u>

Climate Condition : Tropical
Average Temperature : 26.7 degree Celsius (24 hr mean)
23.0 degree Celsius (24 hr mean Minimum)
32.3 degree Celsius (24 hr mean Maximum)

Average Rainfall : 2,767 mm

Rel. Humidity : 82.9 % (24 hr Mean)

Source: Detailed EIA for Proposed Bukit Tagar Sanitary Landfill, 2004. (figures derived from Malaysian Meteorological Services Department at Subang and KLIA stations.)

Waste Amount Received at Bukit Tagar

Monthly Waste Received (actual amount recorded by weight bridge) by Bukit Tagar Sanitary Landfill:

Year / Month	Waste Received (t)	Accumulated Waste Received (t)
2005		
April	**34,157.52**	**34,157.52**
May	**37,667.27**	**71,824.79**
June	**39,198.65**	**111,023.44**
July	**45,893.38**	**156,916.82**
August	**42,778.53**	**199,695.35**
September	**40,545.92**	**240,241.27**
October	**40,715.04**	**280,956.31**
November	**38,320.39**	**319,276.70**
December	**42,641.21**	**361,917.91**
2006		
January	**43,927.22**	**405,845.13**
February	**37,987.66**	**443,832.79**
March	**42,760.70**	**486,593.49**
April	**41,778.86**	**528,372.35**
May	**45,323.88**	**573,696.23**
June	**35,598.18**	**609,294.41**
July	**45,371.65**	**654,666.06**
August	**47,285.23**	**701,951.29**
September	**43,447.36**	**745,398.65**
October	**45,711.24**	**791,109.89**
November	**44,867.50**	**835,977.39**
December	**46,121.46**	**882,098.85**
2007		
January	**48,824.19**	**930,923.04**
February	**44,624.49**	**975,547.53**
March	**49,132.86**	**1,024,680.39**
April	**47,389.69**	**1,072,070.08**
May	**49,692.20**	**1,121,762.28**
June	**47,888.63**	**1,169,650.91**
July	**62,638.61**	**1,232,289.52**
August	**63,096.96**	**1,295,386.48**
September	**58,669.33**	**1,354,055.81**
October	**59,578.60**	**1,413,634.41**
November	**58,491.49**	**1,472,125.90**
December	**57,949.37**	**1,530,075.27**
2008		
January	**62,265.91**	**1,592,341.18**
February	**56,800.97**	**1,649,142.15**
March	**62,477.19**	**1,711,619.34**
April	**65,735.14**	**1,777,354.48**
May	**67,087.48**	**1,844,441.96**
June	**64,835.74**	**1,909,277.70**
July	**72,368.82**	**1,981,646.52**
August	**73,570.97**	**2,055,217.49**

Year / Month	Waste Received (t)	Accumulated Waste Received (t)
September	**71,292.04**	**2,126,509.53**
October	**68,286.72**	**2,194,796.25**
November	**68,518.66**	**2,263,314.91**
December	**74,355.24**	**2,337,670.15**
2009		
January	**77,080.75**	**2,414,750.90**
February	**68,184.56**	**2,482,935.46**
March	**73,007.74**	**2,555,943.20**
April	**71,353.93**	**2,627,297.13**
May	**69,864.16**	**2,697,161.29**
June	**72,166.56**	**2,769,327.85**
July	**77,422.64**	**2,846,750.49**
August	**74,912.58**	**2,921,663.07**
September	**71,693.46**	**2,993,356.53**
October	**75,750.79**	**3,069,107.32**
November	**72,297.47**	**3,141,404.79**
December	**75,710.49**	**3,217,115.28**
2010		
January	**75,509.55**	**3,292,624.83**
February	**71,178.72**	**3,363,803.55**
March	**79,340.67**	**3,443,144.22**
April	**74,821.98**	**3,517,966.20**
May	**75,938.96**	**3,593,905.16**
June	**72,878.26**	**3,666,783.42**
July	**78,989.73**	**3,745,773.15**
August	**81,657.33**	**3,827,430.48**
September	**73,960.45**	**3,901,390.93**
October	**76,365.54**	**3,977,756.47**
November	**74,226.16**	**4,051,982.63**
December	**76,286.52**	**4,128,269.15**
2011		
January	**78,015.26**	**4,206,284.41**
February	**72,962.06**	**4,279,246.47**
March	**76,020.34**	**4,355,266.81**
April	**83,144.26**	**4,438,411.07**
May	**79,296.61**	**4,517,707.68**
June	**77,886.60**	**4,595,594.28**
July	**83,486.40**	**4,679,080.68**
August	**84,927.36**	**4,764,008.04**
September	**113,491.96**	**4,877,500.00**
October	**114,113.37**	**4,991,613.37**
November	**81,034.21**	**5,072,647.58**
December	**87,082.46**	**5,159,730.04**
2012		
January	**88,302.32**	**5,248,032.36**
February	**77,085.17**	**5,325,117.53**
March	**81,381.33**	**5,406,498.86**
April	**75,620.33**	**5,482,119.19**
May	**117,395.09**	**5,599,514.28**
June	**81,196.51**	**5,680,710.79**
July	**84,211.75**	**5,764,922.54**

