MONITORING REPORT FORM (F-CDM-MR)
Version 02.0

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	06/07/2012
Registration date of the project activity	28/08/2009
Monitoring period number and duration of this monitoring period	Monitoring period number: 05 Duration of monitoring period: 01/01/2012 to 30/06/2012 inclusive of both days
Project participant(s)	Japan Carbon Finance, Ltd.
Host Party(ies)	KUB-Berjaya Enviro Sdn. Bhd.
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	105,434 tCO_2e. ** Ex-ante for 182 days (Jan 2012 – June 2012) – 211,448 x (182/365)*
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	107,574 tCO_2e.

1 The ACM 0001 - *Consolidated baseline and monitoring methodology for landfill gas project activities* (Version 8) is no longer valid and is not available for download in UNFCCC.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.

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 engine(s) 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 engine(s)
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 and Phase 1 Cell 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 to generate electricity. The electricity produced by the gas engine 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	17th June 2008	28th August 2009	Continued to operate
Second flaring system	22nd January 2010	7th August 2010	Continued to operate
Gas Engine	3rd January 2011 (delivery to site)	1st June 2011	Continued to operate

The 5th monitoring period is from 1st January 2012 to 30th June 2012 (inclusive of both days). The total emission reductions achieved during this monitoring period is **107,574 tCO_2e.**

A.2. Location of project activity

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.

Figure 1: Location of BTSL and Selangor State

The specific geographical coordinates of the landfill are:

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

A.3. 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
Japan	Japan Carbon Finance, Ltd. (JCF) (Private)	No

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)[2]

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 5, EB 55, Annex 18);
- *Tool to calculate the emission factor for an electricity system* (Version 2, EB 50, Annex 14); and
- *Tool to calculate baseline, project and/or leakage emissions from electricity consumption* (Version 1, EB 39, Annex 7).

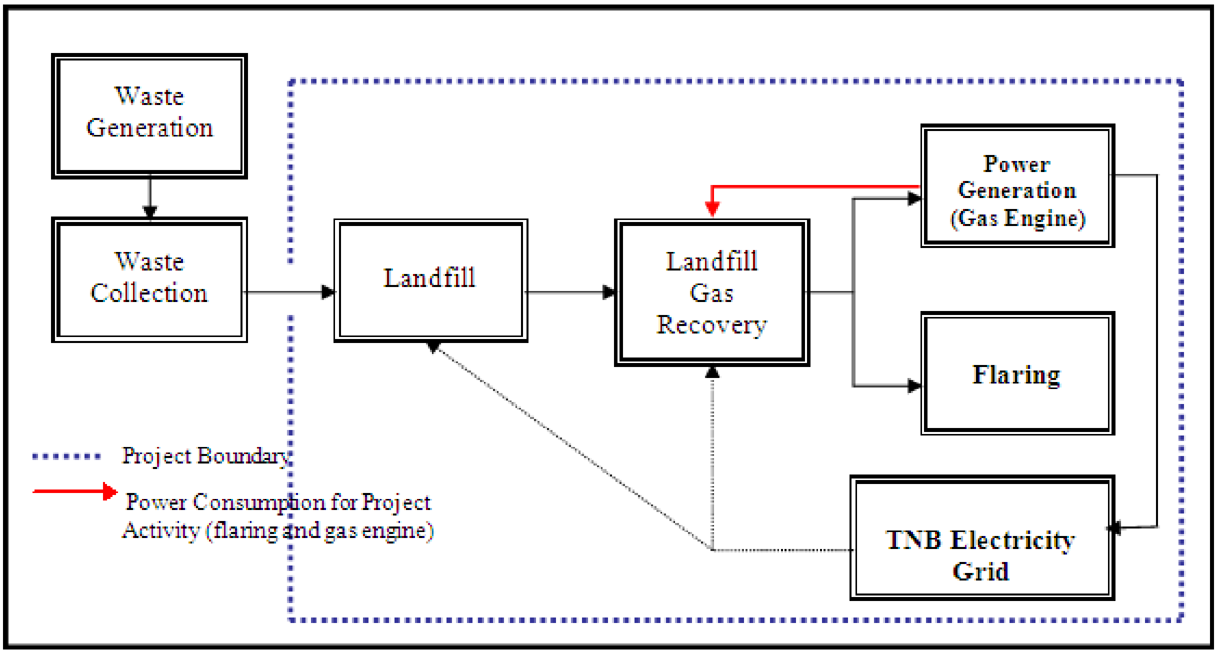
A.5. Crediting period of project activity

The start date of the crediting period of the project activity is 28th August 2009 (date of registration) and the end date of the 1st crediting period is 27th August 2016. The selected crediting period is renewable (7 years). The 5th crediting period is from 1st January 2012 to 30th June 2012 (inclusive of both days).

[2] 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.

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 2 cells in the landfill, i.e. Advance Cell and Phase 1. Both of these phases are included in this project as well as any future phases to be developed in accordance to the PDD.*
2. *Notification of change was submitted earlier to remove the on-site power consumption for landfill operation. Notification of change was approved by UNFCCC on 9th May 2012.*

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

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:

<u>Gas Extraction System in Advance Cell</u>

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^oC
Gas blower	Twin-lobe roots blower
Gas analysers	Gas analysers for CH_4 and O_2

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 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^oC
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 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 the gas engine 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 the gas engine, 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 the gas engine.

A landfill gas blower was installed to ensure that the required gas pressure for gas engine is maintained.

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 Engine(s). 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.

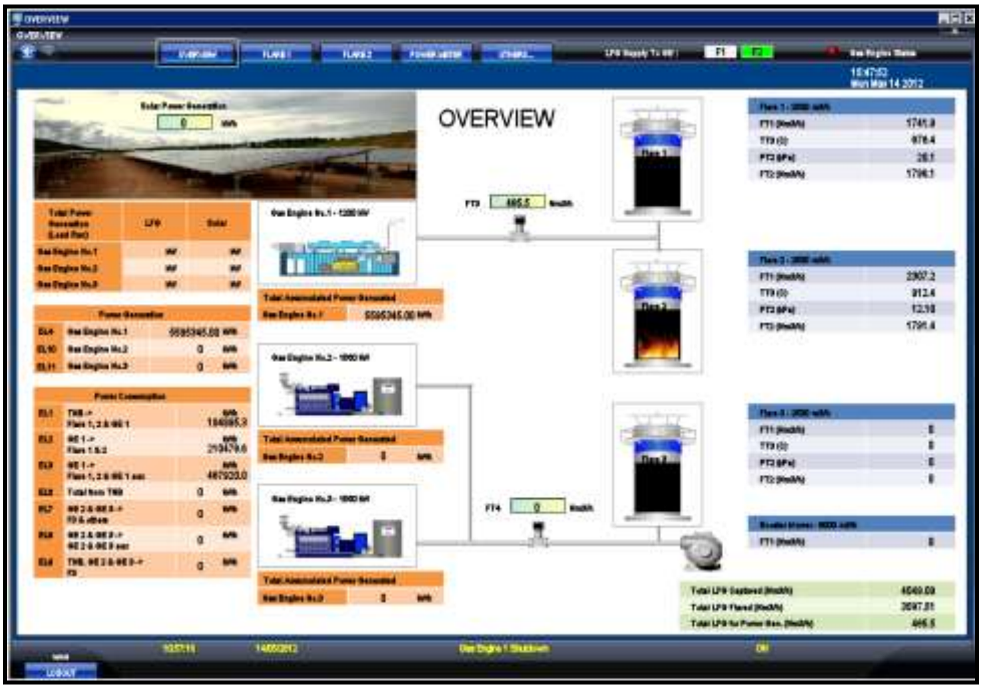


Figure 8: Centralized SCADA Interface

Implementation status of project activity

For the reporting period of 1st January 2012 to 30th June 2012, 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 88% during this monitoring period.

Gas Extraction System in Phase 1 Cell and Flare No.2

The flaring system in Phase 1 Cell was completed during the 2nd monitoring period and has started its operation on 7th August 2010. Flare No.2 was located next to Flare No.1 where most of the LFG extracted from Phase 1 Cell 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 91% during this monitoring period.

Power Generation

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

The details on the downtime of the gas engine are presented in **Appendix 3**.

Currently, the data recording for the amount of gas channelled to gas engine 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.

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 3rd monitoring period, the revision of monitoring plan was submitted to UNFCCC and approved on 9th May 2012[3].

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 3rd monitoring period, the notification of change request was submitted to UNFCCC and approved on 9th May 2012[4].

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.

B.2.5. Changes to start date of crediting period

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

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

Not applicable.

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

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 ℃ 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 ℃ 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 ℃ 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 ℃ 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, the Transmission and Distribution Losses (TDL_y) value applied in this project is 10%. This value was reported in the Tenaga Nasional Berhad (TNB)[5] Annual Report 2007[6] in page 23.

Operation and Management Structure for Monitoring

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

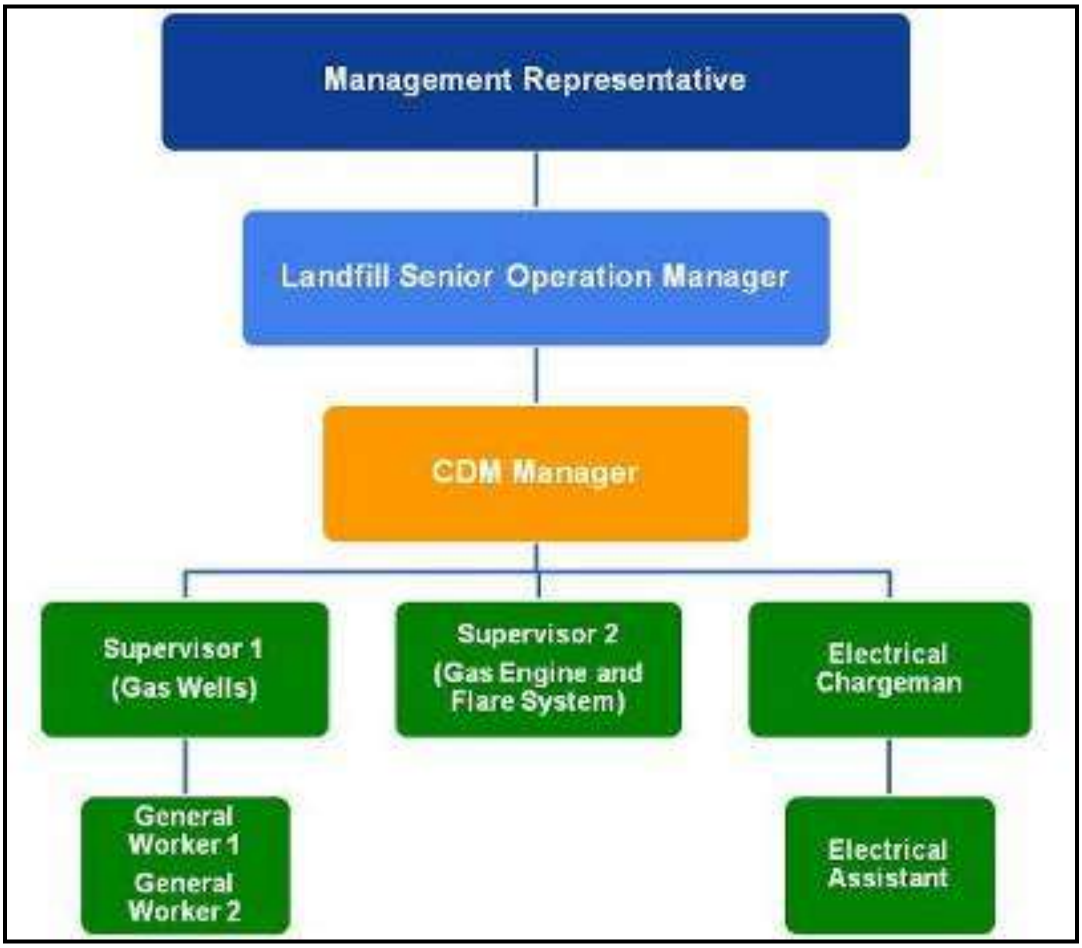


Figure 9: Organisational Structure for CDM Monitoring for BTSL LFG Recovery and Utilisation Project

[5] Tenaga Nasional Berhad is the largest electricity provider in Malaysia and is responsible for the grid transmission and distribution in Peninsular Malaysia.

