Monitoring report form for CDM project activity

(Version 06.0)

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

MONITORING REPORT		
Title of the project activity	Landfill Gas Recovery and Utilization at Bukit Tagar Sanitary Landfill, Hulu Selangor in Malaysia	
UNFCCC reference number of the project activity	2467	
Version number of the PDD applicable to this monitoring report	20.5	
Version number of this monitoring report	1.1	
Completion date of this monitoring report	28/02/2019	
Monitoring period number	2	
Duration of this monitoring period	01/01/2018 – 31/12/2018 inclusive of both days	
Monitoring report number for this monitoring report	1.0	
Project participants	KUB-Berjaya Enviro Sdn. Bhd. (KBE)	
Host Party	Malaysia	
Sectoral scopes	13 – Waste handling and disposal	
Applied methodologies and standardized baselines	• Applied methodologies: ACM0001 – "Flaring or use of landfill gas" (Version 18.0) • Standardized baselines: Not applicable	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	Not applicable	167,381 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	269,207 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

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

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

Carbon emissions are reduced through two major activities:

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

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

One (1) high temperature enclosed flare (Flare No. 2) with maximum capacity of 2,500 Nm3/hr is in operation during this monitoring period, while the other high temperature enclosed flare (Flare No. 1) is no longer in operation starting from 03/01/2017 onwards.

The remaining portion of the gas captured was sent to a unit of 1.2MW Gas Engine (Gas Engine No.1), 2 units of 1.56MW Gas Engines (Gas Engine No.2 and No.3) and one unit of 2MW Gas Engine (Gas Engine No.4) to generate electricity. The electricity produced by the gas engines is exported to the grid.

The 2nd monitoring period of 2nd crediting period is from 01/01/2018 to 31/12/2018 (inclusive of both days). The total emission reductions achieved during this monitoring period is **167,381 tCO_2e.**

A.2. Location of project activity

Information	Description
Host Party(ies)	Malaysia
Region/ State/ Province, etc.	State of Selangor
City/ Town/ Community, etc.	Mukim Sg. Tinggi, District of Hulu Selangor The project location is situated approximately 5km to the west of the Bukit Tagar Interchange along the North-South Expressway and 40km from central Kuala Lumpur. The landfill is easily accessible via expressway and a dedicated Bukit Tagar Interchange has been developed for the access from the North-South Expressway. The landfill is situated in a leased agricultural land, surrounded by hectares of oil palm plantations and rubber trees.
Physical/ Geographical location	Latitude / Longitude / Description: 3°30'168" / 101°28'428" / North 3°29'07" / 101°28'452" / South 3°29'46" / 101°28'20" / West 3°29'69" / 101°29'268" / East

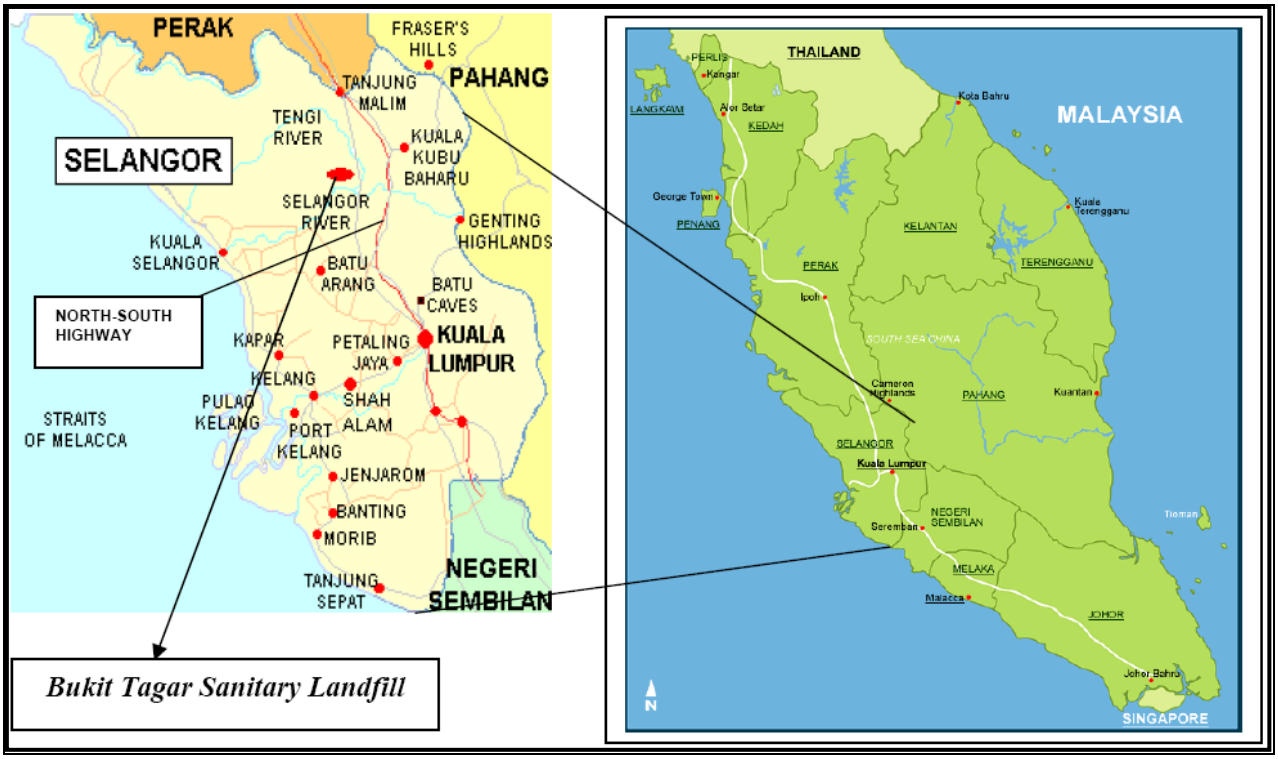


Figure 1: Location of BTSL and Selangor State

A.3. Parties and project participants

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

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

A.4. Reference to applied methodologies and standardized baselines

The project has applied the following approved methodology and tools:

Approved Methodology:

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

Methodological Tools referred to include:

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

A.5. Crediting period type and duration

Date of Registration	28/08/2009
Type of Crediting Period	Renewable (7 Years)
1st Crediting Period	28/08/2009 – 27/08/2016 (Both dates inclusive)
2nd Crediting Period	28/08/2016 – 27/08/2023 (Both dates inclusive)

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

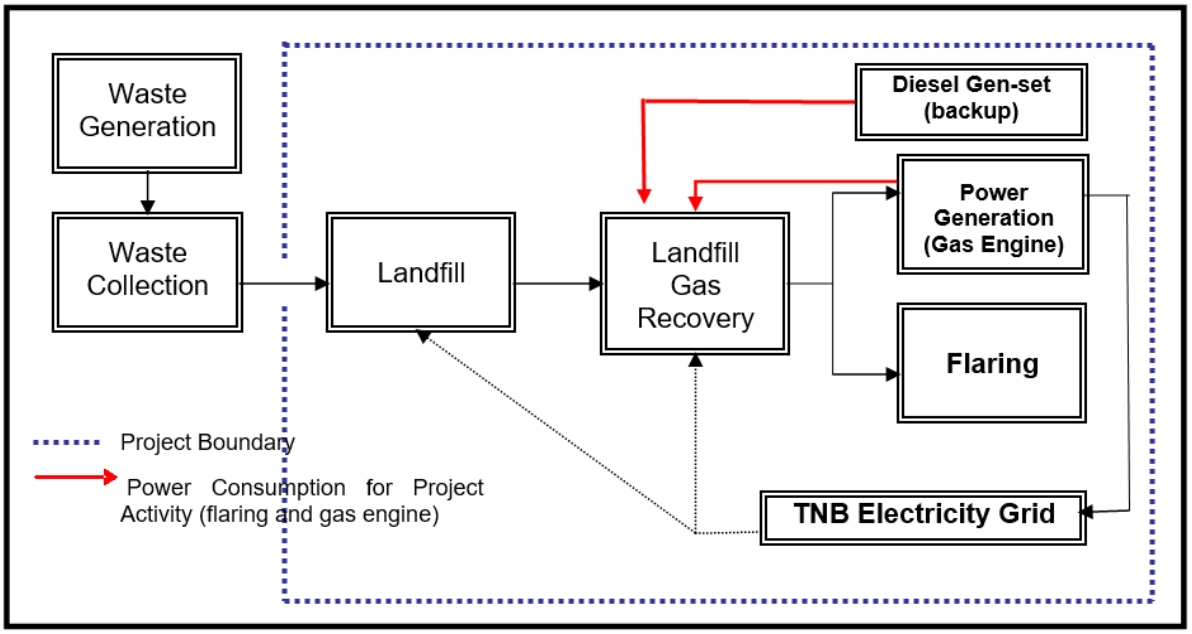
The landfill is being developed in phases. The detail information on the phases is presented as below:

Cell	Status	Duration of Filling	Amount of Waste Disposed (t)
Advance Cell	Closed	Apr 2005 – Nov 2007	1,429,323.47
Phase 1	Closed	Nov 2007 – Dec 2011	3,730,406.57
Phase 2	Closed	Aug 2010 – Dec 2017	6,243,457.40
Phase 3	Operation	Jan 2018 - On-going	667,944.77

Relevant dates for the project activities tabulated below:

Bukit Tagar Project	Construction Start	Commissioned	Continued operation periods
First flaring system (Flare No.1)	17/06/2008	28/08/2009	Stop operation in 03/01/2017
Second flaring system (Flare No.2)	22/01/2010	07/08/2010	Continue to operate
Gas Engine No.1	03/01/2011 (delivery to site)	01/06/2011	Continue to operate
Gas Engine No.2	06/08/2012 (Signed-off Delivery Order)	06/12/2013[1]	Continue to operate
Gas Engine No.3	06/08/2012 (Signed-off Delivery Order)	06/12/2013[2]	Continue to operate
Gas Engine No.4	26/12/2014 (Signed-off Delivery Order)	26/10/2015[3]	Continue to operate

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



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

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

[1] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 6th December 2013.

[2] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 6th December 2013.

[3] Letter to Sustainable Energy Development Authority (SEDA) Malaysia on Notification on Initial Operation Date (IOD) Occurrence on 14th January 2016

Description on the installed technologies

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

Detailed technical description is further described below:

Gas Extraction System in Advance Cell

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

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

These vertical wells can be individually regulated and controlled. Advanced cell has stopped operation and caped in this monitoring period.

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. Flare No.1 has stopped operation started from 03/01/2017 and has been converted to GSS F1. Gas Engine No.1 was attached to Flare 2 previously, is converted to GSSF1 and started commissioned on 01/06/2017.

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 Extraction System in Phase 1 Cell

Stage 1 of Phase 1 Cell was completed in August 2010 and closed in December 2011. The gas extraction from phase 1 cell is continued in operation during this monitoring period. 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 and 2 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 are similar to Flare No.1 (as described above).

Gas Extraction System in Phase 2 Cell

Phase 2 Cell was completed in July 2010. 12 lines of horizontal wells with gas pipeline were installed in the landfill to extract the LFG. The cell stopped receiving waste started on December 2017. The design of the gas extraction wells is based on a series of horizontal gas extraction wells constructed over the cell.

Gas Analyser and Data Logging

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

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

Gas Engine Energy Power Plants

A high-efficiency (electrical efficiency > 42%) Gas Engine (net dispatch of 1 MW) was chosen for the generation of electricity from LFG. This Gas Engine No.1 is no longer attached to Flare No. 2 starting from 03/01/2017 and is attached to Flare No.1 which has been converted to GSS F1 that commissioned on 01/06/2017.

Figure 7: Gas Engine 2 & 3

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

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

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

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

With the additional gas extraction of LFG in Phase 2, 2 units of 1.56 MW gas engines were delivered to the site on 06/08/2012. The gas engines were commissioned on 06/12/2013.

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

Specifications	Details
Manufacturer (Origin)	MWM (Germany)
Model	TCG 2020 V16
Electric power output	1.56 MW
Voltage	415 V
Frequency	50 Hz
Minimum heating value (LHV)	5.0 kWh/m^3

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

An additional 2MW gas engine was delivered to the site on 18/09/2015. The gas engine was commissioned on 26/10/2015. The monitoring parameters for the consumption of the landfill gas and additional power generated from the engine was recorded and included in this monitoring report.

The details of Gas Engine No.4 specifications are listed as below:

Specifications	Details
Manufacturer (Origin)	MTU
Model	GB1948B5
Electric power output	2 MW
Voltage	11000 V
Frequency	50 Hz
Minimum heating value (LHV)	5.0 kWh/m^3

Centralised SCADA System

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

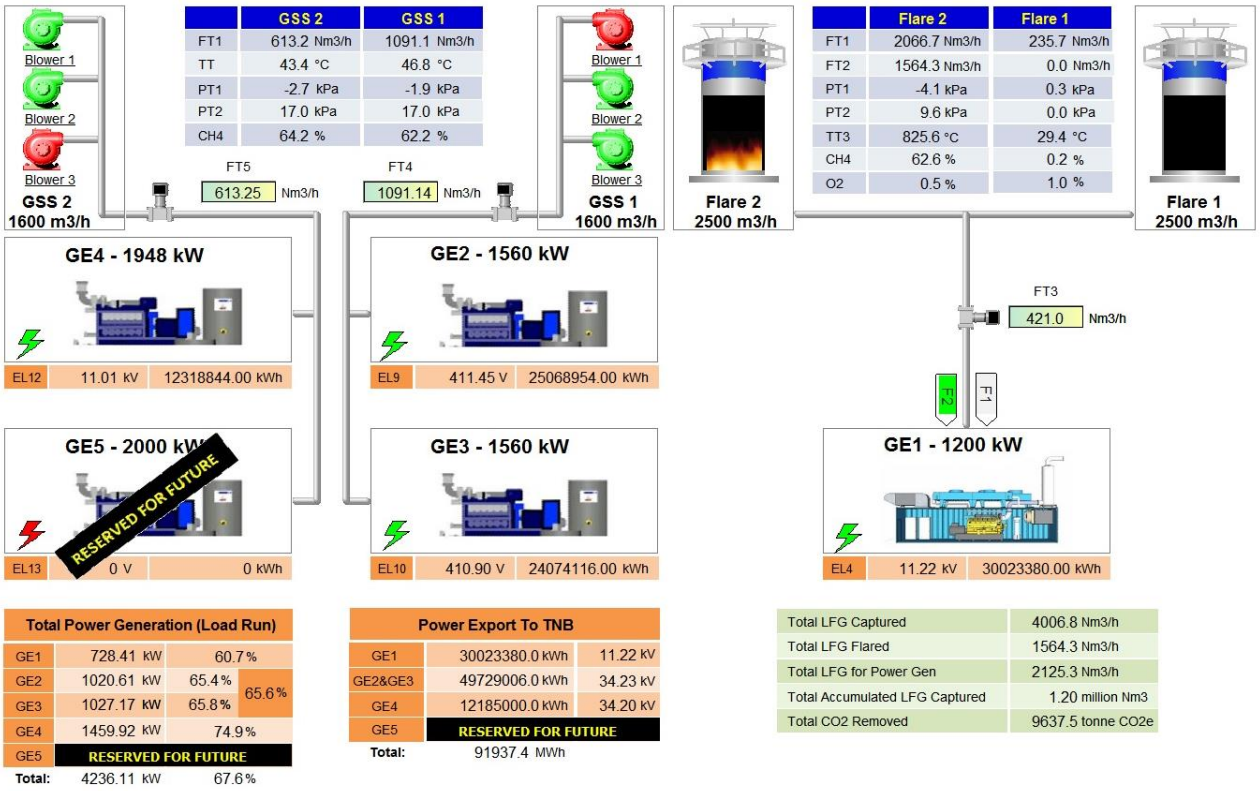


Figure 8: Centralized SCADA Interface

Implementation status of project activity

For the reporting period of 01/01/2018 to 31/12/2018, the key CDM activities implemented are described below:

Gas Extraction System in Advance Cell and Flare No.1

Advanced cell has stopped operation and capped in the 1st monitoring period of 2nd crediting period. Flare No. 1 has officially stopped operation on 03/01/2017.

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

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

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

The total running time for Flare No.2 is 87.9% in this monitoring period.