Year / Month	Waste Received (t)	Accumulated Waste Received (t)
August	**77,740.22**	**5,842,662.76**
September	**77,300.70**	**5,919,963.47**
October	**79,562.37**	**5,999,525.84**
November	**84,788.98**	**6,084,314.82**
December	**89,010.65**	**6,173,325.47**
2013		
January	**85,823.32**	**6,259,148.79**
February	**74,562.47**	**6,333,711.26**
March	**79,047.26**	**6,412,758.52**
April	**80,381.47**	**6,493,139.99**
May	**79,250.39**	**6,572,390.38**
June	**72,570.85**	**6,644,961.23**
July	**83,550.21**	**6,728,511.44**
August	**76,034.42**	**6,804,545.86**
September	**75,069.42**	**6,879,615.28**
October	**79,446.52**	**6,959,061.80**
November	**78,656.48**	**7,037,718.28**
December	**75,258.98**	**7,112,977.26**
2014		
January	**82,567.80**	**7,195,545.06**
February	**72,546.77**	**7,268,091.83**
March	**79,017.72**	**7,347,109.55**
April	**79,511.76**	**7,426,621.31**
May	**83,303.92**	**7,509,925.23**
June	**78,911.84**	**7,588,837.07**
July	**84,235.77**	**7,673,072.84**
August	**84,175.00**	**7,757,247.84**
September	**79,858.61**	**7,837,106.45**
October	**84,525.81**	**7,921,632.26**
November	**80,118.94**	**8,001,751.20**
December	**86,177.22**	**8,087,928.42**
2015		
January	**91,708.05**	**8,179,636.47**
February	**81,135.80**	**8,260,772.27**
March	**85,289.27**	**8,346,061.54**
April	**83,210.79**	**8,429,272.33**
May	**85,172.47**	**8,514,444.80**
June	**86,769.58**	**8,601,214.38**
July	**87,385.03**	**8,688,599.41**
August	**85,985.29**	**8,774,584.70**
September	**79,567.40**	**8,854,152.10**
October	**84,237.06**	**8,938,389.16**
November	**82,443.56**	**9,020,832.72**
December	**84,647.50**	**9,105,480.22**
2016		
January	**83,175.04**	**9,188,655.26**
February	**78,545.62**	**9,267,200.88**
March	**84,500.44**	**9,351,701.32**
April	**79,590.98**	**9,431,292.30**
May	**83,358.41**	**9,514,650.71**
June	**83,071.57**	**9,597,722.28**

Year / Month	**Waste Received** (t)	**Accumulated Waste Received** (t)
July	**81,105.13**	**9,678,827.41**
August	**86,645.19**	**9,765,472.60**
September	**82,261.64**	**9,847,734.24**
October	**82,241.31**	**9,929,975.55**
November	**80,527.49**	**10,010,503.04**
December	**80,261.45**	**10,090,764.49**
2017		
January	**81,913.74**	**10,172,678.23**
February	**73,005.92**	**10,245,684.15**
March	**80,037.25**	**10,325,721.40**
April	**77,964.78**	**10,403,686.18**
May	**83,375.52**	**10,487,061.70**
June	**78,329.19**	**10,565,390.89**
July	**81,085.39**	**10,646,476.28**
August	**81,755.80**	**10,728,232.08**
September	**79,327.25**	**10,807,559.33**
October	**81,872.71**	**10,889,432.04**
November	**81,557.52**	**10,970,989.56**
December	**82,824.50**	**11,053,814.06**
2018		
January	**87,127.01**	**11,140,941.07**
February	**77,355.55**	**11,218,296.62**
March	**84,650.30**	**11,302,946.92**
April	**81,417.47**	**11,384,364.39**
May	**83,778.84**	**11,468,143.23**
June	**77,707.99**	**11,545,851.22**
July	**89,586.87**	**11,635,438.09**
August	**86,320.74**	**11,721,758.83**
September	**78,826.92**	**11,800,585.75**
October	**86,754.91**	**11,887,340.66**
November	**82,955.24**	**11,970,295.90**
December	**86,596.67**	**12,056,892.57**

(Source: Weight bridge record, Bukit Tagar Sanitary Landfill, latest December 2018)

Summarised amount received and projected amounts of waste at the Bukit Tagar Sanitary Landfill:

Year	Average Waste Received (tonnes/day)	Total Waste Received (tonnes/yr)	Accumulated Waste (tonnes/yr)
2005	1,316	361,918	361,918
2006	1,425	520,181	882,099
2007	1,775	647,976	1,530,075
2008	2,207	807,595	2,337,670
2009	2,409	879,445	3,217,115
2010	2,496	911,154	4,128,269
2011	2,826	1,031,461	5,159,730
2012	2,769	1,013,595	6,173,325
2013	2,574	939,652	7,112,977
2014	2,671	974,951	8,087,928
2015	2,788	1,017,552	9,105,480
2016	2,699	985,284	10,090,764
2017	2,638	963,050	11,053,814
2018	2,748	1,003,079	12,056,893
2019	2,886	1,053,232	13,110,125
2020	3,030	1,105,894	14,216,019
2021	3,181	1,161,189	15,377,208
2022	3,340	1,219,248	16,596,456
2023	3,507	1,280,211	17,876,667

Note: *Assuming 5% increase in amount of waste received per year (after year 2019)*

<u>Waste Projections</u>

The National Strategic Plan for Solid Waste Management (2005) by the Ministry of Housing and Local Government anticipated an overall average annual growth of waste generation at 4% by weight.