[6] http://announcements.bursamalaysia.com/EDMS/subweb.nsf/7f04516f8098680348256c6f0017a6bf/303144432ec51
70e482573af00388df6/$FILE/TENAGA-Cover%20to%20Page%2050%20(2.3MB).pdf

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
Electrical Chargeman	• Conducts regular checks on the electrical components of the flaring system

Role	Responsibility in CDM monitoring
	• Ensures continuous power supply to flaring system • Identifies and fixes all electrical and electronic faults detected • Ensures all electrical meters are functioning and calibrated as per the supplier requirement / industrial standards • Records the electricity consumption for the flare system in the daily monitoring log sheets
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, 2 CDM Management Meetings were held on 12th March 2012 and 17th May 2012.

Relevant Monitoring Points

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

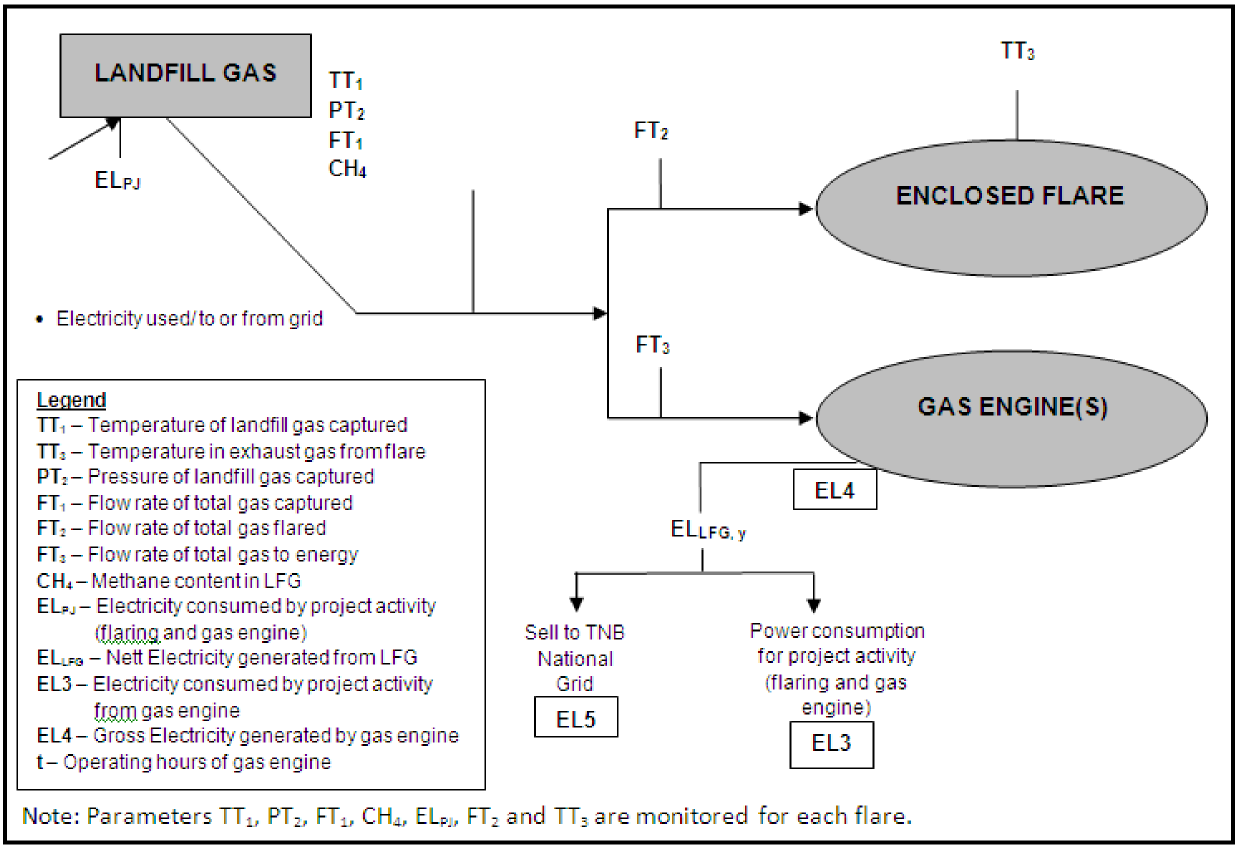


Figure 10: Key Parameters Monitored under the CDM Monitoring Plan

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.

Data Recording and Documentation

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	$T_{TT1,F1}$ $T_{TT1,F2}$	$TT_{1,Flare No.1/Flare No.2}$	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
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	$P_{PT2,F1}$ $P_{PT2,F2}$	$PT_{2,Flare No.1/Flare No.2}$	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	$LFG_{total,Flare No.1/Flare No.2,y}$ $LFG_{flare,Flar}$	$FT_{1,Flare No.1/Flare No.2}$ $FT_{2,Flare}$	V-Cone Differential Pressure Flowmeter	Every 1 min (auto) Daily (manual) –	Softcopy Hardcopy	(.MDB MS Access database) Daily log

Parameter	CDM ID	Equipment ID	Monitoring equipment	Recording frequency	Documentations	Data archive
	e No.1/Flare No.2,y $LFG_{electricity,Flare No.2,y}$	No.1/Flare No.2 $FT_{3,Flare No.2}$		as back-up		sheet will be scanned into PDF format for archiving
Methane Fraction	$W_{CH4,Flare No.1/Flare No.2,y}$	$CH_{4,Flare No.1/Flare No.2}$	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	$EL_{PJ,y}$ $EL_{PJ,GE,auxiliary\ \&\ flare,y}$	EL_{PJ} (EL1) $EL_{PJ,GE,auxiliary\ \&\ flare}$ (EL3)	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	$EL_{LFG,GE,total,y}$	$EL_{LFG,GE,total}$ (EL4)	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, TNB meter)	kWh meter	Daily (manual)	Softcopy (scanned copy)	TNB joint meter reading

Parameter	CDM ID	Equipment ID	Monitoring equipment	Recording frequency	Documentations	Data archive
					Hardcopy	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.

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)	$TT_{1,Flare\ No.1}$	$T_{TT1,F1}$	^oC	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B224836437	±0.5%	0-100°C	28/04/11 & SB 110587 (1 Jan 12 - 25 Apr 12) 26/04/12 & SB 120291 (26 Apr 12 - 30 June 12)	27/04/12 25/04/13	Annually
2	Temperature Transmitter	Flare Temperature ($T_{flare,y}$)	$TT_{3,Flare\ No.1}$	$T_{Flare,F1}$	^oC	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B123070037	±0.5%	0-1200°C	03/03/11 & SB 110454 (1 Jan 12 - 25 Apr 12) 26/04/12 & SB 120293 (26 Apr 12 - 30 June 12)	02/03/12 25/04/13	Annually
3	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,Flare\ No.1}$	$P_{PT2,F1}$	kPa	Rosemount	3051TG1A2B21AB4 E5M5Q4	02255815	±0.25%	0-2 to 0-207 kPa	08/09/11 & SB 110807 (1 Jan 12 - 30 June 12)	07/09/12	Annually
4	Flow Meter	Total Biogas Flow Rate ($LFG_{total,y}$)	$FT_{1,Flare\ No.1}$	$LFG_{total,Flare\ No.1,y}$	NM^3/hr	Kingsway Vcone Flow transmitter	3051 / KVS10IIKC23FSN	4972946 / FT119 (8102101)	±1%	3-5000Nm³/h	28/04/11 & SB 110591 (1 Jan 12 - 30 June 12)	27/04/13	24 months
5	Flow Meter	Flaring Biogas Flow Rate ($LFG_{flare,y}$)	$FT_{2,Flare\ No.1}$	$LFG_{flare,Flare\ No.1,y}$	NM^3/hr	Kingsway Vcone Flow transmitter	3051 / KVS10IIKC23FSN	4972945 / FT120 (8102102)	±1%	3-5000Nm³/h	28/04/11 & SB 110592 (1 Jan 12 - 30 June 12)	27/04/13	24 months
Gas Analysers													
6	CH_4 Meter	Methane fraction of LFG	$CH_{4,Flare\ No.1}$	$W_{CH4,Flare\ No.1,y}$	%	Guardian Plus	97460	28931	±2% of full scale	0-100%	28/04/11 & SB 110593 (1 Jan 12 - 25 Apr 12) 26/04/12 & SB 120288 (26 Apr 12 - 30 June 12)	27/04/12 25/04/13	Annually

** The maximum permissible error of ±5% has to be applied for $T_{Flare,F1}$ from 3rd March 2012 – 26th April 2012 as a conservative approach*

Span Gas			
No	Parameters	Analysis date	Best if used by
1	N_2, CH_4	18/02/09	18/02/14
		01/08/11	01/08/21
2	N_2, CO_2	03/02/09	03/02/14
3	N_2, O_2	26/10/09	26/10/19
		09/01/12	09/01/22

