Monitoring report form
(Version 03.2)

Monitoring report

Title of the project activity	Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor in Malaysia
Reference number of the project activity	2467
Version number of the monitoring report	1.0
Completion date of the monitoring report	10/05/2014
Registration date of the project activity	28/08/2009
Monitoring period number and duration of this monitoring period	Monitoring period number: 08 Duration of monitoring period: 01/09/2013 – 31/03/2014 inclusive of both days
Project participant(s)	KUB-Berjaya Enviro Sdn. Bhd. (KBE)
Host Party(ies)	Malaysia
Sectoral scope(s) and applied methodology(ies)	13 : Waste handling and disposal ACM 0001, version 8[1] Consolidated baseline and monitoring methodology for landfill gas project activities
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	156,882 tCO_2e * *Ex-ante for 212 days (Sept 2013 – Mar 2014) – [263,204 x (122/365)] + [279,458 x (90/365)]*
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	181,426 tCO_2e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period up to 31 December 2012 (if applicable)	Not applicable
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period from 1 January 2013 onwards (if applicable).	375,007 tCO_2e[2]

1 The ACM 0001 - *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8) is no longer valid and is not available for download in UNFCCC. The version has been replaced with Version 8.1.
2 The actual value achieved for the 7th monitoring period from 01/01/2013 – 31/08/2013 is 193,581 tCO_2e and 8th monitoring period from 01/09/2013 – 31/03/2014 is 181,426 tCO_2e.

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The Bukit Tagar Sanitary Landfill (BTSL) is operated by KUB-Berjaya Enviro Sdn. Bhd. (KBE) and located in Hulu Selangor, Malaysia. The landfill receives municipal solid waste (MSW) from the country's capital, Kuala Lumpur and Selayang district in Selangor State.

The main objective for the Clean Development Mechanism (CDM) project is to avoid direct emissions of greenhouse gases (GHGs) from the landfill into the atmosphere through active extraction. The gas collected is destructed by high temperature enclosed flares as well as is used for power generation using Gas Engines with high efficiency.

Carbon emissions are reduced through two major activities:

Emission Reduction Aspects	How will emissions be reduced?
Landfill gas (LFG) Extraction and Destruction (Methane (CH_4) avoidance)	Instead of releasing LFG (consisting CH_4) to the atmosphere, the gas will be collected and destroyed in enclosed flares and Gas Engines
Power Generation (Fuel replacement)	Less carbon dioxide (CO_2) will be emitted by replacing electricity generated from grid power with electricity produced from LFG (considered as renewable)

LFG extraction from Advance Cell, Phase 1 and 2 Cells has continued to operate during this monitoring period.

Two high temperature enclosed flares with maximum capacity of 2,500 Nm^3/hr have continued to be in operation while a portion of the gas captured was sent to a unit of 1MW Gas Engine (Gas Engine No.1) and 2 units of 1.56MW Gas Engines (Gas Engine No.2 and No.3) to generate electricity. The electricity produced by the gas engines was exported to the grid during this monitoring period.

Relevant dates for the project activities tabulated below:

Bukit Tagar Project	Construction Start	Commissioned	Continued operation periods
First flaring system	17/06/2008	28/08/2009	Continued to operate
Second flaring system	22/01/2010	07/08/2010	Continued to operate
Third flaring system	Not commissioned	Not commissioned	Not commissioned
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)	06/12/2014	Commissioned and operating
Gas Engine No.3	06/08/2012 (Signed-off Delivery Order)	06/12/2014	Commissioned and operating

The 8th monitoring period is from 01/09/2013 to 31/03/2014 (inclusive of both days). The total emission reductions achieved during this monitoring period is **181,426 tCO_2e.**

A.2. Location of project activity

Information	Description
Host Party(ies)	Malaysia

Region/ State/ Province, etc.	State of Selangor
City/ Town/ Community, etc.	Mukim Sg. Tinggi, District of Hulu Selangor The project location is situated approximately 5km to the west of the Bukit Tagar Interchange along the North-South Expressway and 40km from central Kuala Lumpur. The landfill is easily accessible via 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.
Physical/ Geographical location	see table below

Latitude	Longitude	Description
3°30'168"	101°28'428"	North
3°29'07"	101°28'452"	South
3°29'46"	101°28'20"	West
3°29'69"	101°29'268"	East

Figure 1: Location of BTSL and Selangor State

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Malaysia **(host)**	KUB-Berjaya Enviro Sdn. Bhd. (KBE) (Private)	No

Note: Japan Carbon Finance, Ltd. (JCF) (Private) was removed from this table as JCF had withdrawn on 21/10/2013 (MoC Annex 2 (Withdraw Project Participant) valid as of 25/10/2013) http://cdm.unfccc.int/Projects/DB/DNV-CUK1238680609.1/view

A.4. Reference of applied methodology

The project has applied the following approved methodology and tools:

Approved Methodology:

ACM 0001 – *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8)[3]

Methodological Tools referred to include:

- *Tool for the demonstration and assessment of additionality* (Version 5.2, EB 39, Annex 10);
- *Tool to determine project emissions from flaring gases containing methane* (Version 1, EB 28, Annex 13);
- *Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site* (Version 05, EB 55, Annex 18);
- *Tool to calculate the emission factor for an electricity system* (Version 02, EB 50, Annex 14); and
- *Tool to calculate baseline, project and/or leakage emissions from electricity consumption* (Version 1, EB 39, Annex 7)
- *Tool to determine the mass flow of a greenhouse gas in a gaseous stream* (Version 02.0.0, EB 61, Annex 11).

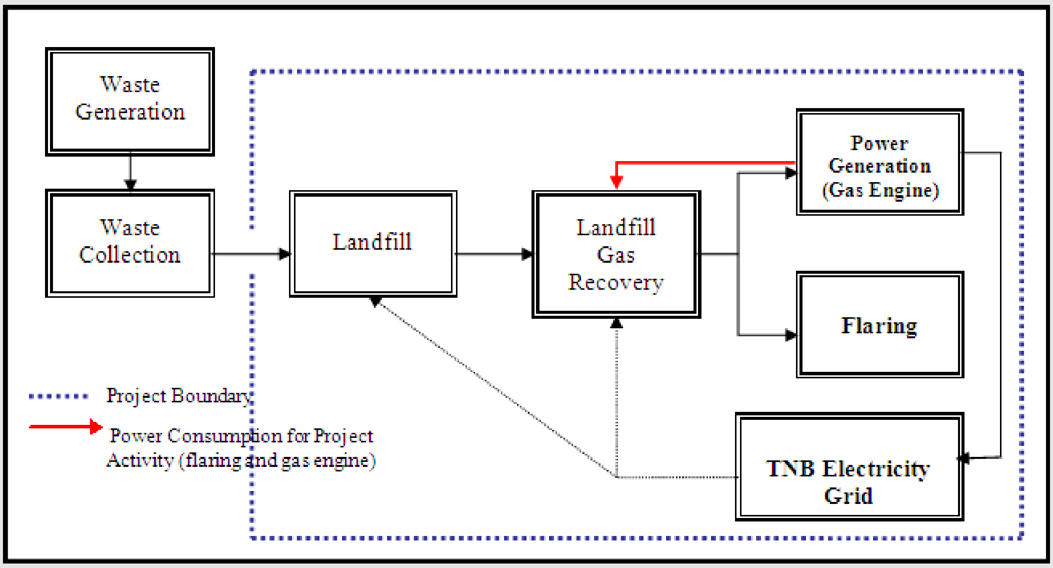
A.5. Crediting period of project activity

The start date of the crediting period of the project activity is 28/08/2009 (date of registration) and the end date of the 1st crediting period is 27/08/2016. The selected crediting period is renewable (7 years). The 8th monitoring period is from 01/09/2013 to 31/03/2014 (inclusive of both days).

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

The landfill gas recovery, flaring and power generation system can be illustrated below:



Note:

1. *With reference to paragraph 3, Section A.2, CDM PDD version 7.2, the landfill is being developed in phases. Currently, landfill gas extraction has been implemented on 3 cells in the landfill, i.e. Advance Cell, Phase 1 and 2. These phases are included in this project as well as any future phases to be developed in accordance to the PDD.*
2. *1st Notification of change was submitted earlier to remove the on-site power consumption for landfill operation. Notification of change was approved by UNFCCC on 09/05/2012.*
3. *2nd Notification of change was submitted on 25/04/2013 to increase the power generation approximately 3MW and upload to the grid by year 2013 and 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. The notification of change was approved by UNFCCC on 09/09/2013.*

Figure 2: Overall LFG Recovery, Flaring and Power Generation Design

[3] The ACM 0001 - *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8) is no longer valid and is not available for download in UNFCCC. The version has been replaced with Version 8.1.

Description on the installed technologies

The technology applied and transferred into this project has been implemented and proven in Europe (Denmark and Germany) as well as in China (extraction and flaring system).

Detailed technical description is further described below:

Gas Extraction System in Advance Cell

Q2 Engineering Sdn. Bhd., a subsidiary of Q2 A/S of Denmark was appointed as the turnkey contractor to construct the gas extraction and flaring system for Advance Cell. 42 vertical gas extraction pipes were installed in the landfill to extract the LFG. These wells were connected to 8 units of main gas collection pipes that led to the LFG flaring system.

Figure 3: An Example of Vertical Well Installed in Advance Cell

These vertical wells can be individually regulated and controlled.

First High-Temperature Enclosed Flaring System (Flare No.1)

One unit of high-temperature enclosed flaring system had been installed to flare off the LFG extracted. The flare system included a containerised blower and flaring system with a maximum capacity to flare off 2,500 Nm^3/hr LFG.

Figure 4: Enclosed Flare Installed at Advanced Cell (Flare No.1)

The details of the flare specifications are listed below:

Specifications	Details
Manufacturer	Fairyland Environmental Technology, China

Gas flow	Maximum – 2,500 Nm^3/hr
Retention time	>0.3 seconds at 800-1,000°C
Gas blower	Twin-lobe roots blower
Gas analysers	Gas analysers for CH_4 and O_2

Gas Extraction System in Phase 1 Cell

Stage 1 of Phase 1 Cell was completed in August 2010. The cell is still an operational cell which will be filled according to the proposed plan of the landfill sequence at a later stage. The design of the gas extraction wells is based on a series of horizontal gas extraction wells constructed over the entire Phase 1 Cell.

Figure 5: Horizontal Gas Extraction Wells in Phase 1 Cell

Second High-Temperature Enclosed Flaring System (Flare No.2)

The second unit of high-temperature enclosed flaring system was installed to cater for the extra LFG extracted from Phase 1 Cell. The flare system included a containerised blower and flaring system with a maximum capacity to flare off 2,500 Nm^3/hr LFG.

Figure 6: High-Temperature Enclosed Flares

The flare was supplied by the same manufacturer for Flare No.1. Details of the flare specifications are listed below:

Specifications	Details
Manufacturer	Fairyland Environmental Technology, China
Gas flow	Maximum – 2,500 Nm^3/hr
Retention time	>0.3 seconds at 800-1,000°C
Gas blower	Twin-lobe roots blower

Gas analysers	Gas analysers for CH_4 and O_2

The analyser and data logging system is similar to Flare No.1 (as described above).

Gas Extraction System in Phase 2 Cell

Phase 2A Cell was completed in October 2012. 12 lines of horizontal wells with gas pipeline were installed in the landfill to extract the LFG. The cell is still an operational cell which will be filled according to the proposed plan of the landfill sequence at a later stage. The design of the gas extraction wells is based on a series of horizontal gas extraction wells constructed over the cell.

Third High-Temperature Enclosed Flaring System (Flare No.3)

Due to the delayed landfill gas extraction in Phase 2B Cell, there is no significant amount of excess LFG captured. Therefore, Flare No.3 was delayed and will be commissioned at a later stage.

Gas Analyser and Data Logging

Monitoring of the correct functioning of the flare system was provided by a continuous-logging system which examines the operational parameters of the flare. The gas analyzing system is a multi-functional environmental monitoring equipment that can monitor up to 14 different measurements and data logging channels. Data from the logging system was presented on a local screen (on-line data) and stored in a local personal computer (PC) unit with external communication via Global System for Mobile Communications (GSM).

Data were downloaded directly from the built-in data logger to a PC and were also transmitted to external server and PC as back-up.

Gas Engine Energy Power Plants

A high-efficiency (electrical efficiency > 42%) Gas Engine (net dispatch of 1 MW) was chosen for the generation of electricity from LFG.

Figure 7: High-Efficiency Landfill Gas Engine Used in BTSL

The details of Gas Engine No.1 specifications are listed below:

Specifications	Details
Manufacturer (Origin)	MWM (Germany)
Model	TCG 2020V12
Electric power output (net to grid)	1 MW (total max. gross output 1.2 MW)
Voltage	11 kV
Frequency	50 Hz
Minimum heating value (LHV)	5.9 kWh/m^3

To ensure that good quality LFG arrives at Gas Engine No.1, a LFG pre-treatment system comprising of a chiller (made in Germany) and activated carbon filter was also set up to remove moisture and impurities such as hydrogen sulphide (H_2S) and siloxanes before Gas Engine No.1.

A landfill gas blower was installed to ensure that the required gas pressure for Gas Engine No.1 is maintained.

With the additional gas extraction of LFG in Phase 2A, 2 units of 1.56 MW gas engines were delivered to the site on 06/08/2012. The gas engines were commissioned on 06/12/2013 and the monitoring parameters for the consumption of landfill gas and additional power generated from the new gas engines were recorded and included in this Monitoring Report.

The details of Gas Engine No.2 and Gas Engine No.3 specifications (identical gas engines) are as listed below:

Specifications	**Details**
Manufacturer (Origin)	MWM (Germany)
Model	TCG 2020 V16
Electric power output	1.56 MW
Voltage	415 V
Frequency	50 Hz
Minimum heating value (LHV)	5.0 kwh/m3

In addition to the new gas engines installation, an additional pipeline equipped with skid mounted LFG gas blower was installed in September 2012.

Centralised SCADA System

The Centralized (Supervisory Control and Data Acquisition) SCADA Interface was developed to integrate all existing SCADA or operation monitor system, ranging from individual Flare to Gas Engines. The objective of the integrated monitoring system is aimed to improve the efficiency of staff movement, monitoring process and data collection as well as serving as additional storage of database. The new system offered remote monitoring option which allows access through internet connection for view-only if provided with the correct authentication key.

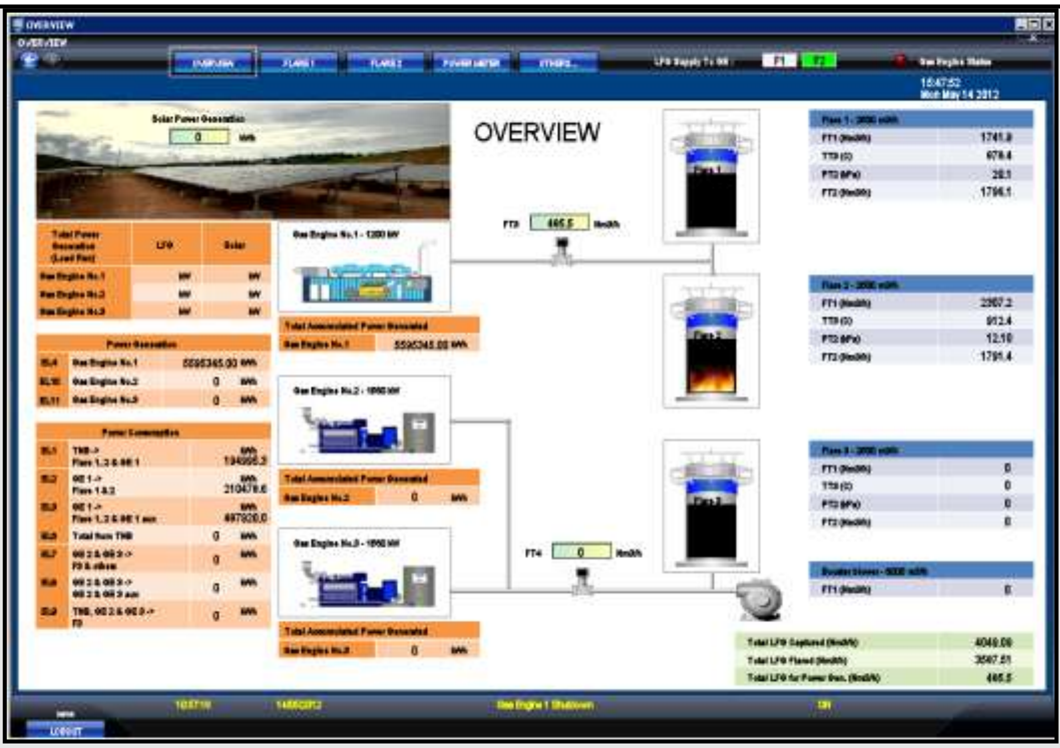


Figure 8: Centralized SCADA Interface

Implementation status of project activity

For the reporting period of 01/09/2013 to 31/03/2014, the key CDM activities implemented are described below:

Gas Extraction System in Advance Cell and Flare No.1

The actual implementation of the flaring system was initiated in August 2009 and has continued through this monitoring period.