For the case of Bukit Tagar, since the waste is mainly received from Kuala Lumpur which is a growing city, a higher increase of waste generation is expected than the national 4% waste growth. Based on the amount of waste received by Bukit Tagar landfill, the waste amount has been growing up with average of 6% by weight per year since its operation in 2005.

A 5% by weight annual increase of waste amount received at landfill was considered from year 2008. This is considered conservative, considering the following reasons:

- Kuala Lumpur, urban dwellers are expected to continue to increase with high in flux of rural population migrating to this capital town for employment and business opportunities;
- The waste amount generation from the urban population is expected to be growing with the improvement in lifestyle and consumption. Such growth trend has been seen in most developed countries in the past.

Waste Composition

Summaries of Organic Composition Used for the Baseline Methane Calculation in this project:

Waste types	% wt (wet basis)
Food waste & organics	47.51%
Paper/Cardboard	18.54%
Textiles	2.13%
Wood	4.41%
Garden and Park waste	2.72%
Nappies	3.81%
Rubber and Leather	1.01%

Rubber and Leather were excluded for the calculations. This is conservative.

The above composition is based on actual waste characterization samples from Bukit Tagar Landfill in 2005. Samples of results are attached:

1st Sample

SE

SATANG ENVIRONMENTAL SDN. BHD. (Co. Reg. No. 546811V)
(Subsidiary of Satang Jaya Sdn. Bhd. - 223732 V)
29 & 31, Jalan Tiara 5, Bandar Baru Klang, 41150 Klang, Selangor Darul Ehsan, Malaysia.
Tel : 60 (03) 3344 8822 Fax: 60 (03) 3344 8811
E-Mail : sjsbenv@satangjaya.com.my http://www.satangjaya.com

WASTE CHARACTERIZATION - BUKIT TAGAR LANDFILL
RESULTS

Our Ref.	SW/0705/028 (2)
Your Ref.	RDM/CONT/004/07
Sample Received	25.07.2005

Test Parameter	Results
Gross Calorific Value	2236
LCV 1	873
LCV 2	1634
LCV 3	2040
LCV 4	1616
LCV 5	2189
LCV 6	3135
Total Moisture	43.48
Volatile Matter	72.34
Ash Content	23.21
Fixed Carbon	4.45
Carbon	51.12
Hydrogen	6.32
Nitrogen	2.76
Sulfur	0.18
Chlorine	0.23
Oxygen	16.41
Sodium	1238
Potassium	407.3
Calcium	365.8
Cadmium	0.172
Copper	0.951
Aluminium	10.05
Nickel	5.95
Iron	335.3
Lead	27.42
Mercury	0.167
Tin	0.058
Zinc	0.664
Chromium	1.17
Arsenic	0.133
Cobalt	ND(<0.05)
Manganese	2.32
Silica	0.034

Component	%
Food/Organic	22.77
Mix Paper	7.81
News Print	3.50
High Grade Paper	6.10
Corrugated Paper	2.66
Plastic (rigid)	6.06
Plastic (film)	9.11
Plastic (foam)	0.02
Diapers	3.78
Textile	1.64
Rubber/Leather	3.01
Wood	0.35
Yard	1.64
Glass (clear)	4.92
Glass (colored)	0.00
Ferrous	0.05
Non - Ferrous	0.00
Aluminium	0.04
Batteries/Hazards	0.01
Fine	0.01
Other Organic	0.21
Other In-Organic	0.00
Others (fruits)	26.30
Total Sum	99.99

Total Paper , Pa	20.07
Total Plastic, P1	15.18
Other Combustible, Oc	5.78
Total Organic/ food, Ga	49.29

2nd Sample

SATANG ENVIRONMENTAL SDN. BHD. (Co. Reg. No. 546811V)
(Subsidiary of Satang Jaya Sdn. Bhd. - 223732 V)
29 & 31, Jalan Tiara 5, Bandar Baru Klang, 41150 Klang, Selangor Darul Ehsan, Malaysia.
Tel : 60 (03) 3344 8822 Fax: 60 (03) 3344 8811
E-Mail : sjsbenv@satangjaya.com.my http://www.satangjaya.com
SE

WASTE CHARACTERIZATION - BUKIT TAGAR LANDFILL
RESULTS

Our Ref.	SW/0705/033 (1)
Your Ref.	RDM/CONT/013/07
Sample Received	30.07.2005

Test Parameter	Results
Gross Calorific Value	2397
LCV 1	920
LCV 2	1771
LCV 3	2033
LCV 4	1728
LCV 5	2111
LCV 6	3108
Total Moisture	42.64
Volatile Matter	76.92
Ash Content	16.23
Fixed Carbon	6.85
Carbon	50.87
Hydrogen	6.85
Nitrogen	2.92
Sulfur	0.07
Chlorine	0.84
Oxygen	23.06
Sodium	1459
Potassium	780.3
Calcium	239.8
Cadmium	0.082
Copper	5.01
Aluminium	4.65
Nickel	3.71
Iron	344.9
Lead	16.46
Mercury	0.085
Tin	ND(<0.05)
Zinc	0.443
Chromium	6.02
Arsenic	0.090
Cobalt	ND(<0.05)
Manganese	3.68
Silica	0.162