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)	$TT_{1,Flare\ No.2}$	$T_{TT1,F2}$	°C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B839917437	±0.5% of span	0-100°C	29/04/11 & SB 110595 (1 Jan 12 - 26 Apr 12) 27/04/12 & SB 120297 (27 Apr 12 - 30 June 12)	28/04/12 26/04/13	Annually
2	Temperature Transmitter	Flare Temperature ($T_{flare,y}$)	$TT_{3,Flare\ No.2}$	$T_{Flare,F2}$	°C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B838901937	±0.5% of span	0-1200°C	29/04/11 & SB 110597 (1 Jan 12 - 26 Apr 12) 27/04/12 & SB 120299 (27 Apr 12 - 30 June 12)	28/04/12 26/04/13	Annually
3	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,Flare\ No.2}$	$P_{PT2,F2}$	kPa	Rosemount	3051TG1A2B21AB4E 5Q4	5584784	±0.25%	0-2 to 0-207 kPa	29/04/11 & SB 110598 (1 Jan 12 - 26 Apr 12) 27/04/12 & SB 120296 (27 Apr 12 - 30 June 12)	28/04/12 26/04/13	Annually
4	Flow Meter	Total Biogas Flow Rate	$FT_{1,Flare\ No.2}$	$LFG_{total,Flare\ No.2,y}$	NM^3/hr	Kingsway Flow transmitter	3051CD1A22A1AM5K 5Q4 /	5476626 / FT141 (10031702)	±0.5%	3-5000Nm^3/h	29/04/11 & SB 110601 (1 Jan 12 - 30 June 12)	28/04/13	24 months
5	Flow Meter	Flaring Biogas Flow Rate	$FT_{2,Flare\ No.2}$	$LFG_{flare,Flare\ No.2,y}$	NM^3/hr	Kingsway Flow transmitter	3051CD1A22A1AM5K 5Q4 /	5476627 / FT140 (10031701)	±0.5%	3-5000Nm^3/h	29/04/11 & SB 110600 (1 Jan 12 - 30 June 12)	28/04/13	24 months
6	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{3,Flare\ No.2}$	$LFG_{electricity,Flare\ No.2,y}$	NM^3/hr	Kingways Control Flow transmitter (Rosemount)	3051CD1A22A1AM5K 5Q4 / KVS08IIKC23FSN	5490821 / FT161 (11011001)	±0.5%	200-2000Nm^3/h	20/01/11 & D11-046-JG (1 Jan 12 - 30 June 12)	19/01/13	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	30548	±2% of full scale	0-100%	21/06/11 & E-0644/0611 (1 Jan 12 - 26 Apr 12) 27/04/12 & SB 120294 (27 Apr 12 - 30 June 12)	20/06/12 26/04/13	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	10/05/11 & 2167 8900 35 (1 Jan 12 - 30 June 12)	09/05/14	36 months
9	Power meter	Electricity consumed (from GE for Flare 1, Flare 2 & GE auxiliaries)	$EL_{PJ,GE,auxiliary\ \&\ flare}$ (EL3)	$EL_{PJ,GE,auxiliary\ \&\ flare,y}$	kWh	IME	NEMO 96HD+ (MF96021)	2153 4300 16	Class 0.5S (±0.5%)	0-500/5A	10/05/11 & 2153 4300 16 (1 Jan 12 - 30 June 12)	09/05/14	36 months
10	Power meter	Total electricity generation (MWh) - recorded by project site	$EL_{LFG,GE,total}$ (EL4)	$EL_{LFG,GE,total,y}$	kWh (to be converted to MWh)	EDMI Limited	Mk6E	210225256	Class 0.5S	99999999.99kWh	15/07/10 & 210225256-1918937 (1 Jan 12 - 30 June 12)	14/07/12	24 months
11	Power meter	Electricity sell to grid (MWh) - recorded by grid operator	EL_{LFG} (EL5)	$EL_{LFG,y}$	kWh	Itron	SL761A071	53099690	Class 0.20	999999999kWh	01/04/11 & TNBM-QR-064 (1 Jan 12 - 30 June 12)	31/03/16	5 years

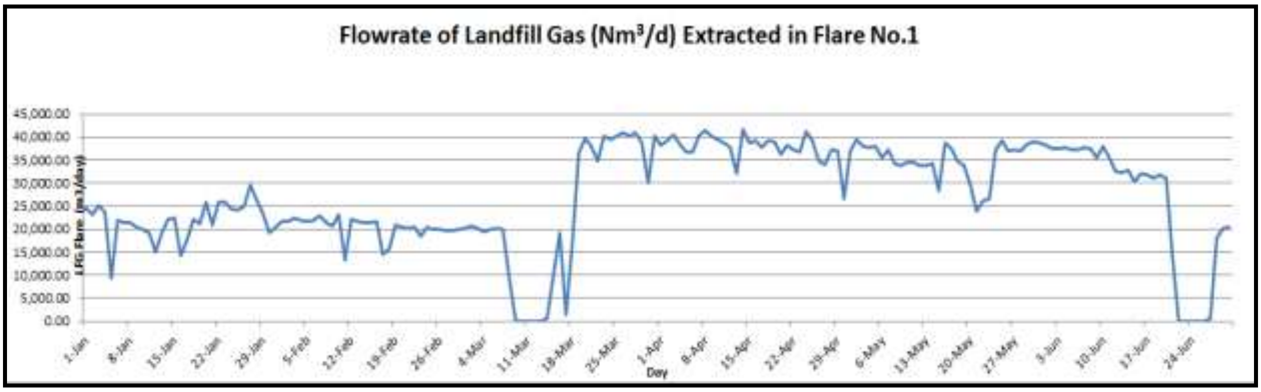
Span Gas			
No	Parameters	Analysis date	Best if used by
1	N_2, CH_4	04/10/10	04/10/20
2	N_2, CO_2	04/10/10	04/10/20
3	N_2, O_2	04/10/10	04/10/20

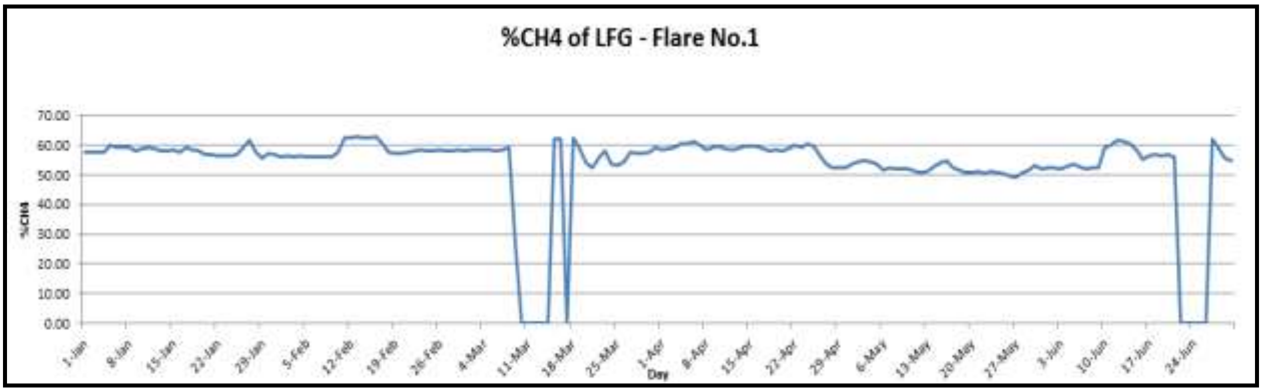
Data Collection (for the whole monitoring period)

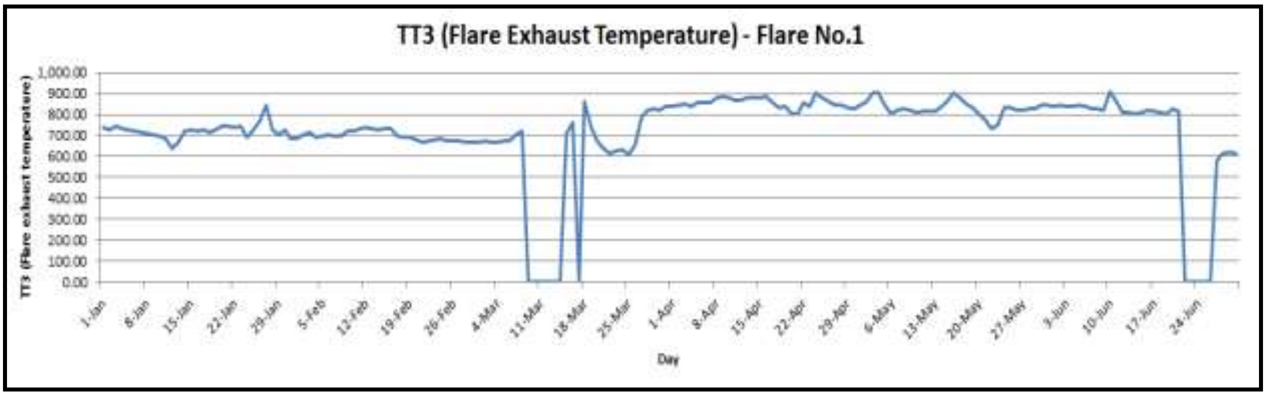
Based on the monitoring plan, key flaring parameters (temperature, pressure, flow of gas, CH_4 concentration in LFG) were continuously monitored and recorded via the data logger at the flare system control room. Continuous flaring data were logged and archived in every minute in the database file. These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

Data recorded for key parameters are compiled and presented below:

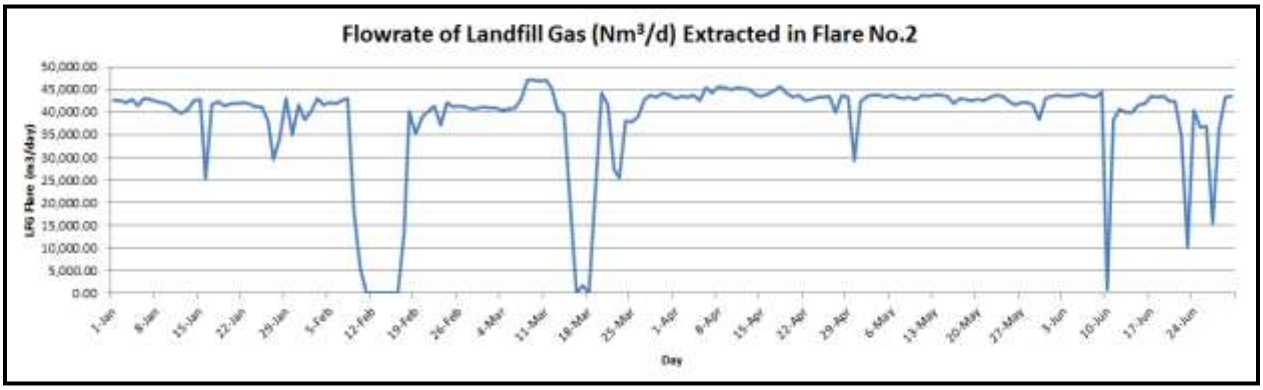
Flare No.1

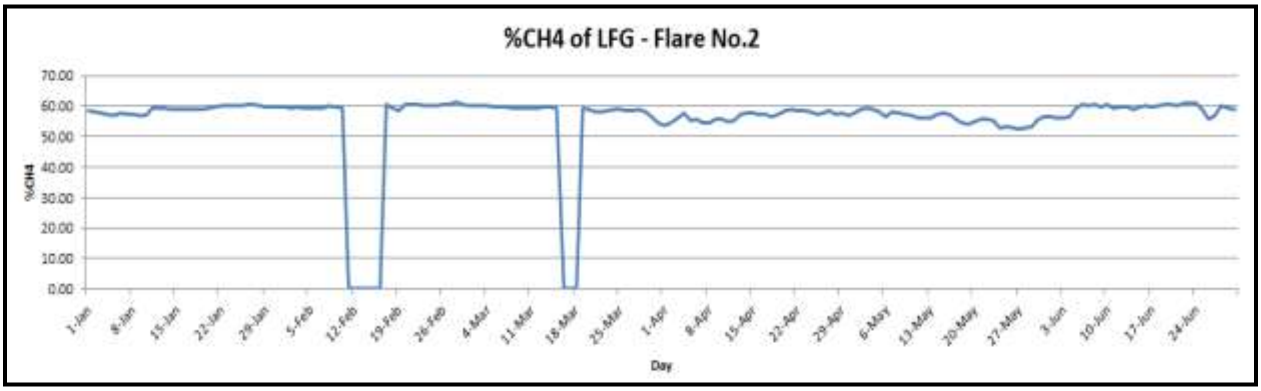


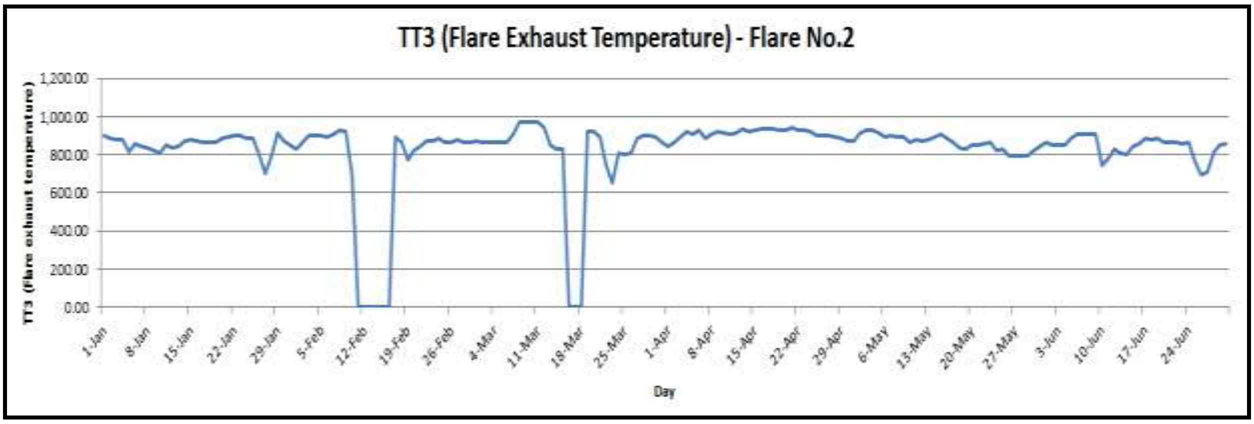


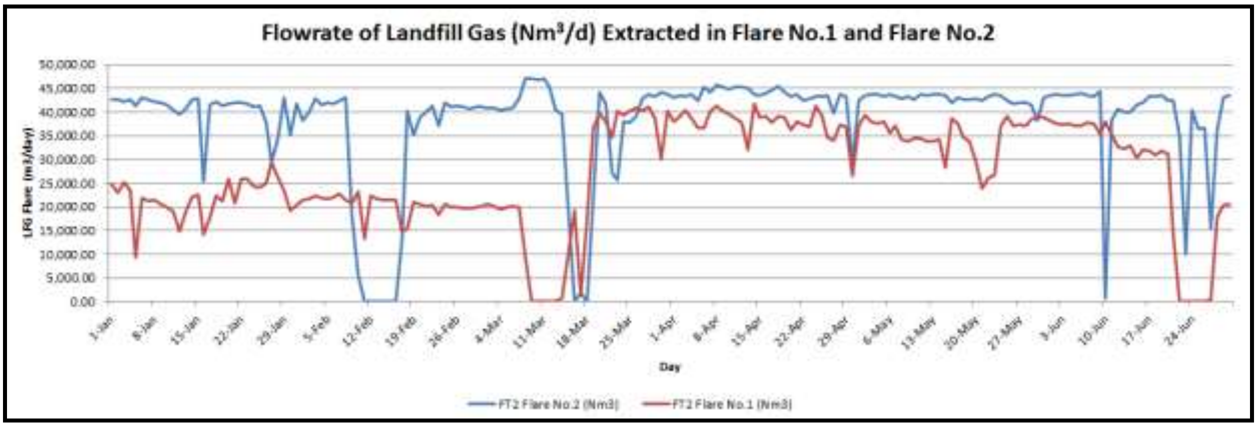


Flare No.2


Flowrate of Landfill Gas (Nm³/d) Extracted in Flare No.2
LFG Flare (m3/day)
Day


%CH4 of LFG - Flare No.2
%CH4
Day


TT3 (Flare Exhaust Temperature) - Flare No.2
TT3 (Flare exhaust temperature)
Day



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.

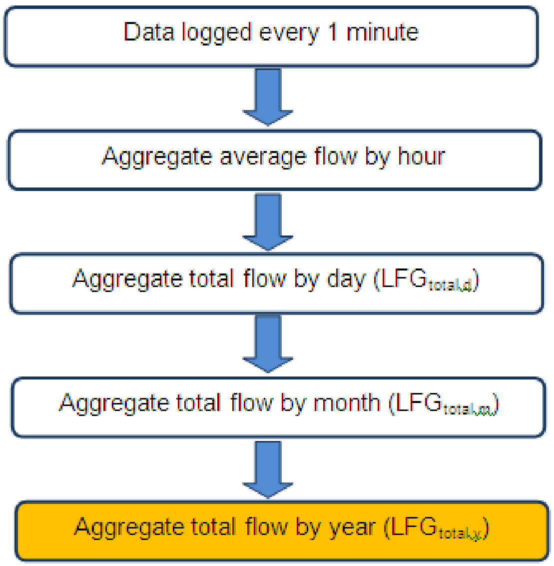
Data Processing

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)



Hour	LFG-Total LFG Flow (m³)
00:00-01:00	780
01:01-02:00	880
02:01-03:00	950
.....	
Total (day)	22,000

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.

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	Weekly	Off-site (consultant's office)

Types of back-up	Frequency	Back-up location
Goshen, Plaza Pantai, Kuala Lumpur, Malaysia)		

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:

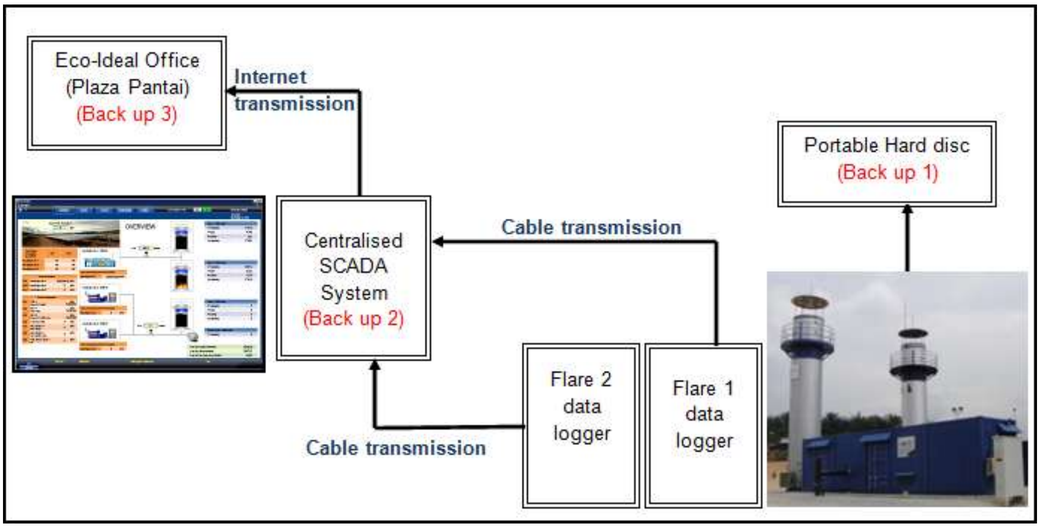


Figure 12: Automatic Data Back-Up for Flaring System at BTSL

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 5th monitoring period planned to be conducted by the consultant (Eco-Ideal Consulting Sdn. Bhd.):

- Audit No. 8 – 13th July 2012

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	Training – Gas Engine	12th February 2012	5
2	Training – Flare No.1	26th March 2012	6
3	Training – SCADA by Interlinx	17th April 2012	6
4	Training – Gas Engine (well extraction)	17th May 2012	7
5	Training – Phase 2A	25th June 2012	5

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 1st monitoring period (28th August 2009 – 28th February 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	Intergovernmental Panel on Climate Change (IPCC), Technical Summary, Working Group 1, page 33 The default value given by IPCC 2006 guideline for GWP of CH_4
Value (s) applied	21
Purpose of data	Baseline emission calculation
Additional Comment	-

Data / Parameter	**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)

<table>
<tr><td>Value (s) applied</td><td>The following values for the different waste fraction (types) were applied:

<table>
<tr><td colspan="3">DOC_j</td></tr>
<tr><td>Waste type j</td><td>DOC_j (% wet basis)</td><td>DOC_j (% dry basis)</td></tr>
<tr><td>Wood and wood products</td><td>43</td><td>50</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td><td>44</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td><td>38</td></tr>
<tr><td>Textiles</td><td>24</td><td>30</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td><td>49</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td><td>0</td></tr>
<tr><td>Nappies</td><td>24</td><td>60</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data</td><td>Baseline emission calculation</td></tr>
<tr><td>Additional Comment</td><td>-</td></tr>
</table>

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)

<table>
<tr><td>Value (s) applied</td><td>The following values for the different waste fraction (types) were applied:
<table>
<tr><th colspan="2" rowspan="2">Waste type j</th><th colspan="2">Boreal and Temperature (MAT<20^{o}C)</th><th colspan="2">Tropical (MAT>20^{o}C)</th></tr>
<tr><th>Dry (MAP/PET<1)</th><th>Wet (MAP/PET>1)</th><th>Dry (MAP<1000mm)</th><th>Wet (MAP>1000mm)</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td><td>0/06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.1</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.4</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data</td><td>Baseline emission calculation</td></tr>
<tr><td>Additional Comment</td><td>The project site is located in the State of Selangor, Malaysia. The climate is tropical with an annual mean 24-hr temperature of</td></tr>
</table>

	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/ Calculated/ Default	Measured
Source of data	Continuous measurement by flow meter during operation of project activity. This parameter was measured continuously and separately for both flares, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the 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 1</u>** According to ACM 0001, version 8[7], page 15 of section III monitoring methodology, the amount of landfill gas generated (in m3 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 2</u>** According to ACM 0001, version 8, page 15 of section III monitoring methodology, the amount of landfill gas generated (in m3 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

[7] 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.