The details on the downtime of the system (over the monitoring period covered by this report) are presented in **Appendix 1**.

The total running time for Flare No.1 is 98% during this monitoring period.

Gas Extraction System in Phase 1 and 2A Cells and Flare No.2

The flaring system in Phase 1 Cell was completed during the 2nd monitoring period and has started its operation on 07/08/2010 during the 6th monitoring period. Flare No.2 was located next to Flare No.1 where most of the LFG extracted from Phase 1 and 2A Cells is transferred via a transfer pipe and fed to Flare No.2.

The details on the downtime of the system (over the monitoring period covered by this report) are presented in **Appendix 2**.

The total running time for Flare No.2 is 99% during this monitoring period.

Power Generation

During this monitoring period, power generated from Gas Engine No.1 continued to be uploaded to the grid.

Currently, the data recording for the amount of gas channelled to Gas Engine No.1 is linked with the Flare

No.2 SCADA system. Hence, the shutdown of Flare No.2 also indicated the shutdown of Gas Engine No.1.

On 06/12/2013, Gas Engine No.2 and No.3 were commissioned and the power generated from these gas engines was uploaded to the grid.

The details on the downtime of the Gas Engine No.1, No.2 and No.3 are presented in **Appendix 3.**

B.2. Post registration changes

B.2.1. Temporary deviations from registered monitoring plan or applied methodology

No temporary deviations from registered monitoring plan or applied methodology during this monitoring period.

B.2.2. Corrections

No corrections during this monitoring period.

B.2.3. Permanent changes from registered monitoring plan or applied methodology

No permanent changes from registered monitoring plan or applied methodology during this monitoring period.

During the 3rd monitoring period, the revision of monitoring plan was submitted to UNFCCC and approved on 09/05/2012[4].

The revision is related to alternative measurement and handling of data during emergency conditions for methane content, flow meters and electricity meter.

B.2.4. Changes to project design of registered project activity

There is no change to project design of registered project activity during this monitoring period.

During the 3rd monitoring period, the notification of change request was submitted to UNFCCC and approved on 09/05/2012[5].

The change is related to the internal use of power generated for the landfill operation which was not successful and was not approved by the relevant authorities and the grid operator. This was due to the technical constraints and removal of on-site utilization from the PDD.

The 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

B.2.5. Changes to start date of crediting period

No changes to start date of crediting period during this monitoring period.

[4] http://cdm.unfccc.int/Projects/DB/DNV-CUK1238680609.1/view
[5] http://cdm.unfccc.int/Projects/DB/DNV-CUK1238680609.1/view

B.2.6. Types of changes specific to afforestation or reforestation project activity

Not applicable.

SECTION C. Description of monitoring system

Monitoring Methodology

The basis of the monitoring plan (MP) was formulated based on the approved methodology ACM 0001 – *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8).

Tool to determine project emissions from flaring gases containing methane

According to page 10 of the *Tool to determine project emissions from flaring gases containing methane*, in case of enclosed flares and use of the default value for the flare efficiency, the flare efficiency in the hour *h* ($\eta_{flare,h}$) is:

- 0%, if the temperature in the exhaust gas of the flare (T_{flare}) is below 500°C for more than 20 minutes during the hour *h*
- 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h*
- 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h*

The manufacturer's specification on proper operation of the flare need to be met in order to apply 90% flare efficiency in the hour *h* whenever the exhaust gas of the flare (T_{flare}) is above 500°C for more than 40 minutes during the hour *h*.

The manufacturer's specification on proper operation of the flare is monitored through the operating set point for the flare which was pre-set at the SCADA system. Whenever there is an issue where the flare operates below or above the set point; the system will be automatically shut down.

Tool to determine the mass flow of a greenhouse gas in a gaseous stream

The MP also referred to the *Tool to determine the mass flow of a greenhouse gas in a gaseous stream*.

Referring to the tools, for LFG temperatures below 60 ^{o}C, moisture could be neglected due to its very low influence on final results and thus, the measurement in wet or dry basis are not important (as reflected in the amendments to ACM 0001, version 9.1 onwards). In case where the LFG temperature exceeds 60^{o}C, the same basis for both CH_4 concentration and flow measurement will be considered according to the tools.

The detailed description on the calculation applied to the CER Calculation Sheet is as shown in **Appendix 4**.

Transmission and Distribution Losses (TDL_y)

According to page 35 of the registered PDD, version 5.3, the Transmission and Distribution Losses (TDL_y) value applied in this project is 10%. This value was reported in the Tenaga Nasional Berhad (TNB)[6] Annual Report 2007[7] in page 23.

[6] Tenaga Nasional Berhad is the largest electricity provider in Malaysia and is responsible for the grid transmission and distribution in Peninsular Malaysia.
[7] http://announcements.bursamalaysia.com/EDMS/subweb.nsf/7f04516f8098680348256c6f0017a6bf/303144432ec51 70e482573af00388df6/$FILE/TENAGA-Cover%20to%20Page%2050%20(2.3MB).pdf

Operation and Management Structure for Monitoring

The organization structure for the Bukit Tagar CDM monitoring team is shown below:

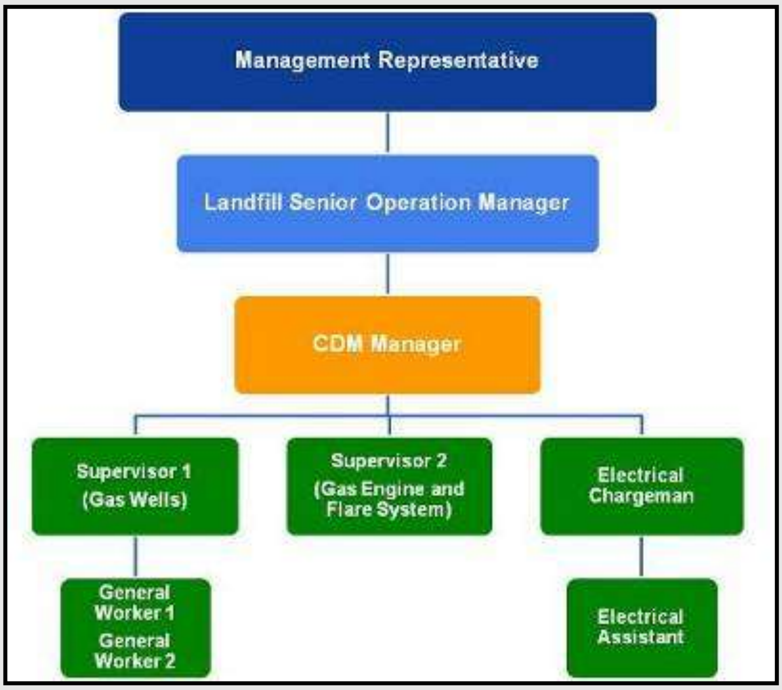


Figure 9: Organisational Structure for CDM Monitoring for BTSL LFG Recovery and Utilisation Project

The roles and responsibilities of the monitoring team in carrying out the MP are detailed as follow:

Table 1: Responsibilities of the CDM Monitoring Team

Role	Responsibility in CDM monitoring
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
Senior Landfill Operation Manager	• 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 Senior Landfill Operation Manager • 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
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
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

The team is overall headed by the MR who oversees the entire CDM monitoring implementation. The MR receives direct updates and support from the site staff headed by the Senior Landfill Operation Manager. The Senior Landfill Operation Manager is supported by the CDM Manager who is the key coordinator to all CDM monitoring matters on-site. The CDM Manager is assisted by a group of technicians and workers who will perform the daily recording and checking tasks.

The CDM Consultant (Eco-Ideal Consulting Sdn. Bhd.) was appointed to assist KBE in ensuring that the monitoring plan and requirements were done according to the MP. The consultant played the role of a trainer and conducted independent audits as part of the QA/QC procedures set up for this project.

During this monitoring period, one CDM Management Meeting was held on 04/04/2014.

Relevant Monitoring Points

The parameters monitored during the monitoring period are illustrated in the following figure:

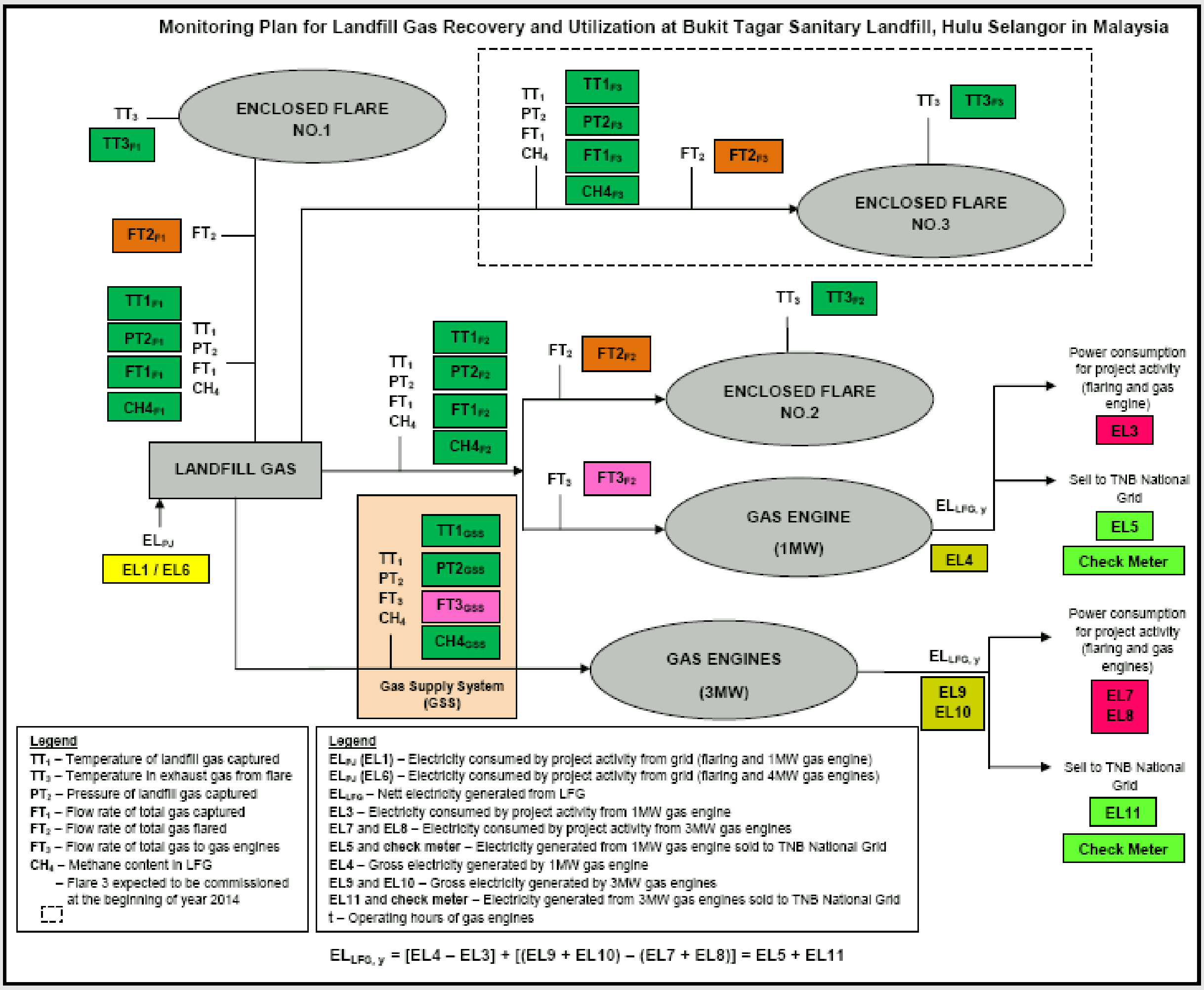


Figure 10: Key Parameters Monitored under the CDM Monitoring Plan

Remark:

The power meter used to measure the electricity consumed by Flare No.1 and Flare No.2 from the grid was no longer in use effective from 22/06/2011. The total power consumption by the project activity from the grid (flaring systems and Gas Engine No.1) was measured by the new power meter installed, i.e. EL1.

Flare No. 3 will be implemented at a later stage and as a result, no data and instrument is available, i.e. $TT1_{F3}$, $PT2_{F3}$, $FT1_{F3}$, $FT2_{F3}$, $CH4_{F3}$, and $TT3_{F3}$.

The new gas engines, Gas Supply System (Gas Engine No.2 and Gas Engine No.3) were commissioned during this monitoring period. As a result, data and instrument is available for $TT1_{GSS}$, $PT2_{GSS}$, $FT3_{GSS}$, $CH4_{GSS}$, EL6, EL7, EL8, EL9, EL10 and EL11.

A physical connection has been installed to allow the transfer of gas from Phase 1 Cell to Flare No.1. When Flare No.2 is unable to operate, the gas from Phase 1 Cell will be channelled to Flare No.1 to be flared. A part of the gas will also be transferred to the gen-set for electricity production if required. Necessary monitoring is carried out to ensure compliance with the MP.

<u>Data Recording and Documentation</u>

All relevant data/measurements of the parameters taken were recorded and kept in an appropriate format and archived after the crediting period to ensure that the data are accessible especially during the monitoring and verification process of the project.

Data was recorded in the following way:

Continuous Monitoring – Data in Softcopy:
Data logger (automatic recording in computer)

Manual Recording – Data in Hardcopy:
Daily monitoring log sheets and record books (manual recording)

Based on the MP, key parameters (temperature, pressure, flow of gas, CH_4 concentration in biogas) were continuously monitored and recorded via the data logger at the control room.

As a back-up data recording system, the on-site workers were required to manually record certain monitored parameters in daily monitoring log sheets. These records were filed and kept in the office which can be accessible by the CDM Manager and technicians whenever necessary. These log sheets (in hard copies) were scanned for electronic filing on a monthly basis.