Component	%
Food/Organic	28.86
Mix Paper	2.68
News Print	5.21
High Grade Paper	5.67
Corrugated Paper	2.68
Plastic (rigid)	6.87
Plastic (film)	2.54
Plastic (foam)	3.20
Diapers	3.69
Textile	1.77
Rubber/Leather	0.01
Wood	12.09
Yard	2.64
Glass (clear)	2.56
Glass (colored)	1.91
Ferrous	1.56
Non - Ferrous	0.00
Aluminium	1.09
Batteries/Hazards	0.13
Fine	0.08
Other Organic	0.71
Other In-Organic	0.00
Others (fruits)	14.06
Total Sum	**100.00**

Total Paper , Pa	16.24
Total Plastic, Pl	12.61
Other Combustible, Oc	18.42
Total Organic/ food, Ga	43.64

3rd Sample

SATANG ENVIRONMENTAL SDN. BHD. (Co. Reg. No. 546811V)

(Subsidiary of Satang Jaya Sdn. Bhd. - 223732 V)

29 & 31, Jalan Tiara 5, Bandar Baru Klang, 41150 Klang, Selangor Darul Ehsan, Malaysia.
Tel : 60 (03) 3344 8822 Fax: 60 (03) 3344 8811
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SE

WASTE CHARACTERIZATION - BUKIT TAGAR LANDFILL
RESULTS

Our Ref.	SW/0705/033 (2)
Your Ref.	RDM/CONT/014/07
Sample Received	30.07.2005

Test Parameter	Results
Gross Calorific Value	2479
LCV 1	944
LCV 2	1813
LCV 3	1902
LCV 4	1424
LCV 5	1917
LCV 6	2916
Total Moisture	46.90
Volatile Matter	71.23
Ash Content	22.85
Fixed Carbon	5.92
Carbon	48.53
Hydrogen	7.12
Nitrogen	3.03
Sulfur	0.19
Chlorine	0.73
Oxygen	18.28
Sodium	1550
Potassium	865.3
Calcium	400.3
Cadmium	0.155
Copper	2.78
Aluminium	10.39
Nickel	6.92
Iron	516.4
Lead	23.05
Mercury	0.126
Tin	0.057
Zinc	1.25
Chromium	5.33
Arsenic	ND(<0.05)
Cobalt	ND(<0.05)
Manganese	5.25
Silica	0.081

Component	%
Food/Organic	34.15
Mix Paper	2.88
News Print	6.44
High Grade Paper	5.62
Corrugated Paper	4.37
Plastic (rigid)	2.26
Plastic (film)	8.64
Plastic (foam)	0.87
Diapers	3.83
Textile	2.99
Rubber/Leather	0.00
Wood	0.80
Yard	3.87
Glass (clear)	3.00
Glass (colored)	3.84
Ferrous	0.86
Non - Ferrous	0.00
Aluminium	0.02
Batteries/Hazards	0.07
Fine	0.01
Other Organic	0.26
Other In-Organic	0.00
Others (fruits)	15.22
Total Sum	**100.00**

Total Paper , Pa	19.30
Total Plastic, Pl	11.77
Other Combustible, Oc	8.50
Total Organic/ food, Ga	49.63

Electricity Consumption by Bukit Tagar, supplied from Peninsular Malaysia Grid (TNB)

KUB-Berjaya Enviro Sdn. Bhd. - Bukit Tagar Sanitary Landfill
Site electricity consumption and cost today

MONTH	Unit/ Rate			Rate			Other Charge	Amount (RM)
				Peak	Off Peak	MD		
	kwh	kwh	KW	RM0.234	RM0.144	RM0.29		
Jun-06	85,400	82,476.67	300	19,983.60	11,876.64	8,700.00		40,560.24
Jul-06	10,183.00	72,070.00	370	2,382.82	10,378.08	10,730.00		44,936.30
Aug-06	112,400.00	80,810.00	370	26,301.60	11,636.64	10,730.00		48,668.24
Sep-06	104,760.00	74,620.00	370	24,513.84	10,745.28	10,730.00		45,989.12
Oct-06	116,780.00	84,030.00	380	27,326.52	12,100.32	11,020.00		50,446.84
Nov-06	102,020.00	73,000.00	400	23,872.68	10,512.00	11,600.00		45,984.68
Dec-06	163,540.00	82,380.00	380	38,268.36	11,862.72	11,020.00		47,701.08
Jan-07	119,770.00	82,560.00	390	28,026.18	11,888.64	11,310.00		51,224.82
Feb-07	103,460.00	71,750.00	380	24,209.64	10,332.00	11,020.00		45,561.64
Mar-07	116,670.00	84,452.71	370	27,300.78	12,161.19	10,730.00		50,191.97
Apr-07	109,040.00	74,850.00	360	25,515.36	10,778.40	10,440.00	152.00	46,885.76
May-07	112,350.00	78,170.00	400	26,289.90	11,256.48	11,600.00	0.17	49,380.61
Jun-07	112,970.00	74,490.00	370	26,434.98	10,726.56	10,730.00		47,891.71
Jul-07	118,900.00	78,860.00	380	27,822.60	11,355.84	11,020.00		50,198.44
Aug-07	111,150.00	71,580.00	400	26,009.10	10,307.52	11,600.00		47,916.62
Sep-07	113,480.00	75,150.00	390	26,554.32	10,821.60	11,310.00		48,685.92
Oct-07	112,840.00	74,016.67	370	26,404.56	10,658.40	10,730.00		47,792.96
Nov-07	118,640.00	82,280.00	390	27,761.76	11,848.32	11,310.00		50,920.08
Dec-07	129,660.00	90,450.00	460	30,340.44	13,024.80	13,340.00		56,705.24
TOTAL	2,074,013	1,487,996	7,230	485,319	214,271	209,670	152	917,642
Average	**109,159**	**78,316**	**381**	**25,543**	**11,277**	**11,035**		**48,297**