Power Generation

During this monitoring period, power generated from Gas Engine No.1, No.2, No.3 and No.4 continued to be uploaded to the grid.

For the period of 28/08/2016 –31/05/2017, the data recording for the amount of gas channelled to Gas Engine No.1 is linked with the Flare No.2 SCADA system. Hence, the shutdown of Flare No.2 also indicated the shutdown of Gas Engine No.1. However, starting from 01/06/2017, Gas Engine No.1 was no longer attached to Flare No.2 and was converted to GSS F1.

Gas Engine No.4 was commissioned on 26/10/2015. The supply of landfill gas for Gas Engine No.4 comes from an independent piping system linked from GSS1 (Gas Engine No.2 and No.3) and passes through GSS2 (Gas Engine No. 4).

The properties of the landfill gas are monitored by independent monitoring equipment, i.e. temperature, pressure, methane content and flow rate for GSS1, GSS2 and GSS F1. The power generated from the gas engines is uploaded to the grid.

The total running time for Gas Engines in this monitoring period is tabulated as below:

No	Description	Total Running Time (%)
1	Gas Engine No. 1	15%
2	Gas Engine No. 2	58%
3	Gas Engine No. 3	60%
4	Gas Engine No. 4	64%

The details on the downtime of Gas Engine No.1, No.2, No.3 and No.4 are presented in **Appendix 3**.

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies or standardized baseline

No temporary deviations have been applied during this monitoring period.

B.2.2. Corrections

No corrections during this monitoring period.

B.2.3. Changes to start date of crediting period

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

B.2.4. Inclusion of a monitoring plan

No inclusion of a monitoring plan to the registered PDD that was not included at registration.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

During the 1st monitoring period of 2nd crediting period, KBE has decided to shut down Flare No.1 starting from 03/01/2017 and converted Flare No.1 to GSSF1. Gas engine No. 1 which was attached to Flare 2 previously has been converted to GSSF1. A revision for the monitoring plan was requested and approved on 21/06/2018 (PRC-2467-005).

B.2.6. Changes to project design

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

SECTION C. Description of monitoring system

Monitoring Methodology

The basis of the monitoring plan (MP) was formulated based on the approved methodology ACM 0001 – *Flaring or use of landfill gas (Version 18.0).*

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

The MP 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°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°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 55 of the registered PDD, version 20.5, the Transmission and Distribution Losses ($TDL_{k,y}$) value applied in this project is 7.39% and 7.74% for 2016 and 2017 respectively. This value was reported in the Tenaga Nasional Berhad (TNB)[4] Annual Report 2016[5].

Operation and Management Structure for Monitoring

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

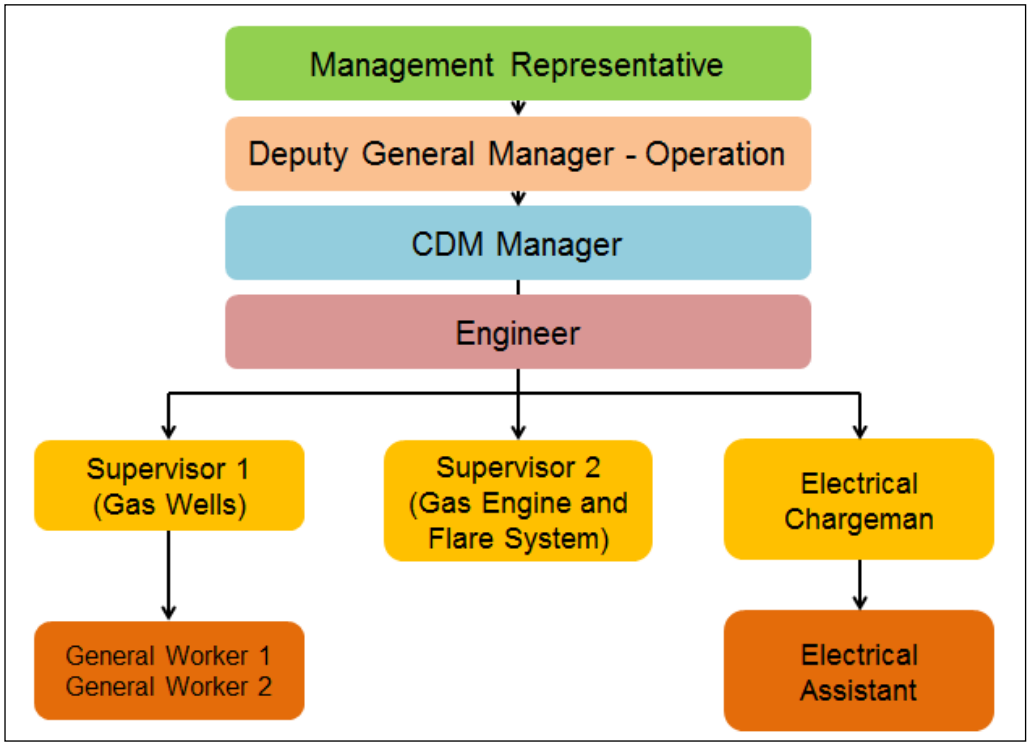


Figure 9: Organisational Structure for CDM Monitoring for BTSL LFG Recovery and Utilisation Project

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

[5] https://www.tnb.com.my/assets/annual_report/TNB_Annual_Report_2016.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
Deputy General Manager - Operation	• Reports to the management representative (MR) • Oversees entire operation of landfills (including LFG management system) • Covers responsibility of CDM Manager when he is not available
CDM Manager	• Reports to the Deputy General Manager - Operation • Oversees and coordinates the entire CDM monitoring plan • Verifies and signs off all relevant monitoring records • Ensures Quality Control / Quality Assurance (QC/QA) is carried out • Ensures all data are recorded and necessary documentations are prepared according to the requirements of CDM monitoring • Responsible in optimising the LFG extraction and utilisation system
Engineer	• Reports to the CDM Manager • Assists the CDM Manager in performing CDM monitoring works • To monitor daily operation for landfill gas operations • To assist in daily monitoring records for all CDM related equipment • To prepare daily summary record for landfill gas operation
CDM Consultant	• Provides advice on all CDM-related matters • Prepares monitoring reports for verifications • Liaises with the verifier on verification process • Conducts regular audits on CDM monitoring
Supervisors	• Report to the CDM Manager on CDM monitoring issues • Check and ensure that the flaring system is functional • Ensure all data recording devices are functioning and calibrated as planned (including performing QA/QC) • Check and sign the daily monitoring log sheets for CDM monitoring • Supervise general workers in maintenance work and record monitored parameters for CDM monitoring • Identify maintenance requirement and contact the supplier if maintenance and support are needed • Optimise the flare operation together with the CDM Manager • Responsible with the security of locked Programmable Logic Controller (PLC) control room. The supervisor will hold the door key for the PLC control room
General Workers	• Perform regular operational and maintenance tasks • Record necessary readings in daily monitoring log sheets and request verification from the supervisors on the log sheets • Report any fault to supervisor-in-charge or the electrical chargeman

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

The CDM Consultant (Eco-Ideal Consulting Sdn. Bhd.) was appointed to assist KBE in ensuring that the monitoring plan and requirements were done according to the MP. The consultant played the role of a trainer and conducted independent audits as part of the QA/QC procedures set up for this project.
During this monitoring period, one CDM Management Meeting was held on 14/08/2017.