01 June 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. *When FT1 is greater than FT2 + FT3*

   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. *When FT1 is lesser than FT2 + FT3*

   When FT1 is lesser, FT1 will then be used in the ER calculation as a conservative approach.

Months	Flare No.2 FT1 Value (Nm^3)	Flare No.2 Total of FT2 & FT3 Value (Nm^3)
January 12	1,591,468	1,574,256
February 12	1,055,385	1,054,140
March 12	1,316,454	1,301,067
April 12	1,594,075	1,587,546
May 12	1,644,122	1,604,052
June 12	1,413,187	1,371,216
Total	**8,614,691**	**8,492,277**

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)
January 12	674,069	1,574,256
February 12	591,423	1,054,140
March 12	697,866	1,301,067
April 12	1,133,434	1,587,546
May 12	1,085,106	1,604,052
June 12	768,137	1,371,216
Total	**4,950,035**	**8,492,277**

For this monitoring period for Flare 2, the total values of FT2 + FT3

	was used in the ER calculation since FT1 is greater than FT2 + FT3
Monitoring equipment	see table below
Measuring/ Reading/ Recording frequency	Measured continuously with a flow meter. Data was aggregated on both monthly and yearly basis
Calculation method (if applicable)	NA
QA/QC procedures	Flow meters were tested, calibrated and maintained regularly
Purpose of data	Project emission calculation
Additional comment	-

Item	**Flare No.1 Description Kingsway V-cone Flow Transmitter (Rosemount)**	**Flare No.2 Description Kingsway V-cone Flow Transmitter (Rosemount)**
	1 Jan – 30 June 12	**1 Jan – 30 June 12**
Type	Differential Pressure Transmitter	Differential Pressure Transmitter
Accuracy class	±1%	±0.5%
Serial No.	4972946 (Rosemount) / FT1 – FT119 (8102101)	5476626 (Rosemount) / FT1 – FT141 (10031702)
Calibration frequency	2 years	2 years
Date of last calibration	28/04/11	29/04/11
Validity	2 years	2 years

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. 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 2** From 01 June 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 lesser 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)
January 12	674,069	1,249,828
February 12	591,423	848,795
March 12	697,866	1,115,857
April 12	1,133,434	1,301,233
May 12	1,085,106	1,327,968
June 12	768,137	1,147,402
Total	**4,950,035**	**6,991,083**

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

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

Item	**Flare No.1 Description Kingsway V-cone Flow Transmitter (Rosemount)**	**Flare No.2 Description Kingsway V-cone Flow Transmitter (Rosemount)**
	1 Jan – 30 June 12	**1 Jan – 30 June 12**
Type	Differential Pressure Transmitter	Differential Pressure Transmitter
Accuracy class	±1%	±0.5%
Serial No.	4972945 (Rosemount) / FT2 – FT120 (8102102)	5476627 (Rosemount) / FT2 – FT140 (10031701)
Calibration frequency	2 years	2 years
Date of last calibration	28/04/11	29/04/11
Validity	2 years	2 years

</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>Measured continuously with flow meter. Data was aggregated on both monthly and yearly basis</td></tr>
<tr><td>Calculation method (if applicable)</td><td>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</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>Baseline and Project emission calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	$\mathbf{LFG_{electricity,y}}$
Unit	m^3
Description	Amount of landfill gas combusted in power plant (gas engine) at normal temperature and pressure
Measured/ Calculated/ Default	Measured
Source of data	Continuous measurement by flow meter during operation of project activity. 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}.

<table>
<tr>
<td>Value (s) of monitored parameter</td>
<td>

<u>Flare 2</u>

From 01 June 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 lesser 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.

<table>
<tr><th>Months</th><th>Flare No.2 Value (Nm³)</th></tr>
<tr><td>January 12</td><td>324,428</td></tr>
<tr><td>February 12</td><td>205,345</td></tr>
<tr><td>March 12</td><td>185,210</td></tr>
<tr><td>April 12</td><td>286,313</td></tr>
<tr><td>May 12</td><td>276,084</td></tr>
<tr><td>June 12</td><td>223,813</td></tr>
<tr><td>Total</td><td>1,501,194</td></tr>
</table>

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

</td>
</tr>
</table>

Monitoring equipment	<table><tr><th>Item</th><th>Flare No.2 Description Kingsway V-cone Flow Transmitter (Rosemount) 1 Jan – 30 June 12</th></tr><tr><td>Type</td><td>Differential Pressure Transmitter</td></tr><tr><td>Accuracy class</td><td>±0.5%</td></tr><tr><td>Serial No.</td><td>5490821 (Rosemount) / FT3 – FT161 (11011001)</td></tr><tr><td>Calibration frequency</td><td>2 years</td></tr><tr><td>Date of last calibration</td><td>20/01/11</td></tr><tr><td>Validity</td><td>2 years</td></tr></table>
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	$\mathbf{PE_{flare,y}}$
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 of the flares, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period.

<table>
<tr><td>Value (s) of monitored parameter</td><td>

Months	Flare No.1 Value (tCO_2e)	Flare No.2 Value (tCO_2e)
January 12	616.30	1,139.67
February 12	563.84	787.42
March 12	618.85	989.70
April 12	1,023.41	1,122.05
May 12	866.46	1,130.39
June 12	654.28	1,056.70
Total	**4,343.14**	**6,225.93**

</td></tr>
<tr><td>Monitoring equipment</td><td>Refer to $\mathbf{T_{flare}}$ below</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>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).</td></tr>
<tr><td>Calculation method (if applicable)</td><td>As per the Tool to determine project emissions from flaring gases containing methane (EB 28, Annex 13, page 10)</td></tr>
<tr><td>QA/QC procedures</td><td>As per the Tool to determine project emissions from flaring gases containing methane (EB 28, Annex 13, page 10)</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	$\mathbf{w_{CH4}}$
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, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the 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

<table>
<tr><td></td><td>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.</td></tr>
<tr><td>Value (s) of monitored parameter</td><td>
<table>
<tr><th>Months</th><th>Flare No.1 Value</th><th>Flare No.2 Value</th></tr>
<tr><td>January 12</td><td>0.58</td><td>0.59</td></tr>
<tr><td>February 12</td><td>0.58</td><td>0.60</td></tr>
<tr><td>March 12</td><td>0.56</td><td>0.59</td></tr>
<tr><td>April 12</td><td>0.58</td><td>0.57</td></tr>
<tr><td>May 12</td><td>0.52</td><td>0.56</td></tr>
<tr><td>June 12</td><td>0.56</td><td>0.59</td></tr>
<tr><td>Average</td><td>0.56</td><td>0.58</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th colspan="2">Flare No.1 Description</th><th colspan="2">Flare No.2 Description</th></tr>
<tr><th>1 Jan – 25 Apr 12</th><th>26 Apr – 30 Jun 12</th><th>1 Jan – 26 Apr 12</th><th>27 Apr – 30 Jun 12</th></tr>
<tr><td>Type</td><td colspan="2">Infra-Red Gas Monitor</td><td colspan="2">Infra-Red Gas Monitor</td></tr>
<tr><td>Accuracy class</td><td colspan="2">±2%</td><td colspan="2">±2%</td></tr>
<tr><td>Serial No.</td><td colspan="2">28931</td><td colspan="2">30548</td></tr>
<tr><td>Calibration frequency</td><td colspan="2">Annually</td><td colspan="2">Annually</td></tr>
<tr><td>Date of last calibration</td><td>28/04/11</td><td>26/04/12</td><td>21/06/11</td><td>27/04/12</td></tr>
<tr><td>Validity</td><td colspan="2">1 year</td><td colspan="2">1 year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>The CH_4 fraction were measured continuously with certified equipment or measured manually with a portable gas analyser during emergency cases</td></tr>
<tr><td>Calculation method (if applicable)</td><td>Raw data logged at 1 minute’s interval was used to compute the daily average readings</td></tr>
<tr><td>QA/QC procedures</td><td>The CH_4 gas analyser was checked and calibrated regularly according to the manual given by the manufacturer</td></tr>
<tr><td>Purpose of data</td><td>Baseline and Project emission calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	**T ($T_{TT1,F1}$ and $T_{TT1,F2}$)**
Unit	℃
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, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period.
Value (s) of monitored parameter	(see table and text below)

Months	Flare No.1 Value (℃)	Flare No.2 Value (℃)
January 12	51.65	47.52
February 12	49.28	41.61
March 12	50.13	44.71
April 12	59.02	50.37
May 12	58.98	49.74
June 12	55.14	48.63
Average	**54.03**	**47.10**

Flare 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 ^{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 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.

During this monitoring period, there was several minutes in each day which LFG temperature exceeds 60^{o}C occurred, the tool was applied in the ER Calculation sheet. The detail of the calculation attached in Appendix 4.

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th colspan="2">Flare No.1 Description</th><th colspan="2">Flare No.2 Description</th></tr>
<tr><th>1 Jan – 25 Apr 12</th><th>26 Apr – 30 Jun 12</th><th>1 Jan – 26 Apr 12</th><th>27 Apr – 30 Jun 12</th></tr>
<tr><td>Type</td><td colspan="2">Temperature Transmitter</td><td colspan="2">Temperature Transmitter</td></tr>
<tr><td>Accuracy class</td><td colspan="2">± 0.5%</td><td colspan="2">±0.5% of span</td></tr>
<tr><td>Serial No.</td><td colspan="2">B224836437</td><td colspan="2">B839917437</td></tr>
<tr><td>Calibration frequency</td><td colspan="2">Annually</td><td colspan="2">Annually</td></tr>
<tr><td>Date of last calibration</td><td>28/04/11</td><td>26/04/12</td><td>29/04/11</td><td>27/04/12</td></tr>
<tr><td>Validity</td><td colspan="2">1 year</td><td colspan="2">1 year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>Measured continuously by temperature meter</td></tr>
<tr><td>Calculation method (if applicable)</td><td>Raw data logged at 1 minute’s interval was used to compute the daily average readings</td></tr>
<tr><td>QA/QC procedures</td><td>The temperature transmitter was calibrated regularly according to the manual given by the manufacturer</td></tr>
<tr><td>Purpose of data</td><td>Baseline and Project emission calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	**P ($P_{PT2,F1}$ and $P_{PT2,F2}$)**
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, i.e. Flare No.1 and Flare No.2. Therefore, 2 sets of equipment were used for the monitoring period.