Source: KBE TNB bills 2006-2007.

The average monthly consumption is around 190,000 kWh. The average capacity load is 381 kW with maximum load up to 460 kW. The average cost incurred from electricity on-site is slightly higher than RM 50,000.00.

Comparison of Project with the Malaysia National CDM Criteria

National CDM Criteria in Malaysia	Conditions for this Project
Criterion 1: Contribute to Sustainable Development in Malaysia	• Improve local environment (air quality, reduce health risk) • Supports renewable energy policy
Criterion 2: Must involve Annex 1 (developed countries) parties	Technology: Gas Con – Q2 A/S (Denmark), Gas Engine Manufacturer – MWM & MTU (Germany)
Criterion 3: Must involve technology transfer or improvement of technology	Transfer of technology from overseas & improvement of technology from existing venting
Criterion 4: Must fulfill International CDM conditions	LFG recovery is voluntary and this project fulfills all conditions outlined by the CDM Executive Board
Criterion 5: Ability of Project Developer to undertake project	KBE is a local incorporated company, Joint Venture by two public listed companies in the KLSE (Malaysian Stock Market)

List of prescribed activities requiring EIA

ENVIRONMENTAL QUALITY (PRESCRIBED ACTIVITIES) (ENVIRONMENTAL IMPACT ASESSMENT) ORDER 1987*

In exercise of the powers conferred by section 34A of the Environmental Quality Act 1974, the Minister, after consultation with the Environmental Quality Council, makes the following order:

1. Citation and commencement.

This order may be cited as the **Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987** and shall come into force on the 1st April 1988.

2. Prescribed activities.

The activities specified in the Schedule are prescribed to be prescribed activities.

3. Order not applicable to Sabah and Sarawak in certain prescribed activities. [*Subs. PU(A) 489/2000*]

This Order shall not apply in respect of—

(*a*) the prescribed activities [except item 7(viii)] listed in the First Schedule of the Conservation of Environment (Prescribed Activities) Order 1999 published under the Second Supplementary of the Sabah Government *Gazette* on the 30 August 1999; and

(*b*) the prescribed activities listed in the First Schedule of the Natural Resources and Environment (Prescribed Activities) Order 1994 published under Part II of the Sarawak Government *Gazette* on the 18 August 1994.

4. Items in the Schedule still applicable to Sabah and Sarawak. [*Am. PU(A) 489/2000*]

Notwithstanding paragraph 3, the prescribed activities listed as Items 2, 5(*a*) and (*b*), 8, 9, 10, 12, 13(*a*), (*c*) and (*d*), 15, 16 and 18 in the Schedule shall continue to apply in respect of the States of Sabah and Sarawak.

SCHEDULE

1. AGRICULTURE:

(*a*) Land development schemes covering an area of 500 hectares or more to bring forest land into agricultural production.

(*b*) Agricultural programmes necessitating the resettlement of 100 families or more.

(*c*) Development of agricultural estates covering an area of 500 hectares or more involving changes in types of agricultural use.

2. AIRPORT:

(*a*) Construction of airports (having an airstrip of 2,500 metres or longer).

(*b*) Airstrip development in state and national parks.

**Published as PU (A) 362/1987. Came into force on 1.4.1988 and amended by PU (A) 117/1995, 44/1996, 489/2000.*

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3. DRAINAGE AND IRRIGATION:

(*a*) Construction of dams and man-made lakes and artificial enlargement of lakes with surface areas of 200 hectares or more.

(*b*) Drainage of wetland, wild-life habitat or of virgin forest covering an area of 100 hectares or more.

(*c*) Irrigation schemes covering an area of 5,000 hectares of more.

4. LAND RECLAMATION:

Coastal reclamation involving an area of 50 hectares or more.

5. FISHERIES:

(a) Construction of fishing harbours.

(b) Harbour expansion involving an increase of 50 percent or more in fish landing capacity per annum.

(c) Land based aquaculture projects accompanied by clearing of mangrove swamp forests covering an area of 50 hectares or more.

6. FORESTRY:

(a) Conversion of hill forest land to other land use covering an area of 50 hectares or more.