A summary of the data directly monitored is tabulated below:

Table 2: CDM Monitoring Parameters, Frequency and Archiving

Parameter	CDM ID	Equipment ID	Monitoring equipment	Recording frequency	Documentations	Data archive
Temperature	$T_{TT1,F1}$ $T_{TT1,F2}$ $T_{TT1,GSS}$	$TT_{1,Flare\ No.1/Flare\ No.2/GSS}$	Thermocouple	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned into PDF format for archiving
Flare Temperature	$T_{Flare,F1}$ $T_{Flare,F2}$	$TT_{3,Flare\ No.1/Flare\ No.2}$	Thermocouple	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned into PDF format for archiving
Pressure	$P_{PT2,F1}$ $P_{PT2,F2}$ $P_{PT2,GSS}$	$PT_{2,Flare\ No.1/Flare\ No.2/GSS}$	Pressure Gauge	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned into PDF format for archiving
Flowrate	$LFG_{total,Flare\ No.1/Flare\ No.2,y}$ $LFG_{flare,F}$	$FT_{1,Flare\ No.1/Flare\ No.2}$ $FT_{2,Flare}$	V-Cone Differential Pressure Flowmeter	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned

	lare No.1/Flare No.2,y $LFG_{electricity,Flare No.2/GSS,y}$	No.1/Flare No.2 $FT_{3,Flare No.2/GSS}$				into PDF format for archiving
Methane Fraction	$W_{CH4,Flare No.1/Flare No.2/GSS,y}$	$CH_{4,Flare No.1/Flare No.2/GSS}$	Continuous Infrared Gas Analyser	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned into PDF format for archiving
Electricity consumed by the project	$EL_{PJ,y}$ $EL_{PJ,GE,GE No.1 auxiliary \& flare,y}$ $EL_{PJ,GE,GSS,y}$ $EL_{PJ,GE,GE No.2 and No.3 auxiliary,y}$	EL_{PJ} (EL1, EL6) $EL_{PJ,GE,GE No.1 auxiliary \& flare}$ (EL3) $EL_{PJ,GE,GSS}$ (EL7) $EL_{PJ,GE,GE No.2 and No.3 auxiliary}$ (EL8)	kWh meter	Daily (manual)	Softcopy (scanned copy) Hardcopy	Data recorded will be compiled into MS Excel and aggregated for monthly amount Daily log sheet will be scanned for archiving
Electricity generated by LFG	$EL_{LFG,GE No.1,y}$ $EL_{LFG,GE No.2,y}$ $EL_{LFG,GE No.3,y}$	$EL_{LFG,GE No.1}$ (EL4) $EL_{LFG,GE No.2}$ (EL9) $EL_{LFG,GE No.3}$ (EL10)	kWh meter	Daily (manual)	Softcopy (scanned copy) Hardcopy	Data recorded will be compiled into MS Excel and aggregated for monthly amount Daily log sheet will be scanned for archiving
	$EL_{LFG,y}$	EL_{LFG} (EL5 and EL11, TNB main energy meters) TNB check energy meters	kWh meter	Daily (manual)	Softcopy (scanned copy) Hardcopy	TNB joint meter reading certificate will be scanned for archiving

NOTE:

Data recorded by the flow meters were normalised to Nm^3 with the temperature and pressure monitored automatically via the software. Thus, there was no need to normalise the recorded flow further. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. The new gas engines, Gas Supply System (Gas Engine No.2 and Gas Engine No.3) were commissioned during this monitoring period.

Monitoring Equipment and Equipment Calibration

The list of CDM monitoring equipment used is shown in Table 3 & Table 4 below:

Table 3: List of CDM Monitoring Equipment and Calibration for Flare No.1

No	Item	Parameters	Equipment ID	CDM Monitoring ID	Unit	Manufacturer	Model No.	Serial No.	Accuracy	Range	Last Calibration Date & Cert No.	Recommended Next Calibration Date	Recommended Frequency of Calibration
Flare System													
1	Temperature Transmitter	Temperature (T)	TT[illegible]	T[illegible]	°C	PR Electronics	5335A	100944768	≤ ± 0.05% of span	0-100°C	07/12/2012 & SB 121010 (01/09/2013 - 09/12/2013)	06/12/2013	Annually
											10/12/2013 & CTT 1354-13 (10/12/2013 - 31/03/2014)	09/12/2014	Annually
2	Temperature Transmitter	Flare Temperature (T[illegible])	TT[illegible]	T[illegible]	°C	PR Electronics	5335A	110910943	≤ ± 0.05% of span	0-1200°C	19/07/2013 & CTT 1260-13 (01/09/2013 - 31/03/2014)	18/07/2014	Annually
3	Pressure Sensor	Pressure Transmitter (P)	PT[illegible]	P[illegible]	kPa	Rosemount	3051TG1A2B21AB4E5M5Q4	02492864	±0.25%	0-2 to 0-207 kPa	21/12/2012 & SB 121094 (01/09/2013 - 09/12/2013)	20/12/2013	Annually
											10/12/2013 & CTP 1523-13 (10/12/2013 - 31/03/2014)	09/12/2014	Annually
4	Flow Meter	Total Biogas Flow Rate (LFG[illegible])	FT[illegible]	LFG[illegible]	NM^3/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051 / KVS10IIKC23FSN	4972948 / FT119 (8102101)	±1%	3-5000Nm^3/h	25/04/2013 & CTP 1139-13 (01/09/2013 - 31/03/2014)	24/04/2015	24 months
5	Flow Meter	Flaring Biogas Flow Rate (LFG[illegible])	FT[illegible]	LFG[illegible]	NM^3/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051 / KVS10IIKC23FSN	02768088 / FT120 (8102102)	±1%	3-5000Nm^3/h	21/12/2012 & SB 121096 (01/09/2013 - 31/03/2014)	20/12/2014	24 months
Gas Analysers													
6	CH_4 Meter	Methane fraction of LFG	CH_4[illegible]	W[illegible]	%	Guardian Plus	97460	32560	±2% of full scale	0-100%	14/05/2013 & E-1359/0413 (01/09/2013 - 31/03/2014)	13/03/2014	Annually

Span Gas			
No	Parameters	Analysis date	Best if used by
1	N_2, CH_4	01/08/2011	01/08/2021
2	N_2, O_2	26/10/2009	26/10/2019
		09/01/2012	09/01/2022

With reference to the Clean Development Mechanism Validation and Verification Standard, version 06.0, section 9.4.4.2, paragraph 273 (a), “Applying the maximum permissible error of the instrument to the measured values taken during the period between the scheduled date of calibration and the actual date of calibration, if the results of the delayed calibration do not show any errors in the measuring equipment, or if the error is smaller than the maximum permissible error”, during this monitoring period, there are 2 equipment which have delay in calibration and the error of new calibration are less than the maximum permission error (MPE) which are as listed below:

1. TT1 (PR Electronics serial number 100944768) – The maximum permissible error of ±0.05% which is the equipment calibration error was applied to TT1 from 07/12/2013 - 10/12/2013 as a conservative approach. The impact of applying this error to the flow normalisation is negligible
2. CH4 (Guardian Plus serial number 32560) – The maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 14/03/2014 - 31/03/2014 as a conservative approach

Table 4: List of CDM Monitoring Equipment and Calibration for Flare No.2

No	Item	Parameters	Equipment ID	CDM Monitoring ID	Unit	Manufacturer	Model No.	Serial No.	Accuracy	Range	Last Calibration Date & Cert No.	Recommended Next Calibration Date	Recommended Frequency of Calibration
Flare System													
1	Temperature Transmitter	Temperature (T)	$TT_{1,Flare No.2}$	$T_{FT1,F2}$	°C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	8839917437	±0.5% of span	0-100°C	25/04/2013 & CTT 1171-13 (01/09/2013 - 31/03/2014)	24/04/2014	Annually
2	Temperature Transmitter	Flare Temperature	$TT_{2,Flare No.2}$	$T_{Flare,F2}$	°C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	8838003937	±0.5% of span	0-1200°C	25/04/2013 & CTT 1172-13 (01/09/2013 - 31/03/2014)	24/04/2014	Annually
3	Pressure Sensor	Pressure Transmitter (P)	$PT_{1,Flare No.2}$	$P_{FT1,F2}$	kPa	Rosemount	3051TG1A2B21AB4E 5Q4	5584784	±0.25%	0-2 to 0-207 kPa	25/04/2013 & CTP 1134-13 (01/09/2013 - 31/03/2014)	24/04/2014	Annually
4	Flow Meter	Total Biogas Flow Rate ($LFG_{total,y}$)	$FT_{1,Flare No.2}$	$LFG_{total,Flare No.2,y}$	NM³/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5K 5Q4 / KVS10(I)KC23FSN	5478626 / FT141 (10031702)	±0.5%	3-5000Nm³/h	25/04/2013 & CTP 1136-13 (01/09/2013 – 31/03/2014)	24/04/2015	24 months
5	Flow Meter	Flaring Biogas Flow Rate ($LFG_{flare,y}$)	$FT_{2,Flare No.2}$	$LFG_{flare,Flare No.2,y}$	NM³/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5K 5Q4 / KVS20(I)KC25PSN	5478627 / FT140 (10031701)	±0.5%	3-5000Nm³/h	25/04/2013 & CTP 1137-13 (01/09/2013 - 31/03/2014)	24/04/2015	24 months
6	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{3,Flare No.2}$	$LFG_{electricity,Flare No.2,y}$	NM³/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5 B4K5Q4 / KVS08(I)KC25PSN	02768007 / FT161 (11011001)	±0.5%	200-2000Nm³/h	04/10/2012 & 80424527 (PO) (01/09/2013 - 31/03/2014)	03/10/2014	24 months
Gas Analysers													
7	CH_4 Meter	Methane fraction of LFG	$CH_{4,Flare No.2}$	$W_{CH4,Flare No.2,y}$	%	Guardian Plus	97460	31453	±2% of full scale	0-100%	14/12/2012 & E-1181/1212 (01/09/2013 - 09/12/2013)	13/12/2013	Annually
											10/12/2013 & CTP 1524-13 (10/12/2013 - 31/03/2014)	09/12/2014	Annually
Power Generation and Electricity Consumption													
8	Power meter	Electricity consumed (from grid for flaring system & GE)	EL_{PJ} (EL1)	$EL_{PJ,y}$	kWh	IME	NEMO 96HD+ (MF96021)	2167 8900 35	Class 0.5S (±0.5%)	0-400/5A	10/05/2011 & 2167 8900 35 (01/09/2013 - 31/03/2014)	09/05/2014	36 months
9	Power meter	Electricity consumed (from GE for Flare 1, Flare 2 & GE auxiliaries)	$EL_{LE,GE No.1}$ auxiliary area (EL3)	$EL_{C,GE No.1}$ auxiliary area,y	kWh	IME	NEMO 96HD+ (MF96021)	2175 4100 36	Class 0.5S (±0.5%)	0-500/5A	21/06/2012 & 2175 4100 36 (01/09/2013 - 31/03/2014)	20/06/2015	36 months
10	Power meter	Total electricity generation (MWh) – recorded by project site	$EL_{PJ,GE No.1}$ (EL4)	$EL_{PJ,GE No.1,y}$	kWh (to be converted to MWh)	EDMI Limited	Mk6E	210225256	Class 0.5S	99999999.99kWh	23/07/2012 & SP/RA/2012/314/001-001 (01/09/2013 - 31/03/2014)	22/07/2014	24 months
11	Power meter	Electricity sell to grid (MWh) – recorded by grid operator	EL_{PJ} (EL5)	$EL_{PJ,y}$	kWh	Itron	SL761A071	53099690	Class 0.2S	999999999kWh	01/04/2011 & TNBM-QR-064 (01/09/2013 - 31/03/2014)	31/03/2016	5 years
12	Power meter	Electricity sell to grid (MWh) – check energy meter recorded by grid operator	-	-	kWh	Itron	SL761A071	53099691	Class 0.2S	999999999kWh	01/04/2011 & TNBM-QR-064 (01/09/2013 - 31/03/2014)	31/03/2016	5 years

Span Gas			
No	**Parameters**	**Analysis date**	**Best if used by**
1	N_2, CH_4	04/10/2010	04/10/2020
2	N_2, CO_2	04/10/2010	04/10/2020
3	N_2, O_2	04/10/2010	04/10/2020

Table 5: List of CDM Monitoring Equipment and Calibration for GSS

No	Item	Parameters	Equipment ID	CDM Monitoring ID	Unit	Manufacturer	Model No.	Serial No.	Accuracy	Range	Last Calibration Date & Cert No.	Recommended Next Calibration Date	Recommended Frequency of Calibration
Flare System													
1	Temperature Transmitter	Temperature (T)	$TT_{1,GSS}$	$T_{FT1,GSS}$	°C	Honeywell	STT25M-0-EN5-000-000-000-00-3H	b527145857	±1%	0-100°C	11/06/2012 & JZ4a2012-06-0464 (06/12/2013 - 31/03/2014)	10/06/2013	Annually
2	Pressure Sensor	Pressure Transmitter (P)	$PT_{1,GSS}$	$P_{FT1,GSS}$	kPa	Rosemount	3051TG1A2B21AB4K 5M5	5916057	±0.1%	0-60 kPa	13/06/2012 & NO.JD1c2012-06-0259 (06/12/2013 - 31/03/2014)	12/06/2013	Annually
3	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{1,GSS}$	$LFG_{electricity,GSS,y}$	NM³/hr	KVS	3051 CD1A22A1AM5B4QF K5	5988022	±0.5%	200-2,000 Nm³/h	05/06/2012 & D12-491-JG-02 (06/12/2013 - 31/03/2014)	04/06/2014	24 months
Gas Analysers													
4	CH_4 Meter	Methane fraction of LFG	$CH_{4,GSS}$	$W_{CH4,GSS,y}$	%	Guardian Plus	97460	54140	±2% of full scale	0-100%	08/06/2012 & NHot2012-3527 (06/12/2013 - 31/03/2014)	07/06/2013	Annually
Power Generation and Electricity Consumption													
5	Power meter	Grid for project activity	EL_{PJ} (EL6)	$EL_{PJ,y}$	kWh	IME	NEMO 96HD+ (MF96021)	2681930098	Class 0.5S (±0.5%)	0-400/5A	Yet to be calibrated (06/12/2013 - 31/03/2014)	Yet to be calibrated	36 months
6	Power meter	3MW GEs for project activity (Gas Supply System (GSS))	$EL_{PJ,GE,GSS}$ (EL7)	$EL_{PJ,GE,GSS,y}$	kWh	IME	NEMO 96HD+ (MF96021)	2175390002	Class 0.5S (±0.5%)	0-400/5A	Yet to be calibrated (06/12/2013 - 31/03/2014)	Yet to be calibrated	36 months

7	Power meter	3MW GEs for project activity (3MW GEs' auxiliaries)	EL[illegible] (EL8)	EL[illegible]	kWh	IME	NEMO 96HD+ (MF96021)	2175410010	Class 0.5S (±0.5%)	0-400/5A	Yet to be calibrated (06/12/2013 - 31/03/2014)	Yet to be calibrated	36 months
8	Power meter	Gross generation from GE No.2	EL[illegible] (EL9)	EL[illegible]	kWh (to be converted to MWh)	EDMI Limited	Genius	211516862	Class 0.5S	99999999.99kWh	Yet to be calibrated (06/12/2013 - 31/03/2014)	Yet to be calibrated	24 months
9	Power meter	Gross generation from GE No.3	EL[illegible] (EL10)	EL[illegible]	kWh (to be converted to MWh)	EDMI Limited	Genius	211516863	Class 0.5S	99999999.99kWh	Yet to be calibrated (06/12/2013 - 31/03/2014)	Yet to be calibrated	24 months
10	Power meter	Electricity sold to grid (MWh) - recorded by grid operator	EL[illegible] (EL11)	EL[illegible]	kWh	EDMI Limited	MkGE	908705152	Class 0.5S	999999999kWh	05/12/2013 & N/A (06/12/2013 - 31/03/2014)	04/12/2015	24 months
11	Power meter	Electricity sell to grid (MWh) - check energy meter recorded by grid operator	-	-	kWh	EDMI Limited	MkGE	908705154	Class 0.5S	999999999kWh	05/12/2013 & N/A (06/12/2013 - 31/03/2014)	04/12/2015	24 months

With reference to the Clean Development Mechanism Validation and Verification Standard, version 06.0, section 9.4.4.2, paragraph 275, "In cases where the results of the delayed calibration are not available, or the calibration has not been conducted at the time of verification, the DOE, prior to finalizing verification, shall request the project participants to conduct the required calibration and shall determine whether the project participants have calculated the emission reductions conservatively using the approach mentioned in paragraph 273 above". During this monitoring period, there are 8 equipment which the calibration have not been conducted at the time of verification. The calibration was only conducted after the monitoring period and the error of the new calibration is less than the maximum permission error (MPE). Hence, the MPE was applied according to paragragh 273 (a) as listed below:

1. TT1 (Honeywell serial number b527143837) - The maximum permissible error of ±1% which is the equipment accuracy error was applied to TT1 from 06/12/2013 – 31/03/2014 as a conservative approach. The impact of applying this error to the flow normalisation is negligible
2. PT2 (Honeywell serial number 5916057) - The maximum permissible error of ±0.1% which is the equipment accuracy error was applied to PT2 from 06/12/2013 – 31/03/2014 as a conservative approach. The impact of applying this error to the flow normalisation is negligible
3. CH4 (Honeywell serial number 34140) - The maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 06/12/2013 – 31/03/2014 as a conservative approach.
4. EL6 (IME serial number 2661930098) - The maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL6 from 06/12/2013 – 31/03/2014 as a conservative approach.
5. EL7 (IME serial number 2175390002) - The maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL7 from 06/12/2013 – 31/03/2014 as a conservative approach.
6. EL8 (IME serial number 2175410010) - The maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL8 from 06/12/2013 – 31/03/2014 as a conservative approach.
7. EL9 (EDMI Limited serial number 211516862) - The maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL9 from 06/12/2013 – 31/03/2014 as a conservative approach.
8. EL10 (EDMI Limited serial number 211516863) - The maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL10 from 06/12/2013 – 31/03/2014 as a conservative approach.