Relevant Monitoring Points

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

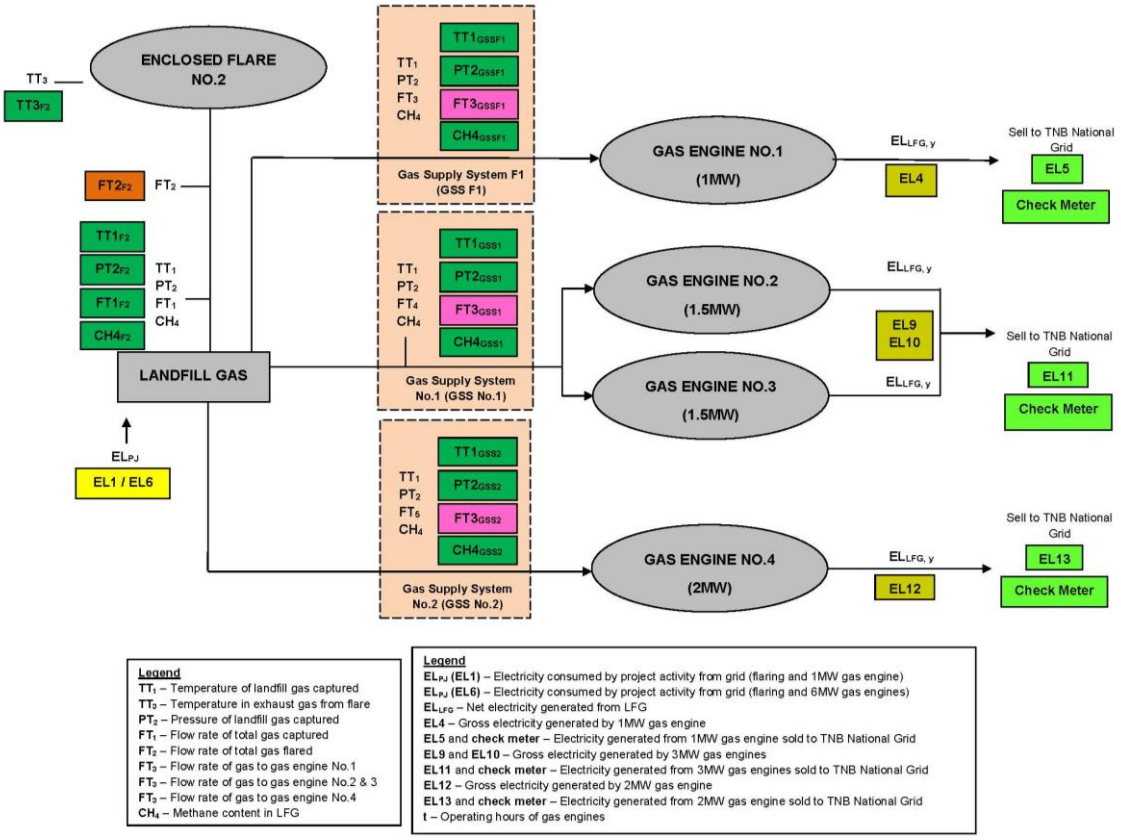


Figure 10: Key Parameters Monitored under the CDM Monitoring Plan

Landfill gas is captured and send to Enclosed Flare No.2, Gas Supply System F1 (GSS F1), Gas Supply System No. 1 (GSS No.1) and Gas Supply System No.2 (GSS No.2). Flow rate of total gas flared by Enclosed Flare No.2 is monitored by FT2 while flow rate of gas to gas engines are monitored by $FT3_{GSSF1}$ (GSS F1), $FT3_{GSS1}$ (GSS No.1) and $FT3_{GSS2}$ (GSS No.2) respectively.

The gross electricity generated by each gas engines are monitored using EL4, EL9, EL10 and EL12. The amount will be compared with EL5, EL11 and EL13 which are managed by Tenaga National Berhad to obtain the lower amount so that the result is conservative.

As data will be captured separately in the flaring and power generation system (Flare No.2, Gas Engine No.1 and so forth), a specific subscript will be assigned to the monitoring parameters of the different equipment installed.

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

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_t ($T_{TT1,F2}$) T_t ($T_{TT1,GSS1}$) T_t ($T_{TT1,GSS2}$) T_t ($T_{TT1,GSSF1}$)	$TT_{1,Flare}$ No.2/GSS1/GSS2/GSS F1	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	$T_{EG,m}$ ($T_{Flare,F2}$)	$TT_{3,Flare}$ 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_t ($P_{PT2,F2}$) P_t ($P_{PT2,GSS1}$) P_t ($P_{PT2,GSS2}$) P_t ($P_{PT2,GSSF1}$)	$PT_{2,Flare}$ No.2/GSS1/GSS2/GSS F1	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

Parameter	CDM ID	Equipment ID	Monitoring equipment	Recording frequency	Documentations	Data archive
Flowrate	$V_{t,wb}$ ($LFG_{total,\ Flare\ No.2,y}$) $V_{t,wb}$ ($LFG_{flare,\ Flare\ No.2,y}$) $V_{t,wb}$ ($LFG_{electricity,Flare\ No.2/GSS,y}$)	$FT_{1,Flare\ No.2}$ $FT_{2,\ Flare\ No.2}$ $FT_{3,Flare\ No.2/GSS1/GSS2/GSS\ F1}$	V-Cone Differential Pressure Flowmeter	Every 1 min (auto) Daily (manual) – as back-up	Softcopy Hardcopy	(.MDB MS Access database) Daily log sheet will be scanned into PDF format for archiving
Methane Fraction	$V_{CH4,m,db}$ ($W_{CH4,Flare\ No.2/GSS,y}$)	$CH_{4,Flare\ No.2/GSS1/GSS2/GSS\ F1}$	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	$EG_{PJ,y}$ ($EL_{PJ,y}$)	EL_{PJ} (EL1, EL6)	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	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.1,y}$) $EG_{PJ,y}$ ($EL_{LFG,GE\ No.2,y}$) $EG_{PJ,y}$ ($EL_{LFG,GE\ No.3,y}$) $EG_{PJ,y}$ ($EL_{LFG,GE\ No.4,y}$)	$EL_{LFG,GE\ No.1}$ (EL4) $EL_{LFG,GE\ No.2}$ (EL9) $EL_{LFG,GE\ No.3}$ (EL10) $EL_{LFG,GE\ No.4}$ (EL12)	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
	$EG_{PJ,y}$ ($EL_{LFG,y}$)	EL_{LFG} (EL5, EL11 and EL13, TNB main energy meters)	kWh meter	Daily (manual)	Softcopy (scanned copy) Hardcopy	TNB joint meter reading certificate will be scanned for archiving

Parameter	CDM ID	Equipment ID	Monitoring equipment	Recording frequency	Documentations	Data archive
		TNB check energy meters				

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 below.

Table 3: 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_t ($T_{TT1,F2}$)	^0C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B839917437	±0.5% of span	0-100°C	13/09/2017 & CTT 1957-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & CTT 3123-18 (11/10/2018 - 31/12/2018)	10/10/2019	Annually
2	Temperature Transmitter	Flare Temperature ($T_{flare,y}$)	$TT_{3,Flare\ No.2}$	$T_{EG,m}$ ($T_{Flare,F2}$)	^0C	Honeywell	STT25M-0-EN0-000-000-000-00-3D	B838901937	±0.5% of span	0-1200°C	13/09/2017 & CTT 1956-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & CTT 3124-18 (11/10/2018 - 31/12/2018)	10/10/2019	Annually
3	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,Flare\ No.2}$	P_t ($P_{PT2,F2}$)	kPa	Rosemount	3051TG1A2B21AB4E5Q4	5584784	±0.25%	0-40 kpa	13/09/2017 & CTP 4820-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & CTP 5488-18 (11/10/2018 - 31/12/2018)	10/10/2019	Annually
4	Flow Meter	Total Biogas Flow Rate ($LFG_{total,y}$)	$FT_{1,Flare\ No.2}$	$V_{t,wb}$ ($LFG_{total,Flare\ No.2,y}$)	NM^3/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5B4K5/ KVS10IIKC23FSN	5476626 / FT141 (10031702)	±0.5%	3-5000Nm^3/h	13/09/2017 & CTP 4819-17 (01/01/2018 - 31/12/2018)	12/09/2019	24 months
5	Flow Meter	Flaring Biogas Flow Rate ($LFG_{flare,y}$)	$FT_{2,Flare\ No.2}$	$V_{t,wb}$ ($LFG_{flare,Flare\ No.2,y}$)	NM^3/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5K5Q4 / KVS10IIKC23FSN	5476627 / FT140 (10031701)	±0.5%	3-5000Nm^3/h	13/09/2017 & CTP 4821-17 (01/01/2018 - 31/12/2018)	12/09/2019	24 months
Gas Analysers													
7	CH_4 Meter	Methane fraction of LFG	$CH_{4,Flare\ No.2}$	$V_{CH4,m,db}$ ($W_{CH4,Flare\ No.2,y}$)	%	Guardian Plus	97460	31453	±2% of full scale	0-100%	05/01/2017 & CTM 1003-17 (01/01/2018 - 03/06/2018)	04/01/2018	Annually
											04/06/2018 & CTM 1296-18 (04/06/2018 - 31/12/2018)	03/06/2019	Annually

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

During this monitoring period, maximum permission error are applied for the equipment which has an delay calibration as conservative approach is as listed below:

1. TT1 - the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT1 from 13/09/2018 - 10/10/2018.
2. TT3 - the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT3 from 13/09/2018 - 10/10/2018.
3. PT2 - the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 13/09/2018 - 10/10/2018.
4. CH4 - the maximum permissible error of ±2.0% which is the equipment accuracy error was applied to CH4 from 05/01/2018 - 03/06/2018.