(b) Logging or conversion of forest land to other land use within the catchment area of reservoirs used for municipal water supply, irrigation or hydro-power generation or in areas adjacent to state and national parks and national marine parks.

(c) Logging covering an area of 500 hectares or more.

(d) Conversion of mangrove swamps for industrial, housing or agricultural use covering an area of 50 hectares or more.

(e) Clearing of mangrove swamps on islands adjacent to national marine parks.

7. HOUSING:

Housing development covering an area of 50 hectares or more.

8. INDUSTRY:

(a) Chemical – Where production capacity of each product or of combined products is greater than 100 tonnes/day.

(b) Petrochemicals – All sizes.

(c) Non-ferrous – Primary smelting:
- Aluminium – all sizes.
- Copper – all sizes.
- Others – producing 50 tonnes/day and above of product.

(d) Non-metallic
- Cement – for clinker throughput of 30 tonnes/hour and above.
- Lime – 100 tonnes/day and above burnt lime rotary kiln or 50 tonnes/day and above vertical kiln:

(e) Iron and steel
- Require iron ore as raw materials for production greater than 100 tonnes/day; or
- Using scrap iron as raw materials for production greater than 200 tonnes/day

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(f) Shipyards	–	Dead Weight Tonnage greater than 5,000 tonnes.
(g) Pulp and paper industry	–	Production capacity greater than 50 tonnes/day.

9. **INFRASTRUCTURE:**

(a) Construction of hospitals with outfall into beachfronts used for recreational purposes.

(b) Industrial estate development for medium and heavy industries covering an area of 50 hectares or more.

(c) Construction of expressways.

(d) Construction of national highways.

(e) Construction of new townships.

10. **PORTS:**

(a) Construction of ports.

(b) Port expansion involving an increase of 50 percent or more in handling capacity per annum.

11. **MINING:**

(a) Mining of minerals in new areas where the mining lease covers a total area in excess of 250 hectares.

(b) Ore processing, including concentrating for aluminium, copper, gold or tantalum.

(c) Sand dredging involving an area of 50 hectares or more.

12. **PETROLEUM:**

(a) Oil and gas fields development.

(b) Construction of off-shore and on-shore pipelines in excess of 50 kilometres in length.

(c) Construction of oil and gas separation, processing, handling, and storage facilities.

(d) Construction of oil refineries.

(e) Construction of product depots for the storage of petrol, gas or diesel (excluding service stations) which are located within 3 kilometres of any commercial, industrial or residential areas and which have a combined storage capacity of 60,000 barrels or more.

13. **POWER GENERATION AND TRANSMISSION:**

(a) Construction of steam generated power stations burning fossil fuels and having a capacity of more than 10 megawatts.

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(b) Dams and hydro-electric power schemes with either or both of the following:

(i) dams over 15 metres high and ancillary structures covering a total area in excess of 40 hectares;

(ii) reservoirs with a surface area in excess of 400 hectares.

(c) Construction of combined cycle power stations.

(d) Construction of nuclear-fueled power stations.

14. **QUARRIES:**

Proposed quarrying of aggregate, limestone, silica, quartzite, sandstone, marble and decorative building stone within 3 kilometres of any existing residential, commercial or industrial areas, or any area for which a licence, permit or approval has been granted for residential, commercial or industrial development.

15. **RAILWAYS:**

(a) Construction of new routes.

(b) Construction of branch lines.

16. **TRANSPORTATION:**

Construction of Mass Rapid Transport projects.

17. **RESORT AND RECREATIONAL DEVELOPMENT:**

(a) Construction of coastal resort facilities or hotels with more than 80 rooms.

(b) Hill station resort or hotel development covering an area of 50 hectares or more.

(c) Development of tourist or recreational facilities in national parks.

(d) Development of tourist or recreational facilities on islands in surrounding waters which are gazetted as national marine parks.

18. **WASTE TREATMENT AND DISPOSAL:**

(a) Toxic and Hazardous Waste—

(i) Construction of incineration plant.
(ii) Construction of recovery plant (off-site).
(iii) Construction of wastewater treatment plant (off-site).
(iv) Construction of secure landfill facility.
(v) Construction of storage facility (off-site).

(b) Municipal Solid Waste—

(i) Construction of incineration plant.
(ii) Construction of composting plant.

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(iii) Construction of recovery/recycling plant.
(iv) Construction of municipal solid waste landfill facility.

(c) Municipal Sewage–
(i) Construction of wastewater treatment plant.
(ii) Construction of marine outfall.

19. **WATER SUPPLY:**

(a) Construction of dams or impounding reservoirs with a surface area of 200 hectares or more.

(b) Groundwater development for industrial, agricultural or urban water supply of greater than 4,500 cubic metres per day.

Made the 30th September 1987.

DATUK AMAR STEPHEN K.T. YONG,
Minister of Science, Technology and Environment

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Appendix 5. Further background information on monitoring plan

The project will monitor the emission reductions by the method, indicators and frequency as required by the Approved Methodology ACM0001 (*Version 18.0*).