Value (s) of monitored parameter

Gauge pressure (Months)	Flare No.1 Value (kPa)	Flare No.2 Value (kPa)
January 12	15.51	10.89
February 12	14.83	8.85
March 12	15.29	9.65
April 12	18.61	12.38
May 12	16.81	11.80
June 12	14.66	10.72
Average	**15.95**	**10.72**

Absolute pressure (Months)	Flare No.1 Value (kPa)	Flare No.2 Value (kPa)
January 12	116.84	112.22
February 12	116.16	110.18
March 12	116.62	110.98
April 12	119.94	113.71
May 12	118.14	113.13
June 12	115.99	112.05
Average	**117.28**	**112.04**

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

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th colspan="2">Flare No.1 Description</th><th colspan="2">Flare No.2 Description</th></tr>
<tr><th>1 Jan – 25 April 12</th><th>26 Apr – 30 June 12</th><th>1 Jan – 26 Apr 12</th><th>27 Apr – 30 June 12</th></tr>
<tr><td>Type</td><td colspan="2">Pressure Transmitter</td><td colspan="2">Pressure Transmitter</td></tr>
<tr><td>Accuracy class</td><td colspan="2">±0.25%</td><td colspan="2">±0.25%</td></tr>
<tr><td>Serial No.</td><td colspan="2">02255815</td><td colspan="2">5584784</td></tr>
<tr><td>Calibration frequency</td><td colspan="2">Annually</td><td colspan="2">Annually</td></tr>
<tr><td>Date of last calibration</td><td>08/09/11</td><td>26/04/12</td><td>29/04/11</td><td>27/04/12</td></tr>
<tr><td>Validity</td><td colspan="2">1 year</td><td colspan="2">1 year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>Measured continuously by a pressure transmitter</td></tr>
<tr><td>Calculation method (if applicable)</td><td>Raw data logged at 1 minute’s interval was used to compute the daily average readings</td></tr>
<tr><td>QA/QC procedures</td><td>The meter was checked and calibrated regularly according to the manual given by the manufacturer</td></tr>
<tr><td>Purpose of data</td><td>Baseline and Project emission calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	EL_{LFG}
Unit	MWh
Description	Net amount of electricity generated using landfill gas
Measured/ Calculated/ Default	Measured
Source of data	Data as measured by electricity meter

Value (s) of monitored parameter	

Months	**Net electricity generated (Total electricity generated (EL4) – electricity consumed from GE for flare 1 & flare 2 & GE auxiliaries (EL3) (MWh)**	**Electricity sell to grid (MWh) - recorded by grid operator EL5 (MWh)**
January 12	621.21	610.71
February 12	400.02	393.51
March 12	356.04	349.15
April 12	520.34	507.79
May 12	493.15	490.94
June 12	429.65	416.04
Total	**2,820.4**	**2,768.1**

From the comparison of the EL4 – EL3 and EL5 values above, the lower value between the two is taken for the calculation of CERs.

Months	**Net amount of electricity generated (MWh)**
January 12	610.71
February 12	393.51
March 12	349.15
April 12	507.79
May 12	490.94
June 12	416.04
Total	**2,768.1**

Monitoring equipment	<table><tr><th>Item</th><th>Flare No.2 Description (EL4)</th><th>Flare No.2 Description (EL5)</th></tr><tr><th></th><th>From 1 Jan – 30 June 12</th><th>From 1 Jan – 30 June 12</th></tr><tr><td>Type</td><td>Power Meter</td><td>Power Meter</td></tr><tr><td>Accuracy class</td><td>Class 0.5S</td><td>Class 0.20</td></tr><tr><td>Serial No.</td><td>210225256</td><td>53099690</td></tr><tr><td>Calibration frequency</td><td>2 years</td><td>5 years</td></tr><tr><td>Date of last calibration</td><td>15/07/10</td><td>01/04/11</td></tr><tr><td>Validity</td><td>2 years</td><td>5 years (Type 2 according to the Malaysian Grid Code, version 1/2010)</td></tr></table>
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) from the gross generated amount recorded by installed electricity meter (EL4).
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 another electricity meter (EL5) 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 meter owned by the grid operator, i.e. EL5) will be checked and calibrated regularly according to manufacturer's recommendations. The meter EL5 is owned by the grid operator and thus, it is not within the control of the project. The calibration of this meter will be based on the grid operator's requirement and standard practice.
Purpose of data	Baseline emission calculation
Additional comment	-

Data / Parameter	$\mathbf{CEF_{elec,PR,y}}$
Unit	tCO_2/MWh
Description	Carbon emission factor of electricity
Measured/ Calculated/ Default	Calculated

Source of data	Grid connected baseline for Peninsular Malaysia for 2009 by Malaysian Energy Centre
Value (s) of monitored parameter	**0.683** tCO_2/MWh based on the latest released grid connected baseline emission factor for Peninsular Malaysia for 2009
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 2009 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 $\mathbf{CEF}_{\mathbf{elec,PR,y}}$ 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
Value (s) of monitored parameter	(see table below)
Monitoring equipment	The operation time of the gas engine is recorded by the gas engine SCADA system known as Total Energy Management (TEM) Evo System. The operation hour of the gas engine is based on the signal provided by the power meter (EL4).
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	NA

Months	Operating time (hr)
January 12	679
February 12	460
March 12	458
April 12	651
May 12	564
June 12	576
Total	**3,388**

applicable)	
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 meter EL4 which is 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
Value (s) of monitored parameter	(see table below)

Months	**Electricity consumed (from grid for project activity-flaring system & Gas Engine) (EL1) (MWh)**	**Electricity consumed (from GE for flare 1 & flare 2 & GE auxiliaries) (EL3) (MWh)**
January 12	6.96	68.12
February 12	9.12	41.16
March 12	22.95	31.82
April 12	8.62	75.04
May 12	18.96	58.97
June 12	23.71	49.46
Total	**90.3**	**324.6**

Electricity consumed from Gas engine for flare 1 & flare 2 and gas engine auxiliaries (EL3) is not included in project emission calculation as the electricity is generated from landfill gas.

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th>Electricity consumed (from grid for flare 1 & flare 2) (EL1)</th><th>Electricity consumed (from GE for flare 1 & flare 2 & GE auxiliaries) (EL3)</th></tr>
<tr><th>1 Jan – 30 June 12</th><th>1 Jan – 30 June 12</th></tr>
<tr><td>Type</td><td>Power Meter</td><td>Power Meter</td></tr>
<tr><td>Accuracy class</td><td>Class 0.5S (±0.5%)</td><td>Class 0.5S (±0.5%)</td></tr>
<tr><td>Serial No.</td><td>2167 8900 35</td><td>2153 4300 16</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>10/05/11</td><td>10/05/11</td></tr>
<tr><td>Validity</td><td>3 years according to manufacturer recommendation</td><td>3 years according to manufacturer recommendation</td></tr>
</table>
The power meter used to measure the electricity consumed from grid by flare 1 and flare 2 was no longer in use effective from 22nd June 2011 onwards. The total power consumption from the grid by project activity (flaring system and gas engine) was measured by the new power meter installed, i.e. EL1 when the gas generators are not in operation. When the gas generators are operating, power consumed by flare 1, flare 2 and gas engine auxiliary will be from the gas generators.
</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>Continuous measurement</td></tr>
<tr><td>Calculation method (if applicable)</td><td>NA</td></tr>
<tr><td>QA/QC procedures</td><td>The electricity meter was tested and calibrated as per the specifications prescribed by the manufacturer</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	$\mathbf{T_{flare,y}}$
Unit	℃
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.

<table>
<tr><td>Value (s) of monitored parameter</td><td>
<table>
<tr><th>Months</th><th>Flare No.1 Value (℃)</th><th>Flare No.2 Value (℃)</th></tr>
<tr><td>January 12</td><td>722.16</td><td>857.03</td></tr>
<tr><td>February 12</td><td>697.82</td><td>865.12</td></tr>
<tr><td>March 12</td><td>711.56</td><td>873.22</td></tr>
<tr><td>April 12</td><td>856.09</td><td>910.41</td></tr>
<tr><td>May 12</td><td>831.14</td><td>863.78</td></tr>
<tr><td>June 12</td><td>792.90</td><td>841.51</td></tr>
<tr><td>Total</td><td>768.61</td><td>868.51</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th colspan="2">Flare No.1 Description</th><th colspan="2">Flare No.2 Description</th></tr>
<tr><th>1 Jan – 25 Apr 12</th><th>26 Apr – 30 June 12</th><th>1 Jan – 26 Apr 12</th><th>27 Apr – 30 June 12</th></tr>
<tr><td>Type</td><td colspan="2">Temperature Transmitter</td><td colspan="2">Temperature Transmitter</td></tr>
<tr><td>Accuracy class</td><td colspan="2">± 0.5%</td><td colspan="2">± 0.5% of span</td></tr>
<tr><td>Serial No.</td><td colspan="2">B123070037</td><td colspan="2">B838901937</td></tr>
<tr><td>Calibration frequency</td><td colspan="2">Annually</td><td colspan="2">Annually</td></tr>
<tr><td>Date of last calibration</td><td>03/03/11</td><td>26/04/12</td><td>29/04/11</td><td>27/04/12</td></tr>
<tr><td>Validity</td><td colspan="2">1 year</td><td colspan="2">1 year</td></tr>
</table>
*The maximum permissible error of ±5% has to be applied for $T_{Flare,F1}$ from 3rd March 2012 – 26th April 2012 as a conservative approach
</td></tr>
<tr><td>Measuring/ Reading/ Recording frequency</td><td>The enclosed flare is monitored continuously by a temperature meter</td></tr>
<tr><td>Calculation method (if applicable)</td><td>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)</td></tr>
<tr><td>QA/QC procedures</td><td>The temperature meter was tested and calibrated as per the specifications prescribed by the manufacturer</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	**Relevant policies and circumstances at the beginning of each crediting period**
Unit	NA
Description	NA

Measured/ Calculated/ Default	NA
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 a 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:

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

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

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)
Jan-12	674,069	0.58	0.0007168	280.39	21	5,888.12	616.30	251.04	251.04
Feb-12	591,423	0.58	0.0007168	247.55	21	5,198.61	563.84	220.70	220.70
Mar-12	697,866	0.56	0.0007168	282.25	21	5,927.17	618.85	252.78	252.78
Apr-12	1,133,434	0.58	0.0007168	473.70	21	9,947.79	1,023.41	424.97	424.97
May-12	1,085,106	0.52	0.0007168	404.16	21	8,487.30	866.46	362.90	362.90
Jun-12	768,137	0.56	0.0007168	308.88	21	6,486.42	654.28	277.72	277.72

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 (m^3 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)
Jan-12	1,249,828	0.59	0.0007168	527.99	21	11,087.74	1,139.67	473.72	324,428	0.59	137.05	610.77
Feb-12	848,795	0.60	0.0007168	365.10	21	7,667.07	787.42	327.60	205,345	0.60	88.33	415.93
Mar-12	1,115,857	0.59	0.0007168	472.09	21	9,913.97	989.70	424.97	185,210	0.59	78.36	503.32
Apr-12	1,301,233	0.57	0.0007168	529.54	21	11,120.35	1,122.05	476.11	286,313	0.57	116.52	592.63
May-12	1,327,968	0.56	0.0007168	533.52	21	11,203.89	1,130.39	479.69	276,084	0.56	110.92	590.61
Jun-12	1,147,402	0.59	0.0007168	487.82	21	10,244.28	1,056.70	437.50	223,813	0.59	95.16	532.66
						Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	
Total quantity of LFG Flare & LFG Electricity (column B + column J)						**1,574,256**	**1,054,140**	**1,301,067**	**1,587,546**	**1,604,052**	**1,371,216**	
Total quantity of LFG Total						**1,591,468**	**1,055,385**	**1,316,454**	**1,594,075**	**1,644,122**	**1,413,187**	

For Flare No.2, 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. Details on how the comparison is made and which values were used are explained in Section D.2, parameter for LFG_{total}, LFG_{Flare}, $LFG_{Electricity}$ above.