Data Collection (for the whole monitoring period)

Based on the monitoring plan, key flaring parameters (temperature, pressure, flow of gas, CH_4 concentration in LFG) were continuously monitored and recorded via the data logger at the flare system control room. Continuous flaring data were logged and archived in every minute in the database file. These raw data were compiled and analysed for the calculation of Certified Emission Reductions (CERs).

As a back-up data recording system, the on-site workers have manually recorded certain monitored

parameters in the Daily Monitoring Log Sheets. These records were scanned into soft copies for electronic filing on a monthly basis.

Data recorded manually (not recorded in the data logger system), i.e. electricity consumed were recorded in daily monitoring log sheets on a daily basis and compiled in Microsoft (MS) Excel format weekly.

Data Processing

The data logged were archived in .db file format and compiled.

Data recorded were further processed to yield the results required. A specific computation programme (in MS Access) was developed by the CDM Consultant to process continuously-monitored data to the required format and summary. An example of data aggregation on-site for flow rate of LFG at the main pipe is shown as follows:

Parameter: FT_1 (Flow rate of LFG at main pipe)

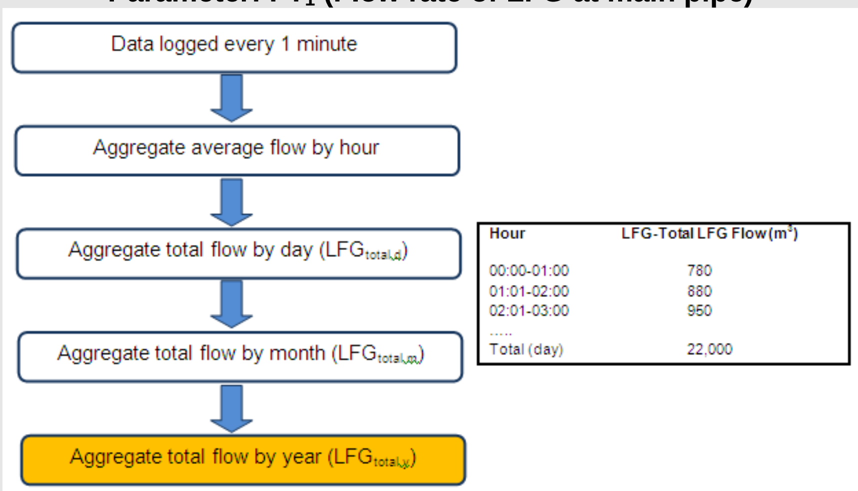


Figure 11: Example of Data Aggregation for Continuous Monitoring

Raw data logged at one (1) minute's interval were used to compute the hourly average. Subsequently, daily readings were computed, followed by aggregation into monthly and finally, yearly summaries.

Similar average values were computed for parameters such as the temperature, pressure and % CH_4.

In accordance to the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13), 3 conditional default values for flare efficiency can be used for the calculation of CERs. The main criteria or condition for choosing the right default values for each hour is to assess the exhaust gas temperature from the flare stack ($T_{flare,h}$). On the other hand, all the operational parameters (temperature, pressure, etc.) related to CDM monitoring will also have to be taken into account as these parameters can affect $T_{flare,h}$. Therefore, the data of these parameters were recorded continuously through the PLC system.

Quality Assurance and Quality Control (QA & QC)

Documented Procedures and QA/QC Measures

QA/QC was applied throughout the monitoring period:

- Daily inspection of LFG extraction, flaring and monitoring systems;
- Checking and counter-signing of data forms by the CDM Manager;
- Data security (restricted access, password control) was applied to ensure the integrity of data;
- Inspection, observations, incidents and follow-up actions were documented;
- Independent audits were carried out by external consultants; and
- Data was analysed on a weekly basis to determine any irregularities.

Data Management and Storage

A proper data back-up system has been set up to ensure that the data will not be compromised in case of any unforeseen incidents at site resulting in total loss of data. The retention/archiving period for verification and CER issuance documents should be kept in electronic form for at least 2 years after the crediting period.

Continuous Monitoring (data logging system)

The data from continuous monitoring (data logger) was primarily stored in the hard disk located in the flare control room. To ensure that all data recorded are safe and properly archived, the following back-up system was applied for this project:

Types of back-up	Frequency	Back-up location
Manual back-up using a portable hard disk (HD)	Monthly	At the flare
Automatic back-up to the CDM Manager's PC located at the site office, BTSL	Weekly	On-site (site office)
Data server in the CDM Consultant's office (Eco-Ideal Consulting Sdn. Bhd., C-7-2, Wisma Goshen, Plaza Pantai, Kuala Lumpur, Malaysia)	Weekly	Off-site (consultant's office)

The data stored in the data server located at the CDM Consultant's office will be used as the primary back-up data in case of any emergency situation resulting in the loss of data from the flare data recording system.

The automatic data back-up system based on internet data transmission can be illustrated as follows:

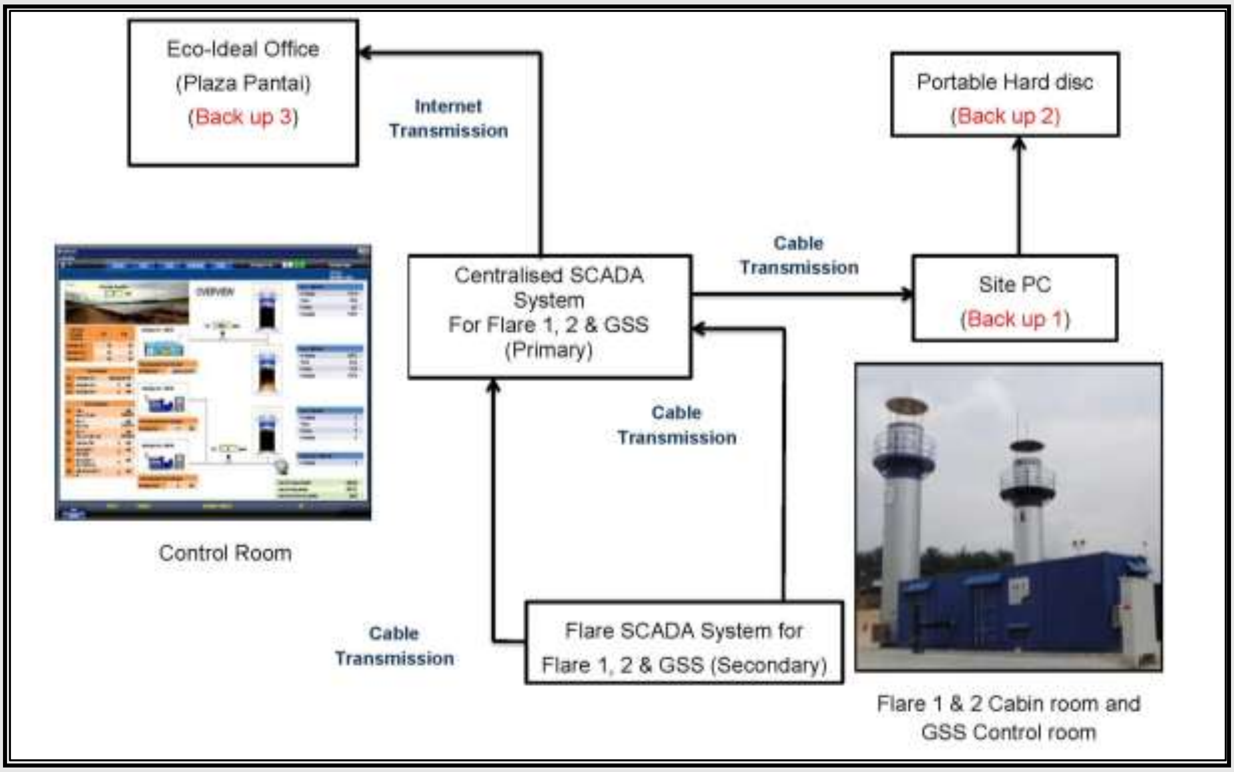


Figure 12: Automatic Data Back-Up for Flaring System at BTSL

Manual Recording

Daily operational data (consisting of CDM parameters monitored) recorded manually was backed-up by scanning all the daily monitoring log sheets on a weekly basis. These data were primarily stored in the computer at the cabin office next to the flare cabin. A copy of these scanned log sheets were handed to the CDM Consultant on a monthly basis for secondary back-up.

Independent Audits and Control Measures

All procedures for audit and QC measures were detailed in the CDM Audit Plan and Procedures. An independent audit relevant to the 8^{th} monitoring period was conducted by the consultant (Eco-Ideal Consulting Sdn. Bhd.):

- Audit No. 11 – 29/04/2014

The independent audit served as an important QC measure to ensure that all the monitoring required are done in accordance to the plan. Through the audit, the project can pre-empt any potential problems, issues as well as identify improvement measures during the monitoring period.

Training

Training is important to ensure that all the involved staff is provided with the needed knowledge and skills to undertake their roles effectively according to the CDM MP.

During this monitoring period, the staff has attended several technical/operational trainings as listed below:

No.	Description	Date	No. of participants
1	Operations – Supervisor	31/10/2013	13
2	Operations – Gas Supply System (GSS)	08/01/2014	8
3	Operations – Gas Engine No.2 and No.3	22/01/2014	6
4	Overall system for LFG software / SCADA	26/02/2014	8

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

Data / Parameter:	**Regulatory requirement relating to landfill gas projects**
Unit:	-
Description:	Regulatory requirement relating to landfill gas projects
Source of data:	There is no regulatory requirement to recover and utilize landfill gas in Malaysia. Confirmation from the Department of National Solid Waste Management of the Ministry of Housing and Local Government regarding regulation aspects of landfill gas has already been obtained at the beginning of the earliest crediting period, i.e. during the 1^{st} monitoring period (28/08/2009 – 28/02/2010).
Value(s) applied):	NA
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**GWP_{CH4}**
Unit:	tCO_2e/tCH_4

Description:	Global Warming Potential (GWP) for CH_4
Source of data:	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
Value(s) applied):	25
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	$\mathbf{D_{CH4}}$
Unit:	t_{CH4}/m^3_{CH4}
Description:	CH_4 density at standard temperature and pressure
Source of data:	ACM 0001 – *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8)
Value(s) applied):	0.0007168
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**Φ**
Unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data:	This uncertainty factor was adopted and the value is 0.9 based on recommendations in the *Tool to determine methane emissions avoided from dumping waste at solid waste disposal site*
Value(s) applied):	0.9
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**f**
Unit:	-
Description:	Fraction of methane captured at the solid waste disposal site (SWDS) and flared, combusted or used in another manner
Source of data:	There is no methane flared, combusted or used for other purposes in the baseline scenario
Value(s) applied):	0
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**OX**
Unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data:	Site-visit reveals that this landfill is well managed and soil cover is applied on a daily basis. Therefore, the value 0.1 was applied as recommended by *the*

	Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site
Value(s) applied):	0.1
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**F**
Unit:	%
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data:	This value was applied based on the recommendation of the IPCC in the *Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site*
Value(s) applied):	0.5
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**DOC_f**
Unit:	%
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data:	This value was applied based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied):	0.5
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**MCF**
Unit:	-
Description:	Methane Correction Factor
Source of data:	This value was applied based on the recommendation of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. BTSL site is a fully anaerobically-managed SWDS. The waste received at the landfill was deposited at a specific tipping phase and there was no scavenging of waste in the landfill. Wastes were covered daily with compacted soil. Compaction as well as levelling is practiced based on the international landfill operational practices
Value(s) applied):	1.0
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**DOC_j**
Unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*
Source of data:	The above values were adopted from IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 2.4)

Value(s) applied):	The following values for the different waste fraction (types) were applied:

DOC_j		
Waste type *j*	**DOC_j (% wet basis)**	**DOC_j (% dry basis)**
Wood and wood products	**43**	50
Pulp, paper and cardboard (other than sludge)	**40**	44
Food, food waste, beverages and tobacco (other than sludge)	**15**	38
Textiles	**24**	30
Garden, yard and park waste	**20**	49
Glass, plastic, metal, other inert waste	**0**	0
Nappies	**24**	60

Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**kj**
Unit:	-
Description:	Decay rate for the waste type *j*
Source of data:	The above values were adopted from IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)

Value(s) applied):	The following values for the different waste fraction (types) were applied:

Waste type *j*		Boreal and Temperature (MAT<20°C)		Tropical (MAT>20°C)	
		Dry (MAP/PET<1)	Wet (MAP/PET>1)	Dry (MAP<1000 mm)	Wet (MAP>1000 mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.04	0/06	0.045	**0.07**
Slowly degrading	Wood, wood products and straw	0.02	0.03	0.025	**0.035**
Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.05	0.1	0.065	**0.17**
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.06	0.185	0.085	**0.4**

Purpose of data:	Baseline emission calculation
Additional comment:	The project site is located in the State of Selangor, Malaysia. The climate is tropical with an annual mean 24-hr temperature of approximately 27°C and annual mean precipitation of around 2,700 mm. These values were long-term averages documented in the Environmental Impact Assessment (EIA) Report prepared for the landfill in 2005. Thus, the K-values for tropical temperature and wet climate were used

D.2. Data and parameters monitored

Data / Parameter:	**$LFG_{total,y}$**
Unit:	m^3
Description:	Total amount of LFG captured during the project at normal temperature and pressure
Measured/	Measured

Calculated / Default:	
Source of data:	Continuous measurement by flow meter during operation of project activity. This parameter was measured continuously and separately for both of the flares and gas engines, i.e. Flare No.1 (1 meter) and Flare No.2 & Gas Engine No.1 (1 meter). Therefore, 2 sets of equipment were used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. During temporary malfunctioning of flow meter or data logging system resulting in unrepresentative data, the value of LFG_{total} for the affected period will be taken as the sum of LFG_{flare} and $LFG_{eletricity.}$
Value(s) of monitored parameter:	**<u>Flare No.1</u>** According to ACM 0001, version 8[8], page 15 of section III monitoring methodology, the amount of landfill gas generated (in m^3 using a continuous flow meter), where the total quantity (LFG_{total}), as well as the quantities fed to the flare (s) (LFG_{flare}), to the power plant (s) ($LFG_{electricity}$) are measured continuously. In the case where LFG is just flared, one flow meter for each flare can be used provided that these meters used are calibrated periodically by an officially accredited entity; The total LFG captured was the same as the total LFG flared for Flare No.1 during the monitoring period as total LFG captured in Flare No1 was only sent to flare. **<u>Flare No.2</u>** According to ACM 0001, version 8, page 15 of section III monitoring methodology, the amount of landfill gas generated (in m^3 using a continuous flow meter), where the total quantity (LFG_{total}), as well as the quantities fed to the flare (s) (LFG_{flare}), to the power plant (s) ($LFG_{electricity}$) are measured continuously. In the case where LFG is just flared, one flow meter for each flare can be used provided that these meters used are calibrated periodically by an officially accredited entity. From 01/06/2011, the total LFG captured (FT1) is the summation of total LFG flared (FT2) and total LFG electricity (FT3). As a conservative approach, during normal operation, the values of FT1 will be compared with the total of FT2 and FT3 and the lower value of the FT will be used for ER calculation. For the comparison, there are 2 cases which will happen: 1. *<u>When FT1 is greater than FT2 + FT3</u>* When FT1 is greater, the total values of FT2 + FT3 will be used and presented as the value of FT1 in the ER calculation as a conservative approach. 2. *<u>When FT1 is lower than FT2 + FT3</u>* When FT1 is lower, FT1 will then be used in the ER calculation as a conservative approach.