The main variables that need to be monitored during project activity include:

- Operation of the equipment that consumes the LFG
- Amount of electricity generated using LFG by the project activity in year *y*
- Amount of electricity consumed by the project activity in year *y*
- Temperature in the exhaust gas of the enclosed flare in minute *m*
- Flame detection of flare in the minute *m*
- Volumetric flow of the gaseous stream in time interval *t* on a wet basis
- Volumetric fraction of greenhouse gas CH_4 in minute *m* on a dry basis
- Pressure of the gaseous stream in time interval *t*
- Volumetric fraction of gas CH_4 in the gaseous stream in minute *m* on a dry basis
- Volumetric fraction of gas CO_2 in the gaseous stream in time interval *t* on a dry basis
- Volumetric fraction of gas O_2 in the gaseous stream in time interval *t* on a dry basis
- Operational status of biogas destruction devices
- Combined margin emission factor for the grid in year *y*

<u>Quality Control / Assurance</u>

Quality control and quality assurance procedures will be carried out on all parameters monitored. The practices to be undertaken in the context of the proposed project are as follows:

1. Gas field monitoring records:
- Daily readings of all field meters will be filled out in paper worksheets and filed consequently. All data collected will also be entered in electronic worksheets and stored in a computer (immediately) and on discs (periodically).
- Periodic controls of the LFG field monitoring records will be carried out to check any deviation from the estimated emission reductions following the guideline for LFG plant operation and monitoring for correction or future references.
- Periodic evaluation reports concerning overall performance will be released to aid future performance management.

2. Equipment calibration and maintenance:
- Flow meters, gas analyzers and other sensors will be subject to regular maintenance and testing according to the technical specifications by the manufacturers to ensure accuracy and good performance.
- Calibration of equipment will be conducted periodically according to technical specifications.

3. Corrective actions:
- Actions to correct deviations from the monitoring plan and the guidelines for LFG plant operation and monitoring will be implemented as these deviations are observed either by the operator or during internal audits.

- Apart from periodic meetings, additional technical meetings will be held in order to define any necessary corrective actions to be undertaken.

4. Site audits:

- A CDM Project Team will make regular site audits to ensure that monitoring and operational procedures are being observed in accordance with the monitoring plan and the guideline for LFG plant operation and monitoring.

5. Training:

- A training plan will be set out for all Bukit Tagar Sanitary Landfill employees. This will ensure that both operational and monitoring staff involved in the project are properly trained so that they are able to undertake the tasks required by this monitoring plan. Appropriate staff training must be provided before the project starts operating and generating emission reductions.

6. Storage of documents:

- List of monitoring equipment (e.g. flow meters, gas analyzers, thermometers) including their numbers, names, manufacturers, specifications, user requirements, etc.
- Calibration lists and reports, including equipment or parts calibrated, date, method and procedures of calibration, precision following these processes, personnel, devices needed, etc.
- Maintenance lists and reports, including equipment or parts maintained, date, method and procedure of maintenance, performance following these procedures, personnel, devices needed, etc.
- Operation manual of the proposed project.
- Registration of minutes during meetings.
- Non-conformance reports.
- Monthly and annual worksheets.
- Training plan.
- Internal audit reports, including personnel, time, findings, corrective actions, follow-up inspections, etc.
- Annual monitoring review.

Quality Control and Maintenance Schedule of LFG Monitoring Equipment

Main task **Inspection task**	Daily	weekly	2 x monthly	monthly	3 months	6 months	Yearly
General							
Inspection round	X						
Fill in operating data log	X						
Check for vibrations	X						
Empty condensate trap	X						
Gas analyzing equipment							
Calibrating CH4 / CO2		x					
Calibrating O2		X					
Check filter in analyzer		X					
Check gas pump		x					
Blowers							
Check safety system							
Check lubricating oil level			X		X		X
Change of lube oil				X		X	
Gas pipe system							
Check / Clean gas filter		X					
Inspection of gas pipe system						X	
Check gas valve system						X	
Alarm system							
Test of function					X		

Electrical switch boards							
Visual control				X			
Cleaning of switch boards					X		
Check electrical connections							X
Other							
Check the fire fighting equipment						X	

Appendix 6. Summary report of comments received from local stakeholders

As described at **Section E2.**

Appendix 7. Summary of post-registration changes

1st revision of monitoring plan was submitted to UNFCCC and approved on 09/05/2012.

The revision is related to alternative measurement and handling of data during emergency conditions for methane content, flow meters and electricity meter.

1st notification of change request was submitted to UNFCCC and approved on 09/05/2012.
The change is related to the internal use of power generated for the landfill operation was not successful and was not approved by the relevant authorities and the grid operator. This was due to technical constraints and deleted the onsite utilization from the PDD.
2nd notification of change request (PRC-2467-001) was submitted to UNFCCC on 25/04/2013 and was approved by UNFCCC on 09/09/ 2013.

The change is related to the following:

- Increase of power generation approximately 3MW and upload to the grid by year 2013
- Installation of an additional pipeline and flare system equipped with skid mounted LFG gas blower to handle any excess LFG captured which is expected to be commissioned at the beginning of year 2014

During 8th monitoring period, there was a temporary deviation from the monitoring plan or the monitoring methodology (PRC-2467-002) submitted to UNFCCC on 30/03/2015 and was approved on 11/09/2015. The deviation is related to the usage of grid electricity by the gas engines 2 & 3 auxiliaries and gas supply system (GSS) are calculated since meter EL6 is not connected to capture the data.