Table 4: List of CDM Monitoring Equipment and Calibration for GSS1

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
Gas Supply System													
1	Temperature Transmitter	Temperature (T)	$TT_{1,GSS1}$	T_t ($T_{TT1,GSS1}$)	^0C	Honeywell	STT25M-0-ENS-000-000-000-00-3H	B527143837	±1%	0-100°C	13/09/2017 & CTT 1955-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & (11/10/2018-31/12/2018)	10/10/2019	Annually
2	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,GSS1}$	P_t ($P_{PT2,GSS1}$)	kPa	Rosemount	3051TG1A2B21AB4K5 M5	5916057	±0.1%	0-60 kPa	13/09/2017 & CTP 4817-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & (11/10/2018-31/12/2018)	10/10/2019	Annually
3	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{3,GSS1}$	$V_{t,wb}$ ($LFG_{electricity,GSS1,y}$)	NM^3/hr	Rosemount	3051 CD1A22A1AM5B4DFK 5	5988022	±0.5%	200-2,000 Nm^3/h	07/06/2016 & CTP 2912-16 (01/01/2018 - 10/10/2018)	06/06/2018	24 months
											11/10/2018 & (11/10/2018 - 31/12/2018)	10/10/2020	24 months
4	CH_4 Meter	Methane fraction of LFG	$CH_{4,GSS1}$	$V_{CH4,m,db}$ ($W_{CH4,GSS1,y}$)	%	Guardian Plus	97460	34140	±2% of full scale	0-100%	09/11/2017 & AL-NG/0134/1117 (01/01/2018 - 31/12/2018)	08/11/2018	Annually
Power Generation and Electricity Consumption													
5	Power meter	Grid for project activity	EL_{PJ} (EL6)	$EG_{EC,y}$ ($EL_{PJ,y}$)	kWh	IME	NEMO 96HDL	2661930098	Class 1 (±1%)	0-250/5A	23/07/2014 & 2661 9300 98 (01/01/2018 - 24/01/2018)	22/07/2017	36 months
											25/01/2018 &SP/RA/2018/065/002 (25/01/2018 - 31/12/2018)	24/01/2021	36 months
6	Power meter	Gross generation from GE No.2	$EL_{LFG,GE\ No.2}$ (EL9)	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.2,y}$)	kWh	EDMI Limited	Genius	211516862	Class 0.5S	99999999.99kW h	13/05/2015 & SP/RA/2015/209/002 (01/01/2018 - 24/01/2018)	12/05/2017	24 months
											25/01/2018 & SP/RA/2018/065/003 (25/01/2018 - 31/12/2018)	24/01/2020	24 months
7	Power meter	Gross generation from GE No.3	$EL_{LFG,GE\ No.3}$ (EL10)	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.3,y}$)	kWh	EDMI Limited	Genius	211516863	Class 0.5S	99999999.99kW h	13/05/2015 & SP/RA/2015/209/001-002 (01/01/2018 - 24/01/2018)	12/05/2017	24 months
											25/01/2018 & SP/RA/2018/065/004 (25/01/2018 - 31/12/2018)	24/01/2020	24 months
8	Power meter	Electricity sold to grid (MWh) - recorded by grid operator	EL_{LFG} (EL11)	$EG_{PJ,y}$ ($EL_{LFG,y}$)	kWh	EDMI Limited	Mk6E	908705152	Class 0.5S	99,999,999kWh	06/12/2009 & TNBM/PJ/09/076 (01/01/2018 - 31/12/2018)	05/12/2014	5 years
9	Power meter	Electricity sell to grid (MWh) - check energy meter recorded by grid operator	-	-	kWh	EDMI Limited	Mk6E	908705154	Class 0.5S	99,999,999kWh	06/12/2009 & TNBM/PJ/09/076 (01/01/2018 - 31/12/2018)	05/12/2014	5 years

During this monitoring period, maximum permission error are applied for the equipment which has an delay calibration as conservative approach is as listed below:

1. TT1 - the maximum permissible error of ±1% which is the equipment accuracy error was applied to TT1 from 13/09/2018 - 10/10/2018.
2. PT2 - the maximum permissible error of ±0.1% which is the equipment accuracy error was applied to PT2 from 13/09/2018 - 10/10/2018.
3. FT3 - the maximum permissible error of 0.5% which is the equipment accuracy error was applied to FT3 from 07/06/2018 - 10/10/2018.
4. CH4 - the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 09/12/2018 - 31/12/2018.
5. EL6 - the maximum permissible error of ±1.0% which is the equipment accuracy error was applied to EL6 from 01/01/2018 - 24/01/2018.

6. EL 9 - the maximum permissible error of ±2.08% which is equipment calibration error was applied to EL9 from 01/01/2018 - 24/01/2018
7. EL10 - the maximum permissible error of ±1.14% which is the equipment calibration error was applied to EL10 from 01/01/2018 - 24/01/2018.
8. EL11 - the maximum permissible error of 0.5% which is the equipment accuracy error was applied to EL11 from 01/01/2018 - 31/12/2018.

Table 5: List of CDM Monitoring Equipment and Calibration for GSS2

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
Gas Supply System													
1	Temperature Transmitter	Temperature (T)	$TT_{1,GSS2}$	T_t ($T_{TT1,GSS2}$)	^0C	Autrol	ATT2100-S11HA3E1-M1	ATT21004151000	±0.1%	0-100°C	05/01/2017 & CTT 1005-17 (01/01/2018 - 03/06/2018)	04/01/2018	Annually
											04/06/2018 & CTT 2120-18 (04/06/2018 - 31/12/2018)	03/06/2019	Annually
2	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,GSS2}$	P_t ($P_{PT2,GSS2}$)	kPa	Autrol	APT3200-G4M11E11S1-M1	APT3200-4150998	±0.075% of span	-100-1,500kPa	05/01/2017 & CTP 1005-17 (01/01/2018 - 03/06/2018)	04/01/2018	Annually
											04/06/2018 & CTP 3662 -18 (04/06/2018 - 31/12/2018)	03/06/2019	Annually
3	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{3,GSS2}$	$V_{t,wb}$ ($LFG_{electricity,GSS2,y}$)	NM^3/hr	Binder	EIA-C100000-1MA100-D1104501-21BS2410	C150327	2.5% of reading + 0.2% of full scale	0.25-25 Nm/s	23/06/2015 & C150327 (01/01/2018 - 09/12/2018)	22/06/2017	24 months
											10/12/2018 & C150327 (10/12/2018 - 31/12/2018)	09/12/2020	24 months
Gas Analyser													
4	CH_4 Meter	Methane fraction of LFG	$CH_{4,GSS2}$	$V_{CH4,m,db}$ ($W_{CH4,GSS2,y}$)	%	Guardian Plus	97460	33542	±2% of full scale	0-100%	13/09/2017 & CTM1337-17 (01/01/2018 - 10/10/2018)	12/09/2018	Annually
											11/10/2018 & CTM 1628-18 (11/10/2018 - 31/12/2018)	10/10/2019	Annually
Power Generation and Electricity Consumption													
5	Power meter	Gross generation from GE No.4	$EL_{LFG,GE\ No.4}$ (EL12)	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.4,y}$)	kWh	EDMI	2000-6N00-30A31-04-L00-02A2-1D	213545834	Class 0.5S	99999999.99kWh	04/02/2016 & SP/RA/2016/081/001-001 (01/01/2018 - 07/08/2018)	03/02/2018	24 months
											08/08/2018 & SP/RA/2018/463/001-001 (08/08/2018 - 31/12/2018)	07/08/2020	24 months
6	Power meter	Electricity sold to grid (MWh) - recorded by grid operator	EL_{LFG} (EL13)	$EG_{PJ,y}$ ($EL_{LFG,y}$)	kWh	Itron	SL761W071	81480576	Class 0.2S	999999999kWh	14/06/2016 & TNB(B)/PP/UPH-PJ17/6/7-141 (01/01/2018 - 31/12/2018)	13/06/2021	5 years
7	Power meter	Electricity sell to grid (MWh) - check energy meter recorded by grid operator	-	-	kWh	Itron	SL761W071	81480578	Class 0.2S	999999999kWh	14/06/2016 & TNB(B)/PP/UPH-PJ17/6/7-141 (01/01/2018 - 31/12/2018)	13/06/2021	5 years