Determination of BE_y

Month	BEy Flare No.1 Total Baseline Emissions Flare No.1 (tCO2e)	$(MD_{project,y} - MD_{BL,y}) * GWP_{CH4}$ Emissions from Flare No.2 (tCO2e)	$EL_{LFG,y} \cdot CEF_{elec,BL,y}$ 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)	BEy Flare No.2 Total Baseline Emissions Flare No.2 (tCO2e)	Total Baseline Emissions BE_y (tCO2e)
Jan-12	5,271.82	12,826.20	610.71	0.683	417.11	13,243.32	18,515
Feb-12	4,634.77	8,734.50	393.51	0.683	268.77	9,003.27	13,638
Mar-12	5,308.32	10,569.80	349.15	0.683	238.47	10,808.27	16,116
Apr-12	8,924.38	12,445.14	507.79	0.683	346.82	12,791.96	21,716
May-12	7,620.84	12,402.78	490.94	0.683	335.31	12,738.09	20,358
Jun-12	5,832.14	11,185.85	416.04	0.683	284.15	11,470.00	17,302
						TOTAL	107,645

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 and 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 2009 was applied to this project and the $CEF_{electricity,y}$ calculated was 0.683tCO_2/MWh

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:

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

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

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)
Jan-12	6.96	0.683	0.1	5.23
Feb-12	9.12	0.683	0.1	6.85
Mar-12	22.95	0.683	0.1	17.24
Apr-12	8.62	0.683	0.1	6.48
May-12	18.96	0.683	0.1	14.25
Jun-12	23.71	0.683	0.1	17.81

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 2009 was applied to this project and the $EF_{grid,y}$ calculated was 0.683tCO_2/MWh
3. TDL = 10% adopted as stated in PDD 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

Time Period	Baseline emissions or baseline net GHG removals by sinks (tCO_2e)	Project emissions or actual net GHG removals by sinks (tCO_{2e})	Leakage (tCO_2e)	Emission reductions or net anthropogenic GHG removals by sinks (tCO_2e)
January 12	18,515	6	0	18,509
February 12	13,638	7	0	13,631
March 12	16,116	18	0	16,098
April 12	21,716	7	0	21,709
May 12	20,358	15	0	20,343
June 12	17,302	18	0	17,284
Total	**107,645**	**71**	0	**107,574**

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 (tCO_2e)	105,434	107,574

** Ex-ante for 182 days (Jan 2012 – June 2012) – 211,448 x (182/365)*

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

The total emission reduction claimed was about 2% higher as compared to the value in the ex-ante calculation. This is mainly due to the higher methane collection rate achieved as well as the high operating rate of flaring system.

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

Date	Flaring stopped		Reason	Remarks
	From	To		
03/01/12	7:01	7:11	Exceed Set Point Limit	Flare shutdown
04/01/12	23:46		Equipment Breakdown	Blower 2 error and motor fault VFD - no power output and no display
05/01/12		14:14		
12/01/12	0:00	3:59	Power Failure	Flare shutdown
13/01/12	18:56	19:08	Exceed Set Point Limit	Flare shutdown
16/01/12	9:48	18:20	Power Failure	TNB power shutdown for planned work by TNB Notice was given by TNB for shutdown
17/01/12	13:42	18:00	Maintenance	Reinstall motor for blower 2 due to faulty Problem with motor which require rewinding by Hydrocare
19/01/12	10:16	12:00	Maintenance	To check filter for moisture separator To service filter with compressed air
	21:28	21:40	Exceed Set Point Limit	Flare shutdown
20/01/12	4:44	4:54	Exceed Set Point Limit	Flare shutdown
	16:46	16:57	Exceed Set Point Limit	Flare shutdown
	17:09	17:48	Exceed Set Point Limit	Flare shutdown
	23:44	23:58	Exceed Set Point Limit	Flare shutdown
21/01/12	2:06	2:16	Exceed Set Point Limit	Flare shutdown
	3:12	3:58	Exceed Set Point Limit	Flare shutdown
	6:04	6:26	Exceed Set Point Limit	Flare shutdown
	7:28	7:40	Exceed Set Point Limit	Flare shutdown
	9:59	12:22	Exceed Set Point Limit	System shutdown
	19:49	20:10	Exceed Set Point Limit	Flare 1 shutdown
	21:30	21:38	Exceed Set Point Limit	Flare shutdown
22/01/12	0:00	0:08	Exceed Set Point Limit	Failure require flare to shutdown
23/01/12	2:08	2:16	Exceed Set Point Limit	Failure require flare to shutdown
	7:10	7:16	Exceed Set Point Limit	Flare shutdown
	15:40	15:48	Exceed Set Point Limit	Failure require flare to shutdown
	22:42	22:52	Exceed Set Point Limit	Failure require flare to shutdown
24/01/12	2:36	2:42	Exceed Set Point Limit	Failure require flare to shutdown
	20:02	20:10	Exceed Set Point Limit	Failure require flare to shutdown
	21:00	21:30	Exceed Set Point Limit	Failure require flare to shutdown
25/01/12	0:38	1:08	Exceed Set Point Limit	Failure require flare to shutdown
	20:24	20:42	Exceed Set Point Limit	Flare shutdown
26/01/12	10:52	11:26	Others	Flare system detect CH_4 under danger set point because MCB - isolating transformer tripped

Date	Flaring stopped		Reason	Remarks
	From	To		
28/01/12	18:42	18:56	Exceed Set Point Limit	Flare shutdown
	19:30	19:48	Exceed Set Point Limit	Flare shutdown
	23:31	23:49	Exceed Set Point Limit	Flare shutdown
29/01/12	17:04	17:24	Exceed Set Point Limit	Flare shutdown
	18:18	18:44	Exceed Set Point Limit	Flare shutdown
02/02/12	21:36	21:50	Others: Flare problem	Flare shutdown
03/02/12	17:23	17:39	Maintenance	Check on SCADA system by Fairyland / THR
	22:36	22:50	Exceed Set Point Limit	Flare shutdown
10/02/12	23:16		Equipment Breakdown	Flare shutdown
11/02/12		9:28		
17/02/12	22:39		Exceed Set Point Limit	Flare shutdown
18/02/12		2:24		
	5:16	8:40	Exceed Set Point Limit	Flare shutdown
23/02/12	19:10	20:56	Power Failure	TNB power failure for total site area
04/03/12	3:06	3:18	Others: Power Surge	Power surge at TNB caused MCB for analyser tripped
05/03/12	19:27	19:41	Power Failure	Flare 1 shutdown
08/03/12	9:20		Didn't indicate reason in form	Flare 1 upgrade work - start by Tai Hoe: Dismantle for motor 1, motor 2 and VDF Reinstall new cable for motor 1 and motor 2
18/03/12		15:34		
22/03/12	9:26	11:23	Others: Flare 1 upgrade	To test run Flare 1 / 2 and gas engine number 1 with gas from Phase 1 with Fairyland after Flare 1 upgrade
30/03/12	11:06	18:14	Maintenance	Tai Hoe - cabling works at motor and VDF Termination (cable) from VDF to motor / breaker
05/04/12	17:10	17:41	Maintenance	Testing for Phase 1 gas - maximum flow
06/04/12	11:00	13:28	Others: Tai Hoe upgrade works	Tai Hoe - wiring from motor (30kW) to VFD Re-do / re-wiring to VFD as part of upgrading project for flare
13/04/12	12:10	17:44	Maintenance	Shutdown for gas engine - GDU service by SPE SPE need to open transfer pipe to gas engine
26/04/12	11:15	15:08	Maintenance	Check on moisture separator filter & analyser tubings
27/04/12	12:09	14:56	Maintenance	Check on CH_4 analyser tubings & silica gel

Date	Flaring stopped		Reason	Remarks
	From	To		
30/04/12	9:19	17:01	Maintenance & Power Failure	Shutdown - TNB power shutdown for site area Installation of insulation transformer at TNB sub-station by Chen Guan
15/05/12	10:45	18:26	Maintenance & Others	Hydrocare - due to replace 2 nos of silencer (blower) Service/maintenance moisture separator filter Trouble-shoot default moisture water pump
21/05/12	9:19	12:37	Maintenance & Others	Check moisture separator filter PT1 too high Flow too low Hydrocare - check the lube oil leaking for blower 2 after service (under warranty from Hydrocare)
23/05/12	14:10	15:45	Maintenance	Check moisture separator filter/PT1 too high/FT1 too low @ 1,000 Nm^3/hr Change filter element with new spare filter
15/06/12	14:47	17:03	Equipment Breakdown	Isolating transformer for equipment
20/06/12	14:05	23:59	Others	SCADA Computer problem
21/06/12	0:00	23:59	Others	SCADA Computer problem
22/06/12	0:00	23:59	Others	SCADA Computer problem
23/06/12	0:00	23:59	Others	SCADA Computer problem
24/06/12	0:00	23:59	Others	SCADA Computer problem
25/06/12	0:00	23:59	Others	SCADA Computer problem
26/06/12	0:00	23:59	Others	SCADA Computer problem
27/06/12	0:00	23:59	Others	SCADA Computer problem
28/06/12	0:00	2:07	Others	SCADA Computer problem