3rd notification of change request (PRC-2467-003) was submitted to UNFCCC on 22/09/2015 and was approved by UNFCCC on 12/11/2015. The change is on non-implementation of Flare No.3.

The 4th notification of change request (PRC-2467-004) was published in UNFCCC on 11/10/2016 and was approved by UNFCCC on 15/11/2016.

- Increase of power generation approximately 2MW and upload to the grid by year 2015; and
- Included diesel generator as backup for project activities during the power failure of the grid.

There is a revision of monitoring plan in renewal crediting period. The revision is related to the shutdown of Flare No.1 and converting Flare No.1 to GSSF1. Gas engine No. 1 which was attached to Flare 2 previously has been converted to GSSF1. Flare no. 1 is no longer in operation starting from 03/01/2017 onwards. Flare no. 1 is converted to GSS F1, where Gas Engine No. 1 is attached to Flare No. 1. Gas Engine No. 1 no longer attached to Flare No. 2 starting from 03/01/2017.

In accordance to the approved revised PDD version 19.0 dated 02/09/2016, section A1 (paragraph 3), it is stated that the landfill is being developed in phases (cells) and any future phases to be developed are part of the project. Phase 2 and Phase 3 cells mentioned in this RCP are subsequent cells developed after the completion of earlier cells, which are part of the future phases to be developed as described in the approved revised PDD version 19.0. As a result, the phase development such as Phase 2 and Phase 3 cells, as well as any future landfill cells to be developed at this landfill are considered in the initial planning during in the 1st crediting period and not considered as post registration changes.

There is a design change and revision of monitoring period in this PRC request. The power generation has been increased from 5.5MW to 9.5MW with the addition of two (2) gas engine with an installed capacity of 2MW. The approved power to be exported will be 4MW.

The baseline emissions have changed causing an increase in emission reductions due to the increase in power generation and development of the landfill in phases as described in the registered PDD section A.1.

With the addition of biogas generators to generate additional electricity for export to grid and power consumed by project activity, parameter $EG_{PJ,y}$: Amount of electricity generated using LFG by the project activity in year y is revised as listed as below:

- In the revised PDD version 21, $EG_{PJ,y}$ will be the lower value of the amount electricity after comparing the total of EL4, EL9, EL10, EL12, EL14 and EL15 with total of EL5, EL11 and EL16.
- The amount of electricity generated by the gas engines will be recorded by meters EL4, EL9, EL10, EL12, EL14 and EL15.
- EL5, EL11 and EL16 measure the amount of electricity exported to the grid.

In the event of future temporary malfunction of meter EL16 whereby no readings are captured, it shall be estimated and/or calculated as described below:

- The power generated and uploaded to grid for Gas Engine No.4, Gas Engine No.5 and Gas Engine No.6 will use the reading captured by EL12, EL14 and EL15, 95% confidence interval and add an addition of 10% based on CDM Project Standard for CDM project activities" (Version 02.0)

With the addition of biogas generators, parameter **$vt_{,wb}$**: Volumetric flow of the gaseous stream in time interval t on a wet basis is revised.

- In the revised PDD version 21, the measurement for $vt_{,wb}$ for the new gas engines (GE5 & GE6) will be combined with gas engines no. 4, there are two (2) sets of flow meter to measure the gas sent to Gas Engine No.4, Gas Engine No.5 and Gas Engine No. 6. 1st set of the meter will measure the total amount of gas sent to GSS2 ($FT3_{GSS2}$) (GE4), and GSS3 ($FT3_{GSS3}$) (GE5 & GE6) before sent to respective gas engines. Another set of the meter will measure the total amount of gas sent to specific gas engine No. 4 (FT7), gas engine No. 5 (FT8) and gas engine No. 6 (FT9).
- The amount of gas sends to Gas Engines 4,5 and 6 will be recorded by meters $FT3_{GSS2}$ and $FT3_{GSS3}$.
- The amount of gas sends to Gas Engines 4,5 and 6 will be recorded by meters FT7, FT8, and FT9.

In the event of future temporary malfunction of meter $FT3_{GSS2,}$ or $FT3_{GSS3}$ whereby no readings are captured, it shall be estimated and/or calculated as described below:

- The flow of gas sent to gas engines will use the reading captured by respective flow meter (FT7, FT8 and FT9). The recorded reading shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6). The lower bound of 95% confidence interval with reference to the above-mentioned guideline will be applied.

In the event of future temporary malfunction of meter $FT3_{GSS2,}$ or $FT3_{GSS3}$ and FT7, FT8 and FT9 whereby no readings are captured, it shall be estimated and/or calculated as described below:

- The flow of gas sent to gas engines will use the reading captured by daily manual log sheet. The recorded reading shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas

Inventories", page 6.6). The lower bound of 95% confidence interval with reference to the above-mentioned guideline will be applied.

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Document information

Version	Date	Description
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the "CDM project standard for project activities" and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the "CDM project standard for project activities" (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the "Project design document form for small-scale CDM project activities" (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the "Standard: Applicability of sectoral scopes" (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.

Version	*Date*	*Description*
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	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).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

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