During this monitoring period, maximum permission error are applied for the equipment which has an delay calibration as conservative approach is as listed below:

1. TT1 - the maximum permissible error of ±0.2% which is the equipment calibration error was applied to TT1 from 05/01/2018 – 03/06/2018.
2. PT2 - the maximum permissible error of ±0.4% which is the equipment calibration error was applied to PT2 from 05/01/2018 – 03/06/2018.
3. FT3 - the maximum permissible error of ±2.7% which is the equipment accuracy error was applied to FT3 from 01/01/2018 – 09/12/2018.
4. CH4 - the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 13/09/2018 – 10/10/2018.
5. EL12 - the maximum permissible error of ±1.17% which is the equipment calibration error was applied to EL12 from 04/02/2018 – 07/08/2018.

Table 6: List of CDM Monitoring Equipment and Calibration for GSS F1

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
Gas Supply System													
1	Temperature Transmitter	Temperature (T)	$TT_{1,GSS\ F1}$	T_t ($T_{TT1,\ GSS\ F1}$)	^0C	PR Electronics	5335A	100944768	≤ ± 0.05% of span	0-100°C	05/01/2017 & CTT 1004-17 (01/01/2018 - 03/06/2018)	04/01/2018	Annually
											04/06/2018 & CTT 2119-18 (04/06/2018 - 31/12/2018)	03/06/2019	Annually
2	Flow Meter	Flow Rate of Total Gas to Energy ($LFG_{electricity,y}$)	$FT_{3,\ GSS\ F1}$	$V_{t,\ wb}$ ($LFG_{electricity,GSS\ F1,y}$)	NM^3/hr	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone	3051CD1A22A1AM5B4K5Q4 / KVS08IIKC23FSN	02768007 / FT161 (11011001)	±0.5%	200-2000Nm^3/h	05/01/2017 & CTP 1006-17 (01/01/2018 - 31/12/2018)	04/01/2019	24 months
3	Pressure Sensor	Pressure Transmitter (P)	$PT_{2,\ GSS\ F1}$	P_t ($P_{PT2,\ GSS\ F1}$)	kPa	Rosemount	3051TG1A2B21AB4E5M5Q4	02492864	±0.25%	0-2 to 0-207 kPa	05/01/2017 & CTP 1004-17 (01/01/2018 - 03/06/2018)	04/01/2018	Annually
											04/06/2018 & CTP 3661-18 (04/06/2018 - 31/12/2018)	03/06/2019	Annually
Gas Analysers													
4	CH_4 Meter	Methane fraction of LFG	$CH_{4,\ GSS\ F1}$	$V_{CH4,\ m,\ db}$ ($W_{CH4,GSS\ F1,y}$)	%	Guardian Plus	97460	33436	±2% of full scale	0-100%	13/09/2017 & CTM 1338-17 (01/01/2018 - 31/12/2018)	12/09/2018	Annually
Power Generation and Electricity Consumption													
5	Power meter	Total electricity generation (MWh) - recorded by project site	$EL_{LFG,GE\ No.1}$ (EL4)	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.1,y}$)	kWh	EDMI Limited	Mk6E	210225256	Class 0.5S	99999999.99kWh	06/01/2017 & SP/RA2017/014/001-001 (01/01/2018 - 31/1/2/2018)	06/01/2019	24 months
6	Power meter	Electricity sell to grid (MWh) - recorded by grid operator	EL_{LFG} (EL5)	$EG_{PJ,y}$ ($EL_{LFG,y}$)	kWh	Itron	SL761A071	53099690	Class 0.20	999999999kWh	01/04/2011 & TNBM-QR-064 (01/01/2018 - 31/12/2018)	31/03/2016	5 years
7	Power meter	Electricity sell to grid (MWh) - check energy meter recorded by grid operator	-	-	kWh	Itron	SL761A071	53099691	Class 0.20	999999999kWh	01/04/2011 & TNBM-QR-064 (01/01/2018 -31/12/2018)	31/03/2016	5 years

During this monitoring period, maximum permission error are applied for the equipment which has an delay calibration as conservative approach is as listed below:

1. TT1 –the maximum permissible error of ±0.3% which is equipment calibration error was applied to TT1 from 05/01/2018 – 03/06/2018.
2. PT2 –the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 05/01/2018 – 03/06/2018.
3. CH4 - the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 13/09/2018 - 31/12/2018.
4. EL5 - the maximum permissible error of ±0.2% which is the equipment accuracy error was applied to EL5 from 01/01/2018 – 31/12/2018.

With reference to the CDM validation and verification standard for project activities, version 01.0, section 9.2.6, paragraph 369 (a), “Applying the maximum permissible error of the instrument to the measured values taken during the period between the scheduled date of calibration and the actual date of calibration, if the results of the delayed calibration do not show any errors in the measuring equipment, or if the error is smaller than the maximum permissible error”, or (b) “Applying the error identified in the delayed calibration test, if the error is beyond the maximum permissible error of the measuring equipment”. During this monitoring period, all the equipment which have delay in calibration, the maximum permissible error (MPE) or the error identified in the delayed in calibration are as listed below:

List of Equipment from Flare 2

1. TT1 – Due to delay calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT1 from 13/09/2018 – 10/10/2018 as a conservative approach.
2. TT3 – Due to delay calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT3 from 13/09/2018 – 10/10/2018 as a conservative approach.
3. PT2 – Due to delay in calibration, the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 13/09/2018 – 10/10/2018 as a conservative approach.
4. CH4 – Due to delay in calibration, the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 05/01/2018 – 03/06/2018 as a conservative approach

List of Equipment from GSS1

1. TT1 – Due to delay in calibration, the maximum permissible error of ±1% which is the equipment accuracy error was applied to TT1 from 13/09/2018 – 10/10/2018 as a conservative approach.
2. PT2 – Due to delay in calibration, the maximum permissible error of ±0.1% which is the equipment accuracy error was applied to PT2 from 13/09/2018 - 10/10/2018 as a conservative approach.
3. FT3 – Due to delay in calibration, the maximum permissible error of 0.5% which is the equipment accuracy error was applied to FT3 from 07/06/2018 – 10/10/2018 as a conservative approach.
4. CH4 – Due to delay in calibration, the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 09/12/2018 - 31/12/2018.
5. EL6 – Due to delay in calibration, the maximum permissible error of ±1.0% which is the equipment accuracy error was applied to EL6 from 01/01/2018 - 24/01/2018 as a conservative approach.
6. EL9 – Due to delay in calibration, the maximum permissible error of ±02.08% which is the equipment calibration error was applied to EL9 from 01/01/2018 - 24/01/2018 as a conservative approach.
7. EL10 – Due to delay in calibration, the maximum permissible error of ±1.14% which is the equipment calibration error was applied to EL10 from 01/01/2018 - 24/01/2018 as a conservative approach.

List of Equipment from GSS2

1. TT1 – Due to delay in calibration, the maximum permissible error of ±0.2% which is the equipment calibration error was applied to TT1 from 05/01/2018 – 03/06/2018 as a conservative approach.
2. PT2 – Due to delay in calibration, the maximum permissible error of ±0.4% which is the equipment calibration error was applied to PT2 from 05/01/2018 – 03/06/2018 as a conservative approach.
3. CH4 – Due to delay in calibration, the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 13/09/2018 – 10/10/2018 as a conservative approach.
4. FT3 - Due to delay in calibration, the maximum permissible error of ±2.7% which is the equipment accuracy error was applied to FT3 from 01/01/2018 – 09/12/2018 as a conservative approach.
5. EL12 - Due to delay in calibration, the maximum permissible error of ±1.17% which is the equipment calibration error was applied to EL12 from 04/02/2018 – 07/08/2018 as a conservative approach

List of Equipment from GSS F1

1. TT1 – Due to delay in calibration, the maximum permissible error of ±0.3% which is the equipment calibration error was applied to TT1 from 05/01/2018 – 03/06/2018 as a conservative approach.