[8] The ACM0001 - *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8) is no longer valid and is not available for download in UNFCCC. The version has been replaced with Version 8.1.

Months	Flare No.2 FT1 Value (Nm^3)	Flare No.2 Total of FT2 & FT3 Value (Nm^3)
September 13	1,622,293	1,558,334
October 13	1,595,662	1,544,128
November 13	1,558,928	1,505,697
December 13	1,345,246	1,294,877
January 14	1,471,940	1,410,018
February 14	1,392,596	1,306,279
March 14	1,498,930	1,401,990
Total	**10,485,595**	**10,021,323**

From the monthly comparison of the FT1 & FT2 + FT3 values above, the lower value between the two is taken for the calculation of CERs.

Months	Flare No.1 Value (Nm^3)	Flare No.2 Value (Nm^3)
September 13	1,065,279	1,558,334
October 13	1,127,033	1,544,128
November 13	1,074,986	1,505,697
December 13	878,670	1,294,877
January 14	517,239	1,410,018
February 14	402,816	1,306,279
March 14	436,806	1,401,990
Total	**5,502,830**	**10,021,323**

For this monitoring period for Flare No.2, the total values of FT2 + FT3 was used in the ER calculation since FT1 is greater than FT2 + FT3.

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

<table>
<tr><td>Monitoring equipment:</td><td>

Item	Flare No.1 Description 01/09/2013 - 31/03/2014	Flare No.2 Description 01/09/2013 - 31/03/2014
Type	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone
Accuracy class	± 1%	± 0.5%
Serial No.	4972946 (Rosemount) / FT1 – FT119 (8102101) (Kingsway)	5476626 (Rosemount) / FT1 – FT141 (10031702) (Kingways)
Calibration frequency	24 months	24 months
Date of last calibration	25/04/2013	25/04/2013
Validity	24 months	24 months

Flare No.3
Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency:</td><td>Measured continuously with a flow meter. Data was aggregated on both monthly and yearly basis</td></tr>
<tr><td>Calculation method (if applicable):</td><td>NA</td></tr>
<tr><td>QA/QC procedures:</td><td>Flow meters were tested, calibrated and maintained regularly</td></tr>
<tr><td>Purpose of data:</td><td>Project emission calculation</td></tr>
<tr><td>Additional comment:</td><td>-</td></tr>
</table>

Data / Parameter:	**$LFG_{flare,y}$**
Unit:	m^3
Description:	Total amount of LFG sent to flare at normal temperature and pressure
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by flow meter during operation of project activity. This parameter was measured separately for both of the flares, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. During temporary malfunctioning of flow meter or data logging system resulting in unrepresentative data, the value of LFG_{flare} for the affected period will be derived by subtracting $LFG_{electricity}$ from LFG_{total}.
Value(s) of monitored parameter:	**Flare No.2** From 01/06/2011, the total LFG flared continued to be measured by FT2. As a conservative approach, during normal operation, the value of FT1 will be compared with the total of FT2 and FT3 and the lower value of the FT will be used for ER calculation.

	For the comparison, there are 2 cases which will happen: 1. *When FT1 is greater than FT2 + FT3* The value of FT2 will be used in the ER calculation as a conservative approach. 2. *When FT1 is lower than FT2 + FT3* The value of FT1 will be used to calculate the proportion of FT2 by ratio (formula: FT2 value = FT2 / (FT2 + FT3) * FT1.) The calculated value of the proportion of FT2 will be used in the ER calculation as a conservative approach.

Months	Flare No.1 Value (Nm^3)	Flare No.2 Value (Nm^3)
September 13	1,065,279	1,220,804
October 13	1,127,033	1,251,748
November 13	1,074,986	1,213,962
December 13	878,670	990,658
January 14	517,239	1,139,260
February 14	402,816	1,055,475
March 14	436,806	1,116,020
Total	**5,502,830**	**7,987,927**

From the monthly comparison of the FT1 & FT2 + FT3 in this monitoring period, the value of FT2 was used in the ER calculation since FT1 is greater than FT2 + FT3.

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Monitoring equipment:

Item	Flare No.1 Description	Flare No.2 Description
	01/09/2013 - 31/03/2014	01/09/2013 - 31/03/2014
Type	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone
Accuracy class	± 1%	± 0.5%
Serial No.	02768008 (Rosemount) / FT120 (8102102) (Kingways)	5476627 (Rosemount) / FT2 – FT140 (10031701) (Kingways)
Calibration frequency	24 months	24 months
Date of last calibration	21/12/2012	25/04/2013
Validity	24 months	24 months

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Measuring/	Measured continuously with flow meter. Data was aggregated on both

Reading/ Recording frequency:	monthly and yearly basis
Calculation method (if applicable):	Raw data logged at 1 minute's interval were used to compute the hourly average. Subsequently, daily readings were computed, followed by aggregation into monthly and finally, yearly records
QA/QC procedures:	Flow meters were tested, calibrated and maintained regularly
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**$LFG_{electricity,y}$**
Unit:	m^3
Description:	Amount of landfill gas combusted in power plant (Gas Engine No.1, 2 and 3) at normal temperature and pressure
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by flow meter during operation of project activity. This parameter was measured separately for the gas engines, i.e. Gas Engine No. 1 (1 meter) and Gas Engine No. 2 and No. 3 (1 meter). Therefore, 2 sets of equipment have to be used for the monitoring period. During temporary malfunctioning of flow meter or data logging system resulting in unrepresentative data, the value of $LFG_{electricity}$ for the affected period will be derived by subtracting LFG_{flare} from LFG_{total}.
Value(s) of monitored parameter:	**<u>Flare No.2</u>** From 01/06/2011, the total LFG for electricity is measured by FT3. As a conservative approach, during normal operation, the value of FT1 will be compared with the total of FT2 and FT3 and the lower value of the FT will be used for ER calculation. For the comparison, there are 2 cases which will happen: 1. *<u>When FT1 is greater than FT2 + FT3</u>* The value of FT3 will be used in the ER calculation as a conservative approach 2. *<u>When FT1 is lower than FT2 + FT3</u>* The value of FT1 will be used to calculate the proportion of FT3 by ratio (formula: FT3 value = FT3 / (FT2 + FT3) * FT1. The calculated value from the proportion of FT3 will be used in the ER calculation as a conservative approach.

Months	Flare No.2 Value (Nm^3)	GSS Value (Nm^3)
September 13	337,530	0
October 13	292,380	0
November 13	291,736	0
December 13	304,220	591,061
January 14	270,758	847,144
February 14	250,804	522,359
March 14	285,970	774,857

	Total | 2,033,396 | 2,735,421 From the monthly comparison of the FT1 & FT2 + FT3 in this monitoring period, the value of FT3 was used in the ER calculation since FT1 is greater than FT2 + FT3.
Monitoring equipment:	(see table below)

Item	Flare No.2 Description	GSS Description
	01/09/2013 - 31/03/2014	06/12/2013 – 31/03/2014
Type	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	KVS
Accuracy class	± 0.5%	± 0.5%
Serial No.	02768007 (Rosemount) / FT161 (11011001) (Kingways)	3051 CD1A22A1AM5B4DFK5
Calibration frequency	24 months	24 months
Date of last calibration	04/10/2012	05/06/2012
Validity	24 months	24 months

Measuring/ Reading/ Recording frequency:	Measured with flow meter. Data will be aggregated both monthly and yearly
Calculation method (if applicable):	Raw data logged at 1 minute's interval were used to compute the hourly average. Subsequently, daily readings were computed, followed by aggregation into monthly and finally, yearly records
QA/QC procedures:	Flow meters were tested, calibrated and maintained regularly
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**$PE_{flare,y}$**
Unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year *y*
Measured/ Calculated / Default:	Calculated
Source of data:	Calculated as per the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13, page 10). This parameter was measured separately for both flares, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Value(s) of monitored parameter:	<table><tr><th>Months</th><th>Flare No.1 Value (tCO_2e)</th><th>Flare No.2 Value (tCO_2e)</th></tr><tr><td>September 13</td><td>878</td><td>1,067</td></tr><tr><td>October 13</td><td>971</td><td>1,150</td></tr><tr><td>November 13</td><td>950</td><td>1,112</td></tr><tr><td>December 13</td><td>721</td><td>871</td></tr><tr><td>January 14</td><td>419</td><td>977</td></tr><tr><td>February 14</td><td>328</td><td>977</td></tr><tr><td>March 14</td><td>353</td><td>990</td></tr><tr><td>**Total**</td><td>**4,620**</td><td>**7,144**</td></tr></table> **<u>Flare No.3</u>** Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.
Monitoring equipment:	Refer to $\mathbf{T_{flare}}$ below
Measuring/ Reading/ Recording frequency:	As per the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13, page 10). As the project has installed an enclosed flaring system, the default value of 0.90 for enclosed flare efficiency for flare temperatures above 500^0C for more than 40 minutes in an hour was applied and monitored during the monitoring period. This is conservative as the enclosed flare was typically designed to operate at a much higher temperature (>900^0C).
Calculation method (if applicable):	As per the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13, page 10)
QA/QC procedures:	As per the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13, page 10)
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$\mathbf{w_{CH4}}$
Unit:	m^3 CH4 / m^3 LFG
Description:	Fraction of CH_4 in LFG
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by using certified equipment. This parameter was measured separately for both flares and the gas engines, i.e. Flare No.1 (1 meter), Flare No.2 & Gas Engine No.1 (1 meter) and Gas Engine No.2 and No.3 (1 meter). Therefore, 3 sets of equipment have to be used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. In case of temporary situation such as the installed CH_4 gas analyser malfunctioned or gave unrepresentative results due to data logging problem, the w_{CH4} shall be measured manually with a portable gas analyser according to ACM 0001 Version 8. At least 8 hourly samples shall be taken per operating day. 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 1). As a conservative approach, the lower bound of the 95% Confidence Interval will be applied as per the guideline.
Value(s) of monitored parameter:	see tables below
Monitoring equipment:	see tables below

Months	Flare No.1 Value (%)	Flare No.2 Value (%)	GSS Value (%)
September 13	0.54	0.59	0
October 13	0.55	0.60	0
November 13	0.55	0.61	0
December 13	0.54	0.58	0.62
January 14	0.53	0.56	0.57
February 14	0.53	0.57	0.56
March 14	0.52	0.58	0.57
Average	**0.54**	**0.58**	**0.58**

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Item	Flare No.1 Description	Flare No.2 Description
	01/09/2013 – 31/03/2014	**01/09/2013 – 09/12/2013**
Type	Guardian Plus (97460) Infra-Red Gas Monitor	Guardian Plus (97460) Infra-Red Gas Monitor
Accuracy class	± 2%	± 2%
Serial No.	32560	31453
Calibration frequency	Annually	Annually
Date of last calibration	14/03/2013	14/12/2012
Validity	1 year	1 year

Item	Flare No.2 Description	GSS Description
	10/12/2013 – 31/03/2014	**06/12/2013 – 31/03/2014**
Type	Guardian Plus (97460) Infra-Red Gas Monitor	Guardian Plus (97460) Infra-Red Gas Monitor
Accuracy class	± 2%	± 2%
Serial No.	31453	34140
Calibration frequency	Annually	Annually

	<table><tr><td>Date of last calibration</td><td>10/12/2013</td><td>08/06/2012</td></tr><tr><td>Validity</td><td>1 year</td><td>1 year</td></tr></table> **Flare No.1** Due to delayed calibration, the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 14/03/2014 - 31/03/2014 as a conservative approach. **Flare No.3** Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. **GSS (Gas Engine No. 2 and 3)** Due to delayed calibration, the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 06/12/2013 - 31/03/2014 as a conservative approach.
Measuring/ Reading/ Recording frequency:	The CH_4 fraction were measured continuously with certified equipment or measured manually with a portable gas analyser during emergency cases
Calculation method (if applicable):	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures:	The CH_4 gas analyser was checked and calibrated regularly according to the manual given by the manufacturer
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**T ($T_{TT1,F1}$,$T_{TT1,F2}$)**
Unit:	°C
Description:	Temperature of the LFG
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by temperature meter. This parameter was measured separately for both flares and the gas engines, i.e. Flare No.1 (1 meter), Flare No.2 & Gas Engine No.1 (1 meter) and Gas Engine No.2 and No.3 (1 meter). Therefore, 3 sets of equipment have to be used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Value(s) of monitored parameter:	

Months	Flare No.1 Value (°C)	Flare No.2 Value (°C)	GSS Value (°C)
September 13	53.44	45.00	0
October 13	50.07	44.54	0
November 13	48.66	43.77	0
December 13	42.95	39.79	45.88
January 14	37.55	41.88	46.85
February 14	39.07	44.79	46.65
March 14	38.89	44.68	48.87
Average	**44.38**	**43.49**	**47.06**

Flare No.1

Referring to the *Tool to determine the mass flow of a greenhouse gas in a gaseous stream*, version 2.0, for LFG temperatures below 60°C, moisture could be neglected due to its very low influence on final results and thus, the measurement in wet or dry basis is not important (as reflected in the amendments to ACM 0001, version 9.1 onwards). In the case where the LFG temperature exceeds 60°C, the same basis for both methane concentration and flow measurement will be considered according to the tools.

During this monitoring period, there were several periods of which the LFG temperature exceeds 60°C. Hence, the tool was applied in the CER Calculation sheet as a conservative approach. The details of the calculation are as attached in **Appendix 4**.

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Monitoring equipment:

Item	Flare No.1 Description		Flare No.2 Description
	01/09/2013 - 09/12/2013	**10/12/2013 - 31/03/2014**	**01/09/2013 – 31/03/2014**
Type	PR Electronics		Honeywell (STT25M-0-EN0-000-000-000-00-3D) Temperature Transmitter
Accuracy class	≤ ± 0.05% of span		± 0.5% of span
Serial No.	100944768		B839917437
Calibration frequency	Annually		Annually
Date of last calibration	07/12/2012	10/12/2013	25/04/2013
Validity	1 year		1 year

	<table><tr><th rowspan="2">Item</th><th>GSS Description</th></tr><tr><th>06/12/2013 – 31/03/2014</th></tr><tr><td>Type</td><td>Honeywell</td></tr><tr><td>Accuracy class</td><td>± 1%</td></tr><tr><td>Serial No.</td><td>b527143837</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of last calibration</td><td>11/06/2012</td></tr><tr><td>Validity</td><td>1 year</td></tr></table> **Flare No.1** Due to overdue calibration, the maximum permissible error of ±0.05% which is the equipment calibration error was applied to TT1 from 07/12/2013 - 10/12/2013 as a conservative approach. The impact of applying this error to the flow normalisation is negligible. **Flare No.3** Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period. **GSS** Due to overdue calibration, the maximum permissible error of ±1% which is the equipment calibration error was applied to TT1 from 06/12/2013 - 31/03/2014 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.
Measuring/ Reading/ Recording frequency:	Measured continuously by temperature meter
Calculation method (if applicable):	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures:	The temperature transmitter was calibrated regularly according to the manual given by the manufacturer
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**P ($P_{PT2,F1}$, $P_{PT2,F2}$)**
Unit:	kPa
Description:	Pressure of the LFG
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by pressure transmitter. This parameter was measured separately for both flares and the gas engines, i.e. Flare No.1 (1 meter), Flare No.2 & Gas Engine No.1 (1 meter) and Gas Engine No.2 and No.3 (1 meter). Therefore, 3 sets of equipment have to be used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Value(s) of monitored parameter:

Gauge pressure (Months)	Flare No.1 Value (kPa)	Flare No.2 Value (kPa)	GSS Value (kPa)
September 13	15.76	10.76	0
October 13	15.50	10.46	0
November 13	15.15	10.43	0
December 13	9.93	7.02	16.94
January 14	4.67	9.09	16.99
February 14	5.04	9.76	16.96
March 14	5.08	9.20	17.00
Average	**10.16**	**9.53**	**16.97**

Absolute pressure (Months)	Flare No.1 Value (kPa)	Flare No.2 Value (kPa)	GSS Value (kPa)
September 13	117.08	112.09	0
October 13	116.83	111.79	0
November 13	116.47	111.76	0
December 13	111.26	108.35	118.27
January 14	106.00	110.42	118.32
February 14	106.37	111.08	118.29
March 14	106.40	110.52	118.32
Average	**111.49**	**110.86**	**118.30**

Referring to the *Tool to determine the mass flow of a greenhouse gas in a gaseous stream* (Version 2.0), page 11, pressure at normal conditions is 101,325 Pa. The values of the absolute pressure are calculated by adding the ambient pressure at normal conditions to the gauge pressure.