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

Date	Flaring stopped		Reason	Remarks
	From	To		
12/01/12	2:11	3:33	Power Failure	Flare shutdown
16/01/12	9:38	19:17	Power Failure	TNB power shutdown for planned work by TNB Notice was given by TNB for shutdown
09/02/12	10:06		Equipment Breakdown	Unable to restart due to Flare 2 computer problem (main board problem)
17/02/12		16:43		
23/02/12	19:06	20:57	Power Failure	TNB power failure for total site area
15/03/12	11:38		Maintenance and Others: Tai Hoe outstanding works	Flare 2 defect - THR / Fairyland rectify all defect / outstanding works: SCADA auto db Painting works for flare stack Change flare stack roof
21/03/12		10:37		
22/03/12	9:18	13:28	Others	To test run Flare 1 / 2 and gas engine number 1 with gas from Phase 1 with Fairyland after Flare 1 upgrade
05/04/12	17:10	17:43	Maintenance	Testing for Phase 1 gas - maximum flow
27/04/12	9:58	11:59	Maintenance	Check on CH_4 analyser tubings, silica gel & chiller system
30/04/12	9:29	17:05	Maintenance & Power Failure	Shutdown - TNB power shutdown for site area Installation of insulation transformer at TNB sub-station by Chen Guan
25/05/12	10:00	10:20	Exceed Set Point Limit	Roots blower 2 detected fault (over current/ampere)
30/05/12	15:10	17:04	Maintenance & Others	Shutdown for reinstall chiller unit (sent for repair) by One Gasmaster
22/06/12	19:08	23:59	TNB Power Failure	TNB Power Failure
23/06/12	0:00	16:47	TNB Power Failure	TNB Power Failure
23/06/12	22:01	23:59	Others	Flare 2 Shut Down due to reconnect
27/06/12	10:02	23:59	TNB Power Failure	TNB Shut Down Problem
28/06/12	0:00	2:19	TNB Power Failure	TNB Shut Down Problem

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

Date	Gas Engine Stopped	Gas Engine Re-started	Description Of Event
	From	At	
26/01/12	10:48		Request for Shut Down by SPE for services
28/01/12		0:45	Request for Shut Down by SPE for services
02/02/12	19:15		Changer Problem
03/02/12		11:37	
09/02/12	10:06		Flare 2 PC Problem and Throtle valve problem
18/02/12		15:37	
06/03/12	21:08		GE Panel converter
13/03/12		2:24	
15/03/12	11:30		Flare 2 upgrade
22/03/12		9:20	
05/04/12	14:20		Testing Phase 1 gas
06/04/12		9:48	
23/04/12	19:27		Reverse VAR
24/04/12		9:36	
02/05/12	12:54		Maintenance - change activated carbon inside scrubber tank
05/05/12		17:01	
14/05/12	10:23		Request for Shut Down by SPE for services
17/05/12		13:44	
12/06/12	22:41		Reverse VAR
13/06/12		0:30	
22/06/12	18:57		TNB Power Failure
23/06/12		0:33	
25/06/12	10:14		TNB & Tai Hoe request for shutdown
28/06/12		16:10	

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 ^oC, 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^oC, 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 1 with LFG temperature exceeding 60^oC, option B measurement was selected and was applied in the CER calculation.

<u>Determination of the absolute humidity of the gaseous stream</u>

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)
$p_{H2O,t,Sat}$	=	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_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. (see table below)
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.

ID	Date	TT1 (ºC)	TT3 (ºC)	PT1 (KPa)	PT2 (KPa)	CH4 (%)	CO2 (%)	O2 (%)	FT1 (Nm3/h)	FT2 (Nm3/h)	MO2	MCH4	MCO2	MMt,db	MH2O	Patm	Pt	PH2O,T,SAT	mH2O,t,db,SAT	vH2O,t,db	Calculated VFT1,t,d	Calculated VFT2,t,d	New FT2
2563	1/3/12 18:44	64.57	[illegible]	[illegible]	[illegible]	[illegible]	39.51	1.18	1274	1229.32	32.0	[illegible]	[illegible]	[illegible]	18.0152	101325	121365	24536.31	0.1690	0.2534	1016.44	980.79	980.79
2564	1/3/12 18:45	64.47	744.38	[illegible]	[illegible]	[illegible]	39.36	1.17	1267.68	1223.99	32.0	[illegible]	[illegible]	[illegible]	18.0152	101325	121375	24426.17	0.1684	0.2519	1012.57	977.67	977.67
2565	1/3/12 18:46	64.45	749.34	[illegible]	[illegible]	[illegible]	39.31	1.16	1268.02	1224.35	32.0	[illegible]	[illegible]	[illegible]	18.0152	101325	121395	24404.19	[illegible]	[illegible]	[illegible]	[illegible]	978.22
2566	1/3/12 18:47	64.47	[illegible]	[illegible]	[illegible]	[illegible]	39.51	1.16	1269.84	1050.14	32.00	16.04	44.01	27.0194	18.0152	101325	121335	24426.17	[illegible]	[illegible]	[illegible]	[illegible]	838.73
2567	1/3/12 18:48	64.43	[illegible]	[illegible]	[illegible]	[illegible]	39.38	1.17	1269.46	1225.38	32.00	16.04	44.01	26.9638	18.0152	101325	121395	24382.23	[illegible]	[illegible]	[illegible]	[illegible]	979.26
2568	1/3/12 18:49	64.39	746.48	-5.19	20.06	57.66	39.43	1.17	1270.13	1226.2	32.00	16.04	44.01	26.9762	18.0152	101325	121385	24338.36	[illegible]	[illegible]	[illegible]	[illegible]	980.34
2569	1/3/12 18:50	64.36	748.31	-5.2	20.06	57.84	39.32	1.16	1269.48	1225.52	32.00	16.04	44.01	26.9535	18.0152	101325	121385	24305.50	[illegible]	[illegible]	[illegible]	[illegible]	980.13
2570	1/3/12 18:51	64.32	746.11	-5.19	20.04	57.82	39.69	1.15	1273.85	1229.89	32.00	16.04	44.01	27.1099	18.0152	101325	121365	24261.75	[illegible]	[illegible]	[illegible]	[illegible]	984.03
2571	1/3/12 18:52	64.25	744.38	-5.2	20.04	57.64	39.48	1.17	1271.49	1227.61	32.00	16.04	44.01	26.9950	18.0152	101325	121365	24185.34	0.1661	0.2489	1018.11	982.97	982.97
2572	1/3/12 18:53	64.23	740.95	-5.2	20.07	57.57	39.39	1.19	1274.38	1230.25	32.00	16.04	44.01	26.9506	18.0152	101325	121395	24163.55	0.1661	0.2485	1020.72	985.37	985.37
2573	1/3/12 18:54	64.22	742.12	-5.2	20.08	57.62	39.48	1.21	1276.09	1232.11	32.00	16.04	44.01	27.0046	18.0152	101325	121405	24152.66	0.1657	0.2484	1022.22	986.99	986.99
2574	1/3/12 18:55	64.09	745.27	-5.21	20.08	57.56	39.38	1.22	1274.02	1229.97	32.00	16.04	44.01	26.9542	18.0152	101325	121405	24011.47	0.1648	0.2465	1022.04	986.71	986.71
2575	1/3/12 18:56	64.12	744.56	-5.21	20.09	57.62	39.67	1.23	1279.46	1234.71	32.00	16.04	44.01	27.0946	18.0152	101325	121415	24043.99	0.1642	0.2469	1026.09	990.20	990.20
2576	1/3/12 18:57	63.96	742.17	-5.22	20.08	57.36	39.18	1.26	1272.93	1229.24	32.00	16.04	44.01	26.8469	18.0152	101325	121405	23870.99	0.1642	0.2447	1022.64	987.54	987.54
2577	1/3/12 18:58	64.01	739.5	-5.22	20.08	57.27	39.42	1.28	1275.17	1231.18	32.00	16.04	44.01	26.9445	18.0152	101325	121405	23924.94	0.1641	0.2454	1023.88	988.55	988.55
2578	1/3/12 18:59	63.92	741.47	-5.22	20.09	57.25	39.26	1.3	1273.76	1229.27	32.00	16.04	44.01	26.8772	18.0152	101325	121415	23827.90	0.1637	0.2442	1023.78	988.02	988.02
2579	1/3/12 19:00	63.88	745.17	-5.21	20.1	57.28	39.3	1.29	1275.29	1231.01	32.00	16.04	44.01	26.8964	18.0152	101325	121425	23784.89	0.1632	0.2436	1025.48	989.88	989.88
2580	1/3/12 19:01	63.89	743.44	-5.22	20.12	57.28	39.17	1.29	1274.34	1230.45	32.00	16.04	44.01	26.8392	18.0152	101325	121445	23795.63	0.1636	0.2437	1024.65	989.36	989.36
2581	1/3/12 19:02	63.76	742.22	-5.23	20.09	57.39	39.22	1.3	1272.78	1060.51	32.00	16.04	44.01	26.8821	18.0152	101325	121415	23656.23	0.1622	0.2420	1024.79	853.88	853.88
2582	1/3/12 19:03	63.77	739.31	-5.23	20.1	57.39	39.41	1.29	1278.69	1234.45	32.00	16.04	44.01	26.9625	18.0152	101325	121425	23666.93	0.1618	0.2421	1029.46	993.84	993.84
2583	1/3/12 19:04	63.7	740.86	-5.23	20.12	57.37	39.48	1.29	1277.34	1232.99	32.00	16.04	44.01	26.9901	18.0152	101325	121445	23592.12	0.1609	0.2411	1029.20	993.47	993.47
2584	1/3/12 19:05	63.62	745.03	-5.23	20.11	57.38	39.36	1.29	1279.38	1235.16	32.00	16.04	44.01	26.9389	18.0152	101325	121435	23506.88	0.1605	0.2400	1031.72	996.06	996.06
2585	1/3/12 19:06	63.55	746.25	-5.24	20.11	57.32	39.2	1.29	1276.02	1231.65	32.00	16.04	44.01	26.8588	18.0152	101325	121435	23432.51	0.1604	0.2391	1029.79	993.99	993.99
2586	1/3/12 19:07	63.5	743.11	-5.25	20.11	57.25	39.18	1.32	1276.92	1232.56	32.00	16.04	44.01	26.8484	18.0152	101325	121435	23379.51	0.1600	0.2384	1031.08	995.26	995.26
2587	1/3/12 19:08	63.52	742.36	-5.24	20.13	57.23	39.21	1.34	1279.84	1235.98	32.00	16.04	44.01	26.8648	18.0152	101325	121455	23400.70	0.1600	0.2387	1033.25	997.84	997.84
2588	1/3/12 19:09	63.39	747.56	-5.24	20.15	57.12	39.36	1.37	1280.91	1236.66	32.00	16.04	44.01	26.9228	18.0152	101325	121475	23263.27	0.1585	0.2369	1035.61	999.83	999.83
2589	1/3/12 19:10	63.34	748.03	-5.25	20.14	56.94	38.98	1.39	1282.07	1238.08	32.00	16.04	44.01	26.7331	18.0152	101325	121465	23210.60	0.1592	0.2362	1037.08	1001.50	1001.50

LFG Temperature > 60°C

Original value for FT2

FT2 calculated using the tool and is applied in the CER calculation

- - - - -

History of the document

Version	Date	Nature of revision
02.0	EB 66 13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	EB 54, Annex 34 28 May 2010	Initial adoption.
Decision Class: Regulatory **Document Type**: Form **Business Function**: Issuance		