2. PT2 – Due to delay in calibration, the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 05/01/2018 – 03/06/2018 as a conservative approach.
3. CH4 - the maximum permissible error of ±2% which is the equipment accuracy error was applied to CH4 from 13/09/2018 - 31/12/2018.

With reference to the CDM validation and verification standard for project activities, version 01.0, section 9.2.6, paragraph 371, "If the results of the delayed calibration are not available, or the calibration has not been conducted at the time of the verification, the DOE, prior to finalizing the verification, shall request the project participants to conduct the required calibration and shall determine whether the project participants have calculated GHG emission reductions or net anthropogenic GHG removals conservatively using the approach mentioned in paragraph 369 above".

During this monitoring period, there are equipment which are not within the control of the project and the calibration have not been conducted at the time of verification. The equipment is as listed below:

List of Equipment from GSS F1

1. EL 5 (Itron, serial no.: 53099690) – The meter is owned by the grid operator, TNB and thus, it is not within the control of the project. However, due to delay in calibration, the maximum permissible error of ±0.2% which is the equipment accuracy error was applied to EL5 from 01/01/2018 – 31/12/2018 as a conservative approach.

List of Equipment from GSS1

1. EL 11 (EDMI Limited, serial no.: 908705152) – The meter is owned by the grid operator, TNB and thus, it is not within the control of the project. However, due to delay in calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL11 from 01/01/2018 – 31/12/2018 as a conservative approach.

Data Collection (for the whole monitoring period)

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

As a back-up data recording system, the on-site workers have manually recorded certain monitored parameters in the Daily Monitoring Log Sheets. These records were scanned into soft copies for electronic filing on a monthly basis.

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

Data Processing

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

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

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

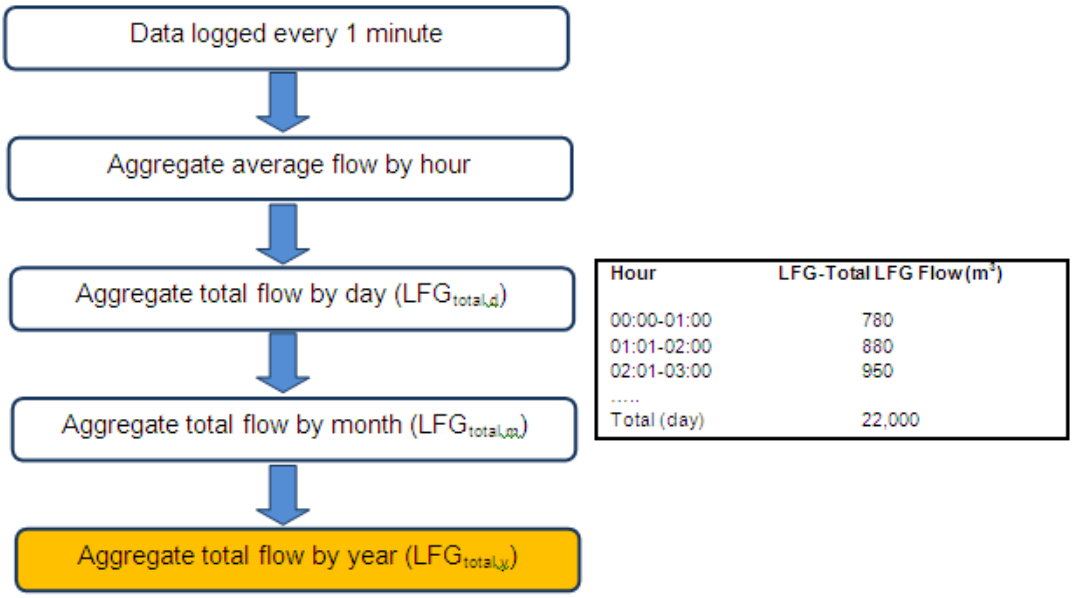


Figure 11: Example of Data Aggregation for Continuous Monitoring

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

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

Quality Assurance and Quality Control (QA & QC)

Documented Procedures and QA/QC Measures

QA/QC was applied throughout the monitoring period:

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

Data Management and Storage

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

Continuous Monitoring (data logging system)

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

Types of back-up	Frequency	Back-up location
Manual back-up using a portable hard disk (HD)	Monthly	At the flare

Types of back-up	Frequency	Back-up location
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., Unit C10-4, Tower C, Wisma Goshen, Bangsar Trade Centre, Kuala Lumpur, Malaysia)	Weekly	Off-site (consultant's office)

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

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

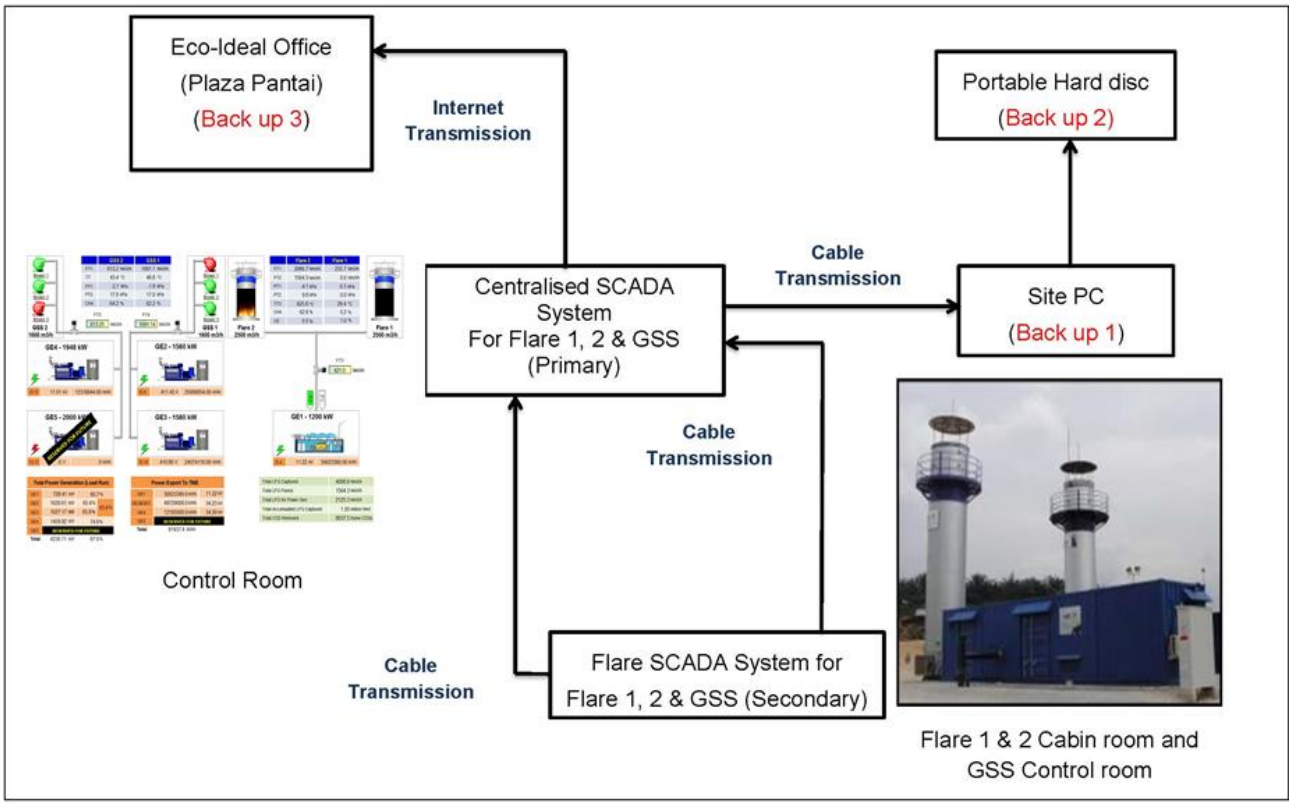


Figure 12: Automatic Data Back-Up for Flaring System at BTSL

Manual Recording

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

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.