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Monitoring equipment:	(see tables and notes below)

Item	Flare No.1 Description		Flare No.2 Description
	01/09/2013 - 09/12/2013	10/12/2013 - 31/03/2014	01/09/2013 - 31/03/2014
Type	Rosemount (3051TG1A2B21AB4E5M5Q4) Pressure Transmitter		Rosemount (3051TG1A2B 21AB4E5Q4) Pressure Transmitter
Accuracy class	± 0.25%		± 0.25%
Serial No.	02492864		5584784
Calibration frequency	Annually		Annually
Date of last calibration	21/12/2012	10/12/2013	25/04/2013
Validity	1 year		1 year

Item	GSS Description
	06/12/2013 - 31/03/2014
Type	Rosemount (3051TG1A2B21AB4K5M5) Pressure Transmitter
Accuracy class	± 0.1%
Serial No.	5916057
Calibration frequency	Annually
Date of last calibration	13/06/2012
Validity	1 year

Flare No.3

Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

GSS

Due to overdue calibration, the maximum permissible error of ±0.1% which is the equipment accuracy error was applied to PT2 from 06/12/2013 - 31/03/2014 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Measuring/ Reading/ Recording frequency:	Measured continuously by a pressure transmitter
Calculation method (if applicable):	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures:	The meter was checked and calibrated regularly according to the manual given by the manufacturer
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Unit:	**EL_{LFG}**
Description:	MWh
Measured/ Calculated /	Net amount of electricity generated using landfill gas

Default:	
Source of data:	Measured
Unit:	Data as measured by electricity meters. This parameter was measured separately for the gas engines, i.e. Gas Engine No.1 (1 meter) and Gas Engine No.2 and No.3 (1 meter). Therefore, 2 sets of equipment have to be used for the monitoring period.
Value(s) of monitored parameter:	(see tables below)

Months	Net electricity generated (Total electricity generated (EL4 + EL9 + EL10) – electricity consumed from GE for Flare No.1, Flare No.2, GE auxiliaries and GSS (EL3 + EL7 + EL8) (MWh)	Electricity sell to grid (MWh) - recorded by grid operator EL5 (MWh)	
		Main energy meter	Check energy meter
September 13	639.35	627.88	628.22
October 13	542.61	533.74	534.02
November 13	555.14	544.16	544.43
December 13	1,771.58	549.18	549.46
January 14	2,167.95	450.78	451.01
February 14	1,513.22	429.89	430.13
March 14	2,189.48	496.96	497.24
Total	**9,379**	**3,633**	**3,635**

Months	Electricity sell to grid (MWh) - recorded by grid operator EL11 (MWh)	
	Main energy meter	Check energy meter
September 13	0.00	0.00
October 13	0.00	0.00
November 13	0.00	0.00
December 13	1,500.00	1,501.00
January 14	1,694.87	1,695.03
February 14	1,070.76	1,070.82
March 14	1,652.61	1,652.73
Total	**5,918**	**5,920**

The readings for EL3, EL7 and EL8 are tabulated under quantity of electricity consumed by project activity ($EL_{PJ,y}$) table below.

There were 2 power meters used to measure the amount of electricity sold to the grid, i.e. the main energy meter and check energy meter. Only the readings recorded by the main energy meter was used by the grid operator

	and the project participant in the calculation of CERs while the readings recorded by the check energy meter were only used to check or confirm on the readings recorded by the main energy meter. From the comparison of the EL4 + EL9 + EL10 – EL3 – EL7 – EL8 and EL5 and EL11 (main meter) values above, the lower value between the two is taken for the calculation of CERs.

Months	Net amount of electricity generated (MWh)
September 13	639.35
October 13	542.61
November 13	555.14
December 13	1,771.58
January 14	2,167.95
February 14	1,513.22
March 14	2,189.48
Total	**9,379**

Monitoring equipment:	(see tables below)

Item	Flare No.2 Description (EL4)	Flare No.2 Description (EL5)	
	01/09/2013 - 31/03/2014	01/09/2013 - 31/03/2014	
		Main energy meter	Check energy meter
Type	EDMI Limited (Mk6E) Power Meter	Itron (SL761A071) Power Meter	
Accuracy class	Class 0.5S	Class 0.20	
Serial No.	210225256	53099690	53099691
Calibration frequency	24 months	5 years	
Date of last calibration	23/07/2012	01/04/2011	
Validity	24 months	5 years (Type 2 according to the Malaysian Grid Code, version 1/2010)	

Item	GSS Description (EL9)	GSS Description (EL10)
	06/12/2013 -31/03/2014	06/12/2013 - 31/03/2014
Type	EDMI Limited (Genius) Power Meter	EDMI Limited (Genius) Power Meter
Accuracy class	Class 0.5S	Class 0.5S
Serial No.	211516862	211516863
Calibration frequency	24 months	24 months
Date of last calibration	Yet to be calibrated	Yet to be calibrated
Validity	24 months	24 months

Item	Flare No.2 Description (EL11)	
	06/12/2013 - 31/03/2014	
	Main energy meter	Check energy meter
Type	EDMI (Mk6E) Power Meter	
Accuracy class	Class 0.5S	
Serial No.	908705152	908705154
Calibration frequency	24 months	
Date of last calibration	05/12/2013	
Validity	24 months	

GSS

Due to overdue calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL9 and EL10 from 06/12/2013 - 31/03/2014 as a conservative approach.

Measuring/ Reading/ Recording frequency:	Measured continuously with electricity meter installed. The net amount of electricity generated shall be derived by deducting the amount consumed by the project activity (EL3 + EL7 + EL8) from the gross generated amount recorded by installed electricity meters (EL4 + EL9 + EL10).

Calculation method (if applicable):	NA
QA/QC procedures:	As a quality control procedure, the amount of electricity actually uploaded to grid will be measured by other electricity meters (EL5 and EL11) and compared with the net amount derived from above. Lower value of the amount will be taken as the net amount for emission reduction calculations. Electricity meters (except the meters owned by the grid operator, i.e. EL5 and EL11) will be checked and calibrated regularly according to manufacturer's recommendations. The meters EL5 and EL11 are owned by the grid operator and thus, they are not within the control of the project. The calibration of these meters will be based on the grid operator's requirement and standard practice.
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter:	**$CEF_{elec,PR,y}$**
Unit:	tCO_2/MWh
Description:	Carbon emission factor of electricity
Measured/ Calculated / Default:	Calculated
Source of data:	Grid connected baseline for Peninsular Malaysia for 2012 by Malaysian Green Technology Corporation (MGTC)
Value(s) of monitored parameter:	**0.741** tCO_2/MWh based on the latest released grid connected baseline emission factor for Peninsular Malaysia for 2012
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	To be re-calculated with the latest release of grid connected baseline emission factor. The emission factor for year 2012 was applied for this monitoring period as this was the latest publicly released data for the grid emission factor for Malaysia during this monitoring period.
Calculation method (if applicable):	The **$CEF_{elec,PR,y}$** was calculated based on the *Tool to calculate the emission factor for an electricity system* (Version 2, EB 50)
QA/QC procedures:	NA
Purpose of data:	Baseline and Project emission calculation
Additional comment:	-

Data / Parameter:	**Operation of the energy plant (t)**
Unit:	Hours
Description:	Operation of the energy plant
Measured/ Calculated / Default:	Measured
Source of data:	Based on actual documented operating hours. This parameter was measured separately for the gas engines, i.e. Gas Engine No.1 (1 meter) and Gas Engine No.2 and No.3 (1 meter).

Value(s) of monitored parameter:	<table><tr><th>Months</th><th>Gas Engine No. 1 Operating time (hr)</th><th>Gas Engine No. 2 & 3 Operating time (hr)</th></tr><tr><td>September 13</td><td>718</td><td>0</td></tr><tr><td>October 13</td><td>714</td><td>0</td></tr><tr><td>November 13</td><td>699</td><td>0</td></tr><tr><td>December 13</td><td>729</td><td>1,097</td></tr><tr><td>January 14</td><td>655</td><td>1,472</td></tr><tr><td>February 14</td><td>628</td><td>874</td></tr><tr><td>March 14</td><td>725</td><td>1,464</td></tr><tr><td>**Total**</td><td>**4,868**</td><td>**2,346**</td></tr></table> The operating time is calculated by using the reading on the 1st day of the following month (m+1) to deduct the reading on the 1st day of the current month (m). The reading used is the total of the operating time at operation hour and operation hour since oil change as stated in the Daily Monitoring Log Sheet for Gas Engine No.1, row No. 6 and for Gas Engine No. 2 and No. 3.
Monitoring equipment:	The operation time of the Gas Engine No.1, No.2 and No.3 is recorded by the Gas Engine SCADA system known as Total Energy Management (TEM) Evo System. The operation hour of the Gas Engine No.1, No.2 and No.3 is based on the signal provided by the power meter (EL4, EL9 and EL10).
Measuring/ Reading/ Recording frequency:	The operation time is recorded continuously and aggregated into monthly data. A daily reading and recording is taken.
Calculation method (if applicable):	NA
QA/QC procedures:	The system will be checked periodically by the engine manufacturer during servicing. The source of the operational hours is from the power meters EL4, EL9 and EL10 which are calibrated regularly according to requirement by the manufacturer.
Purpose of data:	NA
Additional comment:	-

Data / Parameter:	**$EL_{PJ,y}$**
Unit:	MWh
Description:	Quantity of electricity consumed by project activity
Measured/ Calculated / Default:	Measured
Source of data:	Based on continuous measurement by sealed electricity meter installed. This parameter was measured separately for: a) Flare No. 1, Flare No. 2 and Gas Engine No.1 – 1 meter (EL1) b) Flare No. 1, Flare No. 2, Gas Engine No.1, No.2 and No.3 – 1 meter (EL6)

Value(s) of monitored parameter:

Months	Electricity consumed (from grid for project activity-flaring system & Gas Engine No.1) (EL1) (MWh)	Electricity consumed (from grid for project activity-flaring system & Gas Engine No.1, No.2 and No.3) (EL6) (MWh)
September 13	80.78	0.00
October 13	80.64	0.00
November 13	76.84	0.00
December 13	70.88	0.00
January 14	49.59	0.00
February 14	61.00	0.00
March 14	68.80	0.00
Total	**489**	**0**

Months	Electricity consumed (from GE for Flare No.1 & Flare No.2 & GE auxiliaries) (EL3) (MWh)	Electricity consumed (from GE for GSS) (EL7) (MWh)	Electricity consumed (from GE for Gas Engine No.2 and No.3 auxiliaries) (EL8) (MWh)
September 13	0.00	0.00	0.00
October 13	0.00	0.00	0.00
November 13	0.00	0.00	0.00
December 13	2.26	0.00	0.00
January 14	14.54	0.00	0.00

February 14	0.00	0.00	0.00
March 14	0.00	0.00	0.00
Total	**17**	**0**	**0**

Electricity consumed from the Gas Engines for Flare No.1 & Flare No.2 and Gas Engine No.1, No.2 and No.3 auxiliaries and GSS (EL3, EL7 and EL8) is not included in the calculation of project emission as the electricity is generated from landfill gas.

Flare No.2 (EL3)

There was no reading recorded from 01/09/2013 - 31/12/2013, 08/01/2014 - 22/01/2014 and 24/01/2014 - 31/03/2014 as the electricity supply for the operation of Flare No. 1, 2, GE auxiliaries and GSS is from the grid instead of from the gas engines due to operational issues. When the gas engines shut down automatically, the electricity supply to the flare systems, GE auxiliaries & GSS may be disrupted due to the automatic switchover from gas engines to grid. To avoid disruption of operations, the electricity supply to the flare systems, GE auxiliaries & GSS from the gas engines is stopped.

Monitoring equipment:

Item	**Electricity consumed (from grid for project activity-flaring system & Gas Engine No.1) (EL1) (MWh)**	**Electricity consumed (from grid for project activity-flaring system & Gas Engine No.1, No.2 and No.3) (EL6) (MWh)**
	01/09/2013 - 31/03/2014	**06/12/2013 - 31/03/2014**
Type	IME NEMO 96HD+ (MF96021) Power Meter	IME NEMO 96HD+ (MF96021) Power Meter
Accuracy class	Class 0.5S (± 0.5%)	Class 0.5S (± 0.5%)
Serial No.	2167 8900 35	2661930098
Calibration frequency	36 months	36 months

Date of last calibration	10/05/2011	Yet to be calibrated
Validity	3 years according to manufacturer's recommendation	3 years according to manufacturer's recommendation

Item	**Electricity consumed (from GE for Flare No.1 & Flare No.2 & GE auxiliaries) (EL3) (MWh)**	**Electricity consumed (from GE for GSS) (EL7) (MWh)**	**Electricity consumed (from GE for Gas Engine No.2 and No.3 auxiliaries) (EL8) (MWh)**
	01/09/2013 - 31/03/2014	**06/12/2013 - 31/03/2014**	**06/12/2013 - 31/03/2014**
Type	IME NEMO 96HD+ (MF96021) Power Meter	IME NEMO 96HD+ (MF96021) Power Meter	IME NEMO 96HD+ (MF96021) Power Meter
Accuracy class	Class 0.5S (± 0.5%)	Class 0.5S (± 0.5%)	Class 0.5S (± 0.5%)
Serial No.	2175 4100 36	2175390002	2175410010
Calibration frequency	36 months	36 months	36 months
Date of last calibration	21/06/2012	Yet to be calibrated	Yet to be calibrated
Validity	3 years	3 years	3 years

	according to manufacturer’s recommendation3 years according to manufacturer’s recommendation	according to manufacturer’s recommendation	according to manufacturer’s recommendation

GSS

Due to overdue calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL6 from 06/12/2013 - 31/03/2014 as a conservative approach. Due to overdue calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL7 from 06/12/2013 - 31/03/2014 as a conservative approach. Due to overdue calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL8 from 06/12/2013 - 31/03/2014 as a conservative approach.

Measuring/ Reading/ Recording frequency:	Continuous measurement
Calculation method (if applicable):	NA
QA/QC procedures:	The electricity meter was tested and calibrated as per the specifications prescribed by the manufacturer
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	$T_{flare,y}$
Unit:	°C
Description:	Temperature in exhaust gas of the enclosed flare
Measured/ Calculated / Default:	Measured
Source of data:	Continuous measurement by temperature meter. This parameter was measured separately for both flares, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period. Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.

Value(s) of monitored parameter:	<table><tr><th>Months</th><th>Flare No.1 Value (°C)</th><th>Flare No.2 Value (°C)</th></tr><tr><td>September 13</td><td>784.06</td><td>819.56</td></tr><tr><td>October 13</td><td>777.68</td><td>834.71</td></tr><tr><td>November 13</td><td>783.56</td><td>857.57</td></tr><tr><td>December 13</td><td>714.31</td><td>738.17</td></tr><tr><td>January 14</td><td>564.26</td><td>787.75</td></tr><tr><td>February 14</td><td>574.48</td><td>792.18</td></tr><tr><td>March 14</td><td>545.85</td><td>786.28</td></tr><tr><td>**Average**</td><td>**677.74**</td><td>**802.32**</td></tr></table> **Flare No.3** Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.
Monitoring equipment:	<table><tr><th rowspan="2">Item</th><th>Flare No.1 Description</th><th>Flare No.2 Description</th></tr><tr><th>01/09/2013 – 31/03/2014</th><th>01/09/2013 – 31/03/2014</th></tr><tr><td>Type</td><td>PR Electronics</td><td>Honeywell (STT25M-0-EN0-000-000-000-00 3D)Temperature Transmitter</td></tr><tr><td>Accuracy class</td><td>≤ ± 0.05% of span</td><td>± 0.5% of span</td></tr><tr><td>Serial No.</td><td>110910943</td><td>B838901937</td></tr><tr><td>Calibration frequency</td><td>Annually</td><td>Annually</td></tr><tr><td>Date of last calibration</td><td>19/07/2013</td><td>25/04/2013</td></tr><tr><td>Validity</td><td>1 year</td><td>1 year</td></tr></table> **Flare No.3** Flare No.3 will be implemented at a later stage and as a result, no data and instrument is available during this monitoring period.
Measuring/ Reading/ Recording frequency:	The enclosed flare is monitored continuously by a temperature meter
Calculation method (if applicable):	Data logged at 1 minute's interval was used to determine the default flaring efficiency for each hour in accordance to the *Tool to determine project emissions from flaring gases containing methane* (EB 28, Annex 13)
QA/QC procedures:	The temperature meter was tested and calibrated as per the specifications prescribed by the manufacturer
Purpose of data:	Project emission calculation
Additional comment:	-

Data / Parameter:	**Relevant policies and circumstances at the beginning of each crediting period**
Unit:	NA
Description:	NA
Measured/	NA

Calculated / Default:	
Source of data:	Monitoring of change of policies and circumstances was done by consultation with relevant governmental authorities (Department of Environment and Department of National Solid Waste Management, Malaysia)
Value(s) of monitored parameter:	Not applicable during this monitoring period as it is not at the beginning of the next crediting period
Monitoring equipment:	NA
Measuring/ Reading/ Recording frequency:	To be checked at the beginning of each crediting period
Calculation method (if applicable):	NA
QA/QC procedures:	NA
Purpose of data:	NA
Additional comment:	-

D.3. Implementation of sampling plan

Not applicable

SECTION E. Calculation of emission reductions or GHG removals by sinks

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

The total baseline emissions according to ACM0001 (Version 8) were calculated according to the equations below:

$$BE_y = (MD_{project,y} - MD_{BL,y}) \cdot GWP_{CH4} + EL_{LFG,y} \cdot CEF_{elec,BL,y} + ET_{LFG,y} \cdot CEF_{ther,BL,y}$$

BEy	Baseline emissions in year *y* (tCO_2e)
$MD_{project,y}$	The amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario
$MD_{BL,y}$	The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirements, in tonnes of methane (tCH_4)
GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4
$EL_{LFG,y}$	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year *y* (MWh)
$CEF_{elec,BL,y}$	CO_2 emissions intensity of the baseline source of electricity displaced (tCO_2e/MWh)
$ET_{LFG,y}$	The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year *y* (TJ)
$CEF_{ther,BL,y}$	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by LFG based thermal energy generation (tCO_2e/TJ)

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}$$

$MD_{flared,y}$	Quantity of methane destroyed by flaring (tCH_4)
$MD_{electricity,y}$	Quantity of methane destroyed by generation of electricity (tCH_4)
$MD_{thermal,y}$	Quantity of methane destroyed for the generation of thermal energy (tCH_4)
$MD_{PL,y}$	Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)

$$MD_{flared,y} = (LFG_{flare,y} \cdot w_{CH4} \cdot D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$$

$MD_{flared,y}$	Quantity of methane destroyed by flaring (tCH_4)
$LFG_{flare,y}$	Quantity of landfill gas fed to the flare(s) during the year *y* (m^3)
w_{CH4}	Average methane fraction of the landfill gas as measured during the year *y* (m^3CH_4 / m^3LFG)
D_{CH4}	Methane density (tCH_4 / m^3CH_4)
$PE_{flare,y}$	Project emission from flaring of the residual gas stream in year *y* (tCO_2e). This will be determined following the procedure set in the *"Tool to determine project emissions from flaring gases containing methane"*.

$$MD_{electricity,y} = LFG_{electricity,y} \cdot w_{CH4,y} \cdot D_{CH4}$$

$MD_{electricity,y}$	Quantity of methane destroyed be generation of electricity (tCH_4)
$LFG_{electricity,y}$	Quantity of landfill gas fed into the electricity generator (m^3LFG)
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured during the year *y* (m^3CH_4 / m^3LFG)

Determination of $MD_{project,y}$ for Flare No.1

	$MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$								$MD_{project,y}$
Month	Quantity of LFG to Flare No.1 Flare No. 1,y (Nm3)	Methane average fraction Flare No.1 WCH4	Density of Methane Flare No.1 DCH4 (t/Nm3)	Total methane Flare No.1 (tCH4)	Global Warming Potential Flare No.1 GWP (tCO2/tCH4)	Emissions from methane Flare No.1 (tCO2e)	PE Flare No.1 (tCO2e)	Quantity of Methane destroyed by flaring MD flared,y (tCH4)	Quantity of methane that would have been destroyed MD project,y (tCH4)
Sep-13	1,065,279	0.54	0.0007168	415.16	25	10379.0	878.40	380.02	380.02
Oct-13	1,127,033	0.55	0.0007168	443.05	25	11076.2	971.25	404.20	404.20
Nov-13	1,074,986	0.55	0.0007168	420.73	25	10518.2	950.24	382.72	382.72
Dec-13	878,670	0.54	0.0007168	339.75	25	8493.8	720.84	310.92	310.92
Jan-14	517,239	0.53	0.0007168	194.80	25	4870.0	418.59	178.06	178.06
Feb-14	402,816	0.53	0.0007168	153.79	25	3844.6	327.54	140.68	140.68
Mar-14	436,806	0.52	0.0007168	162.89	25	4072.3	353.27	148.76	148.76

Determination of $MD_{project,y}$ for Flare No.2

	$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$								$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$					$MD_{project,y}$
Month	Quantity of LFG to Flare No.2 Flare No.2,y (Nm3)	Methane average fraction Flare No.2 WCH4	Density of Methane Flare No.2 DCH4 (t/Nm3)	Total methane Flare No.2 (tCH4)	Global Warming Potential Flare No.2 GWP (tCO2/tCH4)	Emissions from methane Flare No.2 (tCO2e)	PE Flare No.2 (tCO2e)	Quantity of Methane destroyed by flaring MD flared,y (tCH4)	Quantity of Landfill Gas Fed into the Electricity Generator No. 1 LFG electricity,y (m³ LFG)	Average methane fraction of the landfill gas as measured WCH4	Quantity of Landfill Gas Fed into the Electricity Generators No. 2 & 3 LFG electricity,y (m³ LFG)	Average methane fraction of the landfill gas as measured WCH4	Quantity of methane destroyed by generation of electricity MD electricity,y (tCH4)	Quantity of methane that would have been destroyed MD project,y (tCH4)
Sep-13	1,228,804	0.59	0.0007168	514.41	25	12860.2	1067.27	471.72	337530.08	0.59	0.00	0.00	142.22	613.94
Oct-13	1,251,748	0.60	0.0007168	537.14	25	13428.4	1150.48	491.12	292380.04	0.60	0.00	0.00	125.46	616.58
Nov-13	1,213,962	0.61	0.0007168	529.54	25	13238.6	1112.08	485.06	291735.50	0.61	0.00	0.00	127.26	612.32
Dec-13	990,658	0.58	0.0007168	413.01	25	10325.2	870.68	378.18	304219.55	0.58	591,061.28	0.62	389.81	767.99
Jan-14	1,138,260	0.56	0.0007168	455.93	25	11398.3	977.22	416.84	270757.68	0.56	847,143.73	0.57	457.33	874.17
Feb-14	1,055,475	0.57	0.0007168	434.74	25	10868.6	876.52	395.68	250803.76	0.57	522,359.31	0.58	314.35	710.04
Mar-14	1,116,020	0.58	0.0007168	461.49	25	11537.3	990.18	421.89	285969.91	0.58	774,857.05	0.57	436.19	858.08

	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Total quantity of LFG Flare & LFG Electricity (column B + column J)	1,558,334	1,544,128	1,505,697	1,294,877	1,410,018	1,306,279	1,401,990
Total quantity of LFG Total	1,622,293	1,595,662	1,558,928	1,345,246	1,471,940	1,392,596	1,498,930
From the monthly comparison of the FT1 & FT2 + FT3 in this monitoring period, the value of FT2 was used in the CER calculation since FT1 is greater than FT2 + FT3.							

For Flare No.2, from the monthly comparison of the FT1 and FT2 + FT3 in this monitoring period, the value of FT2 was used in the CER calculation since FT1 is greater than FT2 + FT3. Details on how the comparison was made and which values were used are explained in Section D.2 above for the parameters LFG_{total}, LFG_{flare} and $LFG_{electricity}$.

Determination of BE_y

	$(MD_{project,y} - MD_{BL,y}) * GWP_{CH4}$	BEy Flare No.1	$(MD_{project,y} - MD_{BL,y}) * GWP_{CH4}$	$EL_{LFG,y} \cdot CEF_{elec,BL,y}$			BEy Flare No.2
Month	Emissions from Flare No.1 (tCO2e)	Total Baseline Emissions Flare No.1 (tCO2e)	Emissions from Flare No.2 (tCO2e)	Total electricity generated EL,LFG,y (MWh)	CoEF for electricity Flare No.2 CEF electricity,y	Baseline Emission from electricity generation Flare No.2 (tCO2e)	Total Baseline Emissions Flare No.2 (tCO2e)
Sep-13	9500.56	9,500.55	15348.48	627.88	0.741	465.26	15,813.75
Oct-13	10104.95	10,104.95	15414.53	533.74	0.741	395.50	15,810.04
Nov-13	9568.00	9,568.00	15307.99	544.16	0.741	403.22	15,711.21
Dec-13	7773.01	7,773.01	19199.72	1771.58	0.741	1312.74	20,512.46
Jan-14	4451.39	4,451.39	21854.32	2145.65	0.741	1589.93	23,444.25
Feb-14	3517.11	3,517.11	17750.92	1500.64	0.741	1111.98	18,862.89
Mar-14	3719.00	3,719.00	21451.97	2149.56	0.741	1592.83	23,044.80

For this project, the following applies:

1. $MD_{thermal,y}$ and $MD_{PL.y}$ are not applicable (=0) to this project since there are no heat generation and feeding to natural gas pipeline
2. For this project, $MD_{BL,y}$ is zero since there are no destruction or combustion of methane today due to regulatory a 2nd contractual requirements
3. $ET_{LFG,y}$ and $CEF_{ther,BL,y}$ are not applicable (=0) to this project since there are no thermal energy production
4. Density of methane for Flare No.2 LFG is obtained from ACM 0001, version 8.0, page 14
5. Power generation of landfill gas was only implemented in June 2011
6. The grid connected baseline for Peninsula Malaysia for 2012 was applied to this project and the $CEF_{electricity,y}$ calculated was 0.741tCO_2/MWh
7. $MD_{electricity,y}$ is not applicable (=0) for Flare No.1 during this monitoring period as no LFG from Flare No.1 sent to Gas Engine No.1
8. $EL_{LFG,y}$ and $CEF_{elec,BL,y}$ are not applicable (=0) for Flare No.1 during this monitoring period as no LFG from Flare No.1 sent to Gas Engine No.1
9. The total electricity generated ($EL_{LFG,y}$) is the amount based on the monthly invoices to the grid operator (Tenaga National Berhad (TNB)) which is also the lower reading from the comparison between (EL4 + EL9 + EL10 - EL3 - EL7 - EL8) and (EL5 + EL11)
10. 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

E.2. Calculation of project emissions or actual net GHG removals by sinks

The total project emissions according to ACM0001 (Version 8) were estimated according to the equations below:

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

$$PE_{EC,y} = EC_{PJ,y} \cdot EF_{grid,y} \cdot (1+TDL_y)$$

$PE_{EC,y}$	Project emissions from consumption of electricity by the project activity during the year y (tCO2e/yr)
$EC_{PJ,y}$	Quantity of electricity consumed by the project activity during the year y (MWh)
TDL_y	Average technical transmission and distribution losses in the ECPG in the year y for the voltage level at which electricity is obtained from the grid at the project site
EF_{grid}	Emission factor for the grid in year y (tCO2eq/MWh)

Month	Electricity consumed by project activity ELPJ,y (MWh)	Coefficient for grid electricity EF grid,y	Transmission and Distribution Losses TDL,y	Total Project Emission from project activity (tCO2e)
Sep-13	80.78	0.741	0.1	65.85
Oct-13	80.64	0.741	0.1	65.73
Nov-13	76.84	0.741	0.1	62.64
Dec-13	70.88	0.741	0.1	57.77
Jan-14	49.59	0.741	0.1	40.42
Feb-14	61.00	0.741	0.1	49.72
Mar-14	68.80	0.741	0.1	56.08

For this project, the following applies:

1. $PE_{fc,y}$ is zero as no heat from fossil fuel is used to generate electricity for this project
2. The grid connected baseline for Peninsula Malaysia for 2012 was applied to this project and the $EF_{grid,y}$ calculated was 0.741tCO_2/MWh
3. TDL = 10% adopted as stated in the registered PDD, version 5.3 page 35 (TNB annual report 2007) (http://announcements.bursamalaysia.com/EDMS%5Csubweb.nsf/LsvAllByID/8B0DC73587EFBC114825750B0033ED71?OpenDocument)

E.3. Calculation of leakage

No leakage.

E.4. Summary of calculation of emission reductions or net anthropogenic GHG removals by sinks

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	Emission reductions or net anthropogenic GHG removals by sinks (t CO_2e)
September 13	25,313	66	0	25,247

October 13	25,914	66	0	25,848
November 13	25,279	63	0	25,216
December 13	28,285	58	0	28,227
January 14	27,895	41	0	27,854
February 14	22,379	50	0	22,329
March 14	26,762	57	0	26,705
Total	**181,827**	**401**	**0**	**181,426**

E.5. Comparison of actual emission reductions or net anthropogenic GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks ($t\ CO_2e$)	156,882*	181,426

** Ex-ante for 212 days (Sept 2013 – Mar 2014) – [263,204 x (122/365)] + [279,458 x (90/365)]*

E.6. Remarks on difference from estimated value in registered PDD

The total CERs claimed in the 8th monitoring period was 13.5% higher as compared to the value reported in the ex-ante calculations. This is due to ex-ante GWP, the revised PDD, version 9.0, a default value of GWP 21 has been applied while in the 8th Monitoring Report, the default was updated to GWP 25[9] and applied.

In order to have a fair comparison between CERs claimed during the 8th Monitoring Report and estimated CERs calculated in the revised PDD, version 9.0, a revision of GWP 25 was applied in revised PDD, version 9.0. The comparison is tabulated as below:

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks ($t\ CO_2e$)	169,560*	181,426

** Ex-ante for 212 days (Sept 2013 – Mar 2014) – [283,702 x (122/365)] + [303,088 x (90/365)]*

The total CERs claimed in the 8th monitoring period was 6.5% higher as compared to the value reported in the ex-ante calculations. This is due to the following reason:

1. Both flares have low downtime and have operated at high efficiency as compared to the previous monitoring period (7th Monitoring Report).

7th monitoring period flares running time

Month	Time (minute) from January - August 2013		% of total flare running time
	Total actual flare running time	Total time	
Flare 1	338,705	349,920	97
Flare 2	337,558	349,920	96

[9] 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. This factor has contributed a significant impact to the increase in CERs.

8th monitoring period flares running time

Month	Time (minute) from September 2013 - March 2014		% of total flare running time
	Total actual flare running time	Total time	
Flare 1	298,471	305,280	98
Flare 2	302,023	305,280	99

Note: The total running time of the flares is calculated from the information provided in the System Shutdown Forms recorded on-site

E.7. Actual emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

Item	Actual values achieved up to 31 December 2012	Actual values achieved from 1 January 2013 onwards
Emission reductions or GHG removals by sinks (t CO_2e)	Not applicable	375,007[10]

Appendix 1: Details on the downtime of Flare No.1

Date	Flaring stopped		Reason	Remarks
	From	To		
09/09/2013	16:22	16:31	Equipment Breakdown	Main flame not detected. Suspect faulty flame amplifier/ sensor. To monitor. Restart
27/09/2013	9:14	15:30	Maintenance	To check condensate/ moisture separator. SCADA computer- monitor problem
01/10/2013	17:26	18:42	Equipment Breakdown	Main flame not detected
02/10/2013	8:43	9:26	Maintenance	Check Flare 1 SCADA Computer System. Monitor problem, change to DELL monitor
07/10/2013	17:08	17:29	Equipment Breakdown	Main flame is not detected
10/10/2013	11:56	16:00	Power Failure	F1 Breaker open, waiting for TNB to reset the breaker
17/10/2013	17:33	17:41	Power Failure	Power surge
26/10/2013	17:02	17:07	Equipment Breakdown	Main flame not detected
27/10/2013	15:30	20:19	Equipment Breakdown	Pilot flame not detected
02/11/2013	14:36	14:53	Power Failure	Power surge-main flame not detected
07/11/2013	18:49	19:01	Others: O_2 high	Main flame not detected
	21:52	22:01	Others: O_2 high	Main flame not detected
12/11/2013	9:25	9:48	Others: Testing	Conduct testing for Advance Phase. O_2 high (main flare not detected)

10 The actual value achieved for the 7th monitoring period from 01/01/2013 – 31/08/2013 is 193,581 tCO_2e and 8th monitoring period from 01/09/2013 – 31/03/2014 is 181,426 tCO_2e.

	10:04	10:33	Others: Testing	Conduct testing for Advance Phase. O_2 high (main flare not detected)
	10:49	10:58	Others: Testing	Conduct testing for Advance Phase. O_2 high (main flare not detected)
	14:17	14:19	Others: Testing	Conduct testing for Advance Phase. O_2 high (main flare not detected)
13/11/2013	9:46	10:04	Others: Testing	Testing for Advance Phase Gas Quality & Performance. Line by line testing with minimum flow to monitor LFG extraction performance
	16:17	16:19	Others: Testing	Testing for Advance Phase Gas Quality & Performance. Line by line testing with minimum flow to monitor LFG extraction performance
14/11/2013	17:10	17:20	Equipment Breakdown	Main flame not detected
10/12/2013	10:53	13:16	Others: Annual calibration	Flare 1 annual calibration CDM eqquipment by Nectar F1-PT2/ F1-TT1/ F2-CH4/ Spare TT3
07/01/2014	12:00	12:20	Power Failure	TNB power surge. Isolating transformer tripped. Reset and restart
10/01/2014	12:19	16:30	Others: Proper shutdown	Proper shutdown- LFG pipe connection, new connection lateral link to 2A main pipe. Blower 1 (Flare 1) jam/ struck. To call Hydrocare for service and repair
16/01/2014	15:51	16:47	Others: Proper shutdown	Proper shutdown to remove blower 1 (Flare 1) by Hydrocare
10/02/2014	10:58		Equipment Breakdown	Blower 2 jammed - Arrange Hydrocare
11/02/2014		16:45		
18/02/2014	15:18		Others: Proper shutdown	Shutdown to install cable marker (overhead) near helli pad. Unable to restart
19/02/2014		12:32		
09/03/2014	12:28	17:54	Equipment Breakdown	Blower 2 jammed. VFD shown fault. Check FT1/ FT2. Service pneumatic valve. Check signal isolator for low FT2 value. Restart with 1 blower
10/03/2014	9:50	14:46	Others: Proper shutdown	To check FT1/ FT2 transmitter. Service & check pneumatic valve/ remove condensate. Reset computer clock (windows)

20/3/2014	10:10	11:55	Maintenance	To check air compressor for pneumatic valve. Install additional valve for condensate removal
	13:50	16:29	Maintenance	To check air compressor for pneumatic valve. Install additional valve for condensate removal

Appendix 2: Details on the downtime of Flare No.2

Date	Flaring stopped		Reason	Remarks
	From	To		
17/09/2013	17:46	19:00	Equipment Breakdown	UPS fail to back-up power failure @ computer + PLC system + recheck system
17/10/2013	17:31	17:47	Power Failure	Power surge
02/11/2013	14:24	14:36	Power Failure	Power surge - main flame not detected
15/12/2013	20:09	20:36	Equipment Breakdown	Flare 2 shutdown due to UPS problem. Temperature too high
10/01/2014	12:15	16:39	Others: Proper shutdown	Proper shutdown - LFG pipe connection, new connection lateral link to 2A main pipe
28/01/2014	9:10	10:25	Others: Proper shutdown	To install new UPS at Flare 2 - for PC and PLC backup
	19:41	20:06	Equipment Breakdown	F2 - main flame not detected
30/01/2014	3:23	4:48	Equipment Breakdown	Main flame is not detected
	13:53	14:38	Others: Proper shutdown	To change power supply to PLC
01/02/2014	10:40	11:14	Equipment Breakdown	Main flame is not detected
02/02/2014	13:33	14:07	Exceed set point limit	O_2 is above alarm set point
5/2/2014	18:53	19:30	Exceed set point limit	PT1 above danger set point
	21:11	21:34	Exceed set point limit	PT1 above danger set point
6/2/2014	8:48	9:35	Maintenance	Shutdown to check for missing data/ PLC. Few second- Flare 2 system. Install another DC power supply
7/2/2014	11:11	12:23	Equipment Breakdown	Main flame is not detected. Problem with PLC
9/2/2014	2:52	4:02	Equipment Breakdown	Main flame is not detected. Problem with PLC
	17:44	18:15	Equipment Breakdown	Main flame is not detected. Problem with PLC & missing data

10/2/2014	7:03	11:11	Equipment Breakdown	Main flame is not detected. Problem with PLC
	15:05	15:43	Equipment Breakdown	Main flame is not detected. Problem with PLC & missing data
	16:51	17:08	Equipment Breakdown	Main flame is not detected. Problem with PLC & missing data
11/2/2014	10:08	12:21	Others: Service	Proper shutdown - Hydrocare to service Blower Flare 2
18/2/2014	15:30	16:57	Others: Proper shutdown	To install overhead cable marker near helli pad

Appendix 3: Details on the downtime of Gas Engine No.1, No.2 and No.3

Date	Gas Engine No.1 Stopped		Description Of Event
	From	To	
09/10/2013	23:52		Reverse VAR – restart Gas Engine No.1
10/10/2013		00:03	
04/11/2013	23:32		Reverse VAR – restart Gas Engine No.1
05/11/2013		02:12	
12/11/2013	21:02		Reverse VAR. Unable to restart immediately due to busbar too voltage high. To monitor before restart GE1. To monitor busbar
13/11/2013		08:49	
20/01/2014	10:18		GE 1 scheduled maintenance. Service interval 2,000 h change LT fen / change activated carbon / service GDU refill HT tank pressure / check alternator / change spark plug B1
23/01/2014		12:00	
02/02/2014	13:33		Reverse Power. GE1 unable to restart. Check ignition gas quality / gas valve
03/02/2014		10:36	

Date	Gas Engine No.2 Stopped		Description Of Event
	From	To	
08/12/2013	11:14		Main fault
09/12/2013		10:07	
10/12/2013	16:32		Main fault
11/12/2013		16:34	
25/12/2013	18:43		Combustion Chamber A2 (T462),Temperature too high. SPE change temperature sensor for A2 - combustion chamber
27/12/2013		15:18	

Date	Gas Engine No.3 Stopped		Description Of Event
	From	To	
11/02/2014	9:54		Request by SP Energy for schedule service. Unable to restart - found B8 Compression low. Need to check with MWM before resume operation
01/03/2014		18:14	

Appendix 4: Description on the calculation applied in ER Calculation Sheet for Tool to determine the mass flow of a greenhouse gas in a gaseous stream, version 2.0

Referring to the tools, for LFG temperatures below 60 ^{o}C, moisture could be neglected due to its very low influence on final results and thus, the measurement in wet or dry basis is not important (as reflected in the amendments to ACM 0001, version 9.1 onwards). In the case where the LFG temperature exceeds 60^{o}C, the

same basis for both methane concentration and flow measurement will be considered according to the tools.

There are 6 measurement options as tabulated below:

Option	Flow of gaseous stream	Volumetric fraction
A	Volume flow – dry basis	dry or wet basis[3]
B	Volume flow – wet basis	dry basis
C	Volume flow – wet basis	wet basis
D	Mass flow – dry basis	dry or wet basis
E	Mass flow – wet basis	dry basis
F	Mass flow – wet basis	wet basis

During this monitoring period, for Flare No.1 with LFG temperature exceeding 60°C, option B measurement was selected and was applied in the CER calculation.

Determination of the absolute humidity of the gaseous stream

The absolute humidity is a parameter required for Option B. It can be determined from the measurement of moisture content (Option 1) or by assuming the gaseous stream is dry or saturated in a simplified conservative approach (Option 2).

Option 2 which assumes that the gaseous stream is dry or saturated in a simplified conservative approach was selected for the CER calculation.

Option 2: Simplified calculation without measurement of the moisture content

This option provides a simple and conservative approach to determine the absolute humidity by assuming the gaseous stream is dry or saturated depending on which is the conservative situation. If it is conservative to assume that the gaseous stream is dry, then $m_{H2O,t,db}$ is assumed to equal to 0. If it is conservative to assume that the gaseous stream is saturated, then $m_{H2O,t,db}$ is assumed to be equal to the saturation absolute humidity ($m_{H2O,t,db,sat}$) and is calculated using the equation below:

$$m_{H2O,t,db,Sat} = \frac{p_{H2O,t,Sat} * MM_{H2O}}{(P_t - p_{H2O,t,Sat}) * MM_{t,db}}$$

Where:

$m_{H2O,t,db,sat}$	=	Saturation absolute humidity in time interval t on a dry basis (kg H_2O/kg dry gas)
$p_{H20,t,Sat}$	=	Saturation pressure of H_2O at temperature T_t in time interval t (Pa)
T_t	=	Temperature of the gaseous stream in time interval t (K)
P_t	=	Absolute pressure of the gaseous stream in time interval t (Pa)
MM_{H2O}	=	Molecular mass of H_2O (kg H_2O/kmol H_2O)
$MM_{t,db}$	=	Molecular mass of the gaseous stream in a time interval t on a dry basis (kg dry gas/kmol dry gas)

Parameter	Formula/ description
$p_{H20,t,Sat}$	1 | 2 | — Filonenko/ Ginzburg (1973) and Filonenko et al. (1971) | 0…100 | $p_s = \exp(6.416 + 17.3 \cdot t / (238 + t))$, P_s – Saturation pressure of H_2O t – LFG Temperature

P_t

Absolute Pressure	
$P_a = P_g + P_{at}$	
$P_a = P_g + 101325$	
where,	
P_a = Absolute Pressure,	
P_g = Gauge Pressure,	
P_{at} = Atmospheric Pressure.	

MM_{H2O}

18.0152 kg/kmol
Default value from the tool

$MM_{t,db}$

$$MM_{t,db} = \sum_k (v_{k,t,db} * MM_k)$$

Where:

$MM_{t,db}$	=	Molecular mass of the gaseous stream in 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, O2, CO, H2, CH_4, N_2O, NO, NO2, SO_2, SF_6 and PFCs). See available simplification below

Default value for $MM_{i,k}$, Gases involve in the calculation are CH_4, CO_2, and O_2

Data / Parameter:	MM_i
Data unit:	kg/kmol
Description:	Molecular mass of greenhouse gas *i*
Value to be applied:	(see table below)
Any comment:	

Compound	Structure	Molecular mass (kg / kmol)
Carbon dioxide	CO_2	44.01
Methane	CH_4	16.04
Nitrous oxide	N_2O	44.02
Sulfur hexafluoride	SF_6	146.06
Perfluoromethane	CF_4	88.00
Perfluoroethane	C_2F_6	138.01
Perfluoropropane	C_3F_8	188.02
Perfluorobutane	C_4F_{10}	238.03
Perfluorocyclobutane	$c\text{-}C_4F_8$	200.03
Perfluoropentane	C_5F_{12}	288.03
Perfluorohexane	C_6F_{14}	338.04

Data / Parameter:	MM_k
Data unit:	kg/kmol
Description:	Molecular mass of gas *k*
Value to be applied:	For gases *k* that are greenhouse gases appy values for MM_i.
Any comment:	

Compound	Structure	Molecular mass (kg / kmol)
Nitrogen	N_2	28.01
Oxygen	O_2	32.00
Carbon monoxide	CO	28.01
Hydrogen	H_2	2.02
Nitric oxide	NO	30.01
Nitrogen dioxide	NO_2	46.01
Sulfur dioxide	SO_2	64.06

Option B of measurement options

The volumetric flow of the gaseous stream in time interval *t* on a dry basis ($V_{t,db}$) is determined by converting the measured volumetric flow from wet basis to dry basis as follows:

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

Where:

$V_{t,db}$	=	Volumetric flow of the gaseous stream in time interval *t* on a dry basis (m³ dry gas/h)
$V_{t,wb}$	=	Volumetric flow of the gaseous stream in time interval *t* on a wet basis (m³ wet gas/h)
$v_{H2O,t,db}$	=	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m³ H_2O/m³ dry gas)

The volumetric fraction of H_2O in time interval *t* on a dry basis ($v_{H2O,t,db}$) is estimated according to the equation below:

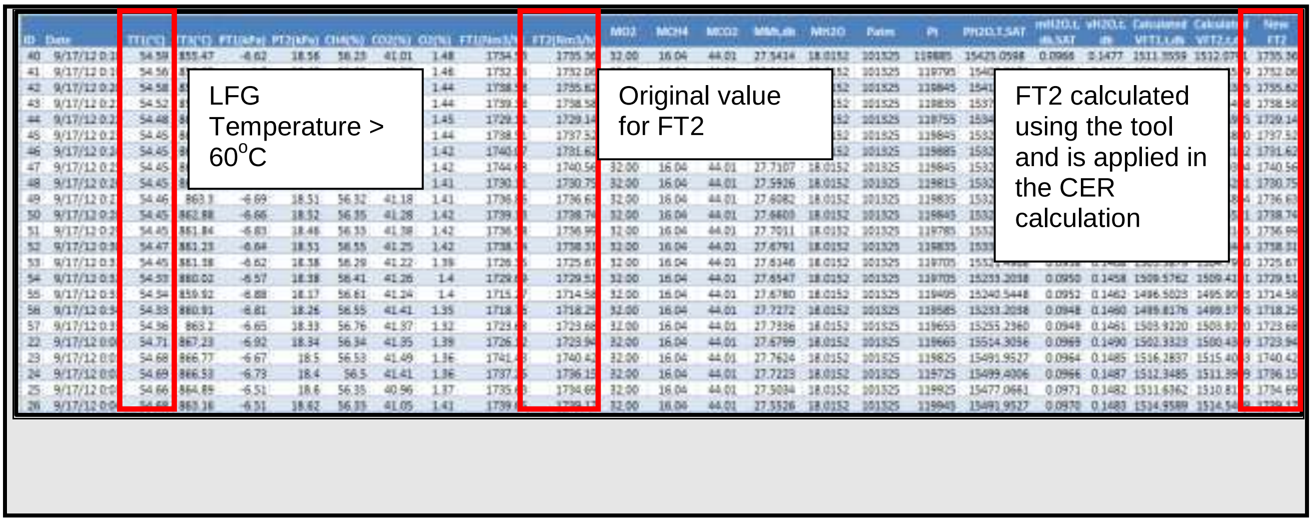
$$v_{H2O,t,db} = \frac{m_{H2O,t,db} * MM_{t,db}}{MM_{H2O}}$$

Where:

$v_{H2O,t,db}$	=	Volumetric fraction of H_2O in the gaseous stream in time interval *t* on a dry basis (m³ H_2O/m³ 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)

The absolute humidity of the gaseous stream ($m_{H2O,t,db}$) is determined using Option 2 above ($MM_{t,db}$) which is as demonstrated above.

Example of the calculation using the *Tool to determine the mass flow of a greenhouse gas in a gaseous stream*, version 2.0.



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Document information

Version	Date	Description
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net anthropogenic GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
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