The staff has also attended several technical/operational trainings as listed below:

No.	Description	Date	No. of participants
1	Landfill Gas Operation – Refresher Training for Gas Well Monitoring	15/02/2018	7
2	Landfill Gas- Condensate Pump Maintenance	19/04/2018	7
3	LFG – Flare 2 Blower Maintenance Check	16/07/2018	6
4	Training – Landfill Gas SCADA System Data Log	18/7/2018	7
5	RE – GCP for Gas Engine (Engine Start Up & Monitoring	10/10/2018	6

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

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

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

Data / Parameter	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global Warming Potential (GWP) for CH_4
Source of data	IPCC
Value(s) applied)	25
Choice of data or measurement methods and procedures	Shall be updated according to any future COP/MOP decisions
Purpose of data	Baseline emissions calculation
Additional comment	25 for the second commitment period. Shall be updated according to any future COP/MOP decisions

Data / Parameter	η_{PJ}
Unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	-
Value(s) applied)	90%
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	Technical specification of the LFG capture system to be installed (if available) or a default value of 90%

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

Data / Parameter	**OX**
Unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the "IPCC 2006 Guidelines for National Greenhouse Gas Inventories"
Value(s) applied)	0.1
Choice of data or measurement methods and procedures	-
Purpose of data:	Baseline emission calculation
Additional comment:	-

Data / Parameter	**F**
Unit	-
Description	Fraction of methane in the SWDS gas (volume fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied)	0.5
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	$DOC_{f,default}$
Unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied)	0.5

Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	$DOC_{f,y} = DOC_{f,default}$

Data / Parameter	**$MCF_{default}$**
Unit	-
Description	Methane Correction Factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied)	1.0
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	$MCF_y = MCF_{default}$.

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

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

Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>kj</td></tr>
<tr><td>Unit</td><td>1/yr</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Value(s) applied)</td><td>The following values for the different waste types j is applied:

Default values for k_j
<table>
<tr><th colspan="2" rowspan="2">Waste type j</th><th>Tropical (MAT > 20°C)</th></tr>
<tr><th>Wet (MAP > 1,000 mm)</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.40</td></tr>
</table>
Note: MAT – mean annual temperature, MAP – mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration.</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>Baseline emissions calculation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

"Project emissions from flaring" (Version 02.0.0)

Data / Parameter	$SPEC_{flare}$
Unit	Temperature - °C Flow rate or heat flux – kg/h or m^3/h
Description	Manufacturer's flare specifications for temperature and flow rate and maintenance schedule
Source of data	Flare manufacturer
Value(s) applied)	Minimum and maximum operating temperature = 0 to 1,200°C Minimum and maximum inlet flow rate = 0 – 2,500 Nm^3/h
Choice of data or measurement methods and procedures	-
Purpose of data	Baseline emissions calculation
Additional comment	-

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

Data / Parameter	$TDL_{k,y}$
Unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *k* in year *y*
Source of data	Tenaga Nasional Berhad (TNB) Annual Report 2016[6] in page 61
Value(s) applied)	7.74%
Choice of data or measurement methods and procedures	Average calculated from year 2014 – 2016 2014 – 8.15% 2015 – 7.68% 2016 – 7.39%
Purpose of data	Project emissions calculation and baseline emissions
Additional comment	For the project emission calculation, TDL of 7.74% is applied from 2017 onwards. 7.74% is calculated from the average of TDL from year 2014 – 2016, the % of the average TDL calculated is higher if compare to TDL in year 2016. This can be concluded that the TDL 7.74% apply for project emission from 2017 onwards is considered conservative approach.

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

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

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

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

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

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

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

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

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

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

D.2. Data and parameters monitored

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

Data / Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Measured/calculated/default	-
Source of data	Different sources of data available: (a) Origin design of the landfill; (b) Technical specification for the management of the SWDS; or (c) Local or national regulations.
Value(s) of monitored parameter	Local or national regulations, the reporting is based on the environmental monitoring report submitted to Department of Environment
Monitoring equipment	-
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Refer to the original design of the landfill to monitor any practice to increase methane generation during the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity will be justified by referring to technical or regulatory specifications.
QA/QC procedures	-
Purpose of data/parameter	-
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>$Op_{j,h}$</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Operation of the equipment that consumes the LFG</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Project participant</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>On or Off for flare temperature and gas engine, refer to $T_{EG,m}$
<table>
<tr><th rowspan="2">Months</th><th>Operating Time (Hr)</th></tr>
<tr><th>Flare No. 2</th></tr>
<tr><td>January 18</td><td>736</td></tr>
<tr><td>February 18</td><td>668</td></tr>
<tr><td>March 18</td><td>701</td></tr>
<tr><td>April 18</td><td>486</td></tr>
<tr><td>May 18</td><td>155</td></tr>
<tr><td>June 18</td><td>719</td></tr>
<tr><td>July 18</td><td>744</td></tr>
<tr><td>August 18</td><td>723</td></tr>
<tr><td>September 18</td><td>697</td></tr>
<tr><td>October 18</td><td>686</td></tr>
<tr><td>November 18</td><td>660</td></tr>
<tr><td>December 18</td><td>731</td></tr>
<tr><td>Total</td><td>7,705</td></tr>
</table>
<table>
<tr><th rowspan="2">Months</th><th colspan="4">Operating Time (Hr)</th></tr>
<tr><th>Gas Engine No.1</th><th>Gas Engine No.2</th><th>Gas Engine No.3</th><th>Gas Engine No.4</th></tr>
<tr><td>January 18</td><td>63</td><td>711</td><td>0</td><td>730</td></tr>
<tr><td>February 18</td><td>0</td><td>660</td><td>334</td><td>657</td></tr>
<tr><td>March 18</td><td>0</td><td>698</td><td>653</td><td>667</td></tr>
<tr><td>April 18</td><td>0</td><td>541</td><td>390</td><td>624</td></tr>
<tr><td>May 18</td><td>0</td><td>729</td><td>268</td><td>688</td></tr>
<tr><td>June 18</td><td>0</td><td>231</td><td>462</td><td>114</td></tr>
<tr><td>July 18</td><td>0</td><td>0</td><td>731</td><td>526</td></tr>
<tr><td>August 18</td><td>0</td><td>592</td><td>639</td><td>683</td></tr>
<tr><td>September 18</td><td>395</td><td>104</td><td>703</td><td>581</td></tr>
<tr><td>October 18</td><td>367</td><td>0</td><td>318</td><td>337</td></tr>
<tr><td>November 18</td><td>1</td><td>60</td><td>16</td><td>0</td></tr>
<tr><td>December 18</td><td>493</td><td>731</td><td>738</td><td>0</td></tr>
<tr><td>Total</td><td>1,319</td><td>5,057</td><td>5,252</td><td>5,607</td></tr>
</table></td></tr>
<tr><td>Monitoring equipment</td><td>-</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Hourly</td></tr>
</table>

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

Data / Parameter	$\mathbf{EG_{PJ,y}}$ $\mathbf{(EL_{LFG,GE\ No.1,y,}\ EL_{LFG,GE\ No.2,y,}\ EL_{LFG,GE\ No.3,y,}\ EL_{LFG,GE\ No.4,y,}\ EL_{LFG,y})}$
Unit	MWh
Description	Amount of electricity generated using LFG by the project activity in year *y*
Measured/calculated/default	Measured

Source of data	Data as measured by electricity meters. This parameter was measured separately for the gas engines, i.e. Gas Engine No.1 (1 meter), Gas Engine No.2 and No.3 (1 meter) and Gas Engine No.4 (1 meter). Therefore, 3 sets of equipment have to be used for the monitoring period.
Value(s) of monitored parameter	There were 2 sets of power meters used to measure the amount of electricity sold to the grid, i.e. the main energy meter and check energy meter. Only the readings recorded by the main energy meter was used by the grid operator and the project participant in the calculation of CERs while the readings recorded by the check energy meter were only used to check or confirm on the readings recorded by the main energy meter. From the comparison of EL4 and EL5 (main meter), the lower value between the two is taken for the calculation of net amount of electricity generated for Gas Engine No.1. From the comparison of EL9 + EL10 and EL11 (main meter), the lower value between the two is taken for the calculation of net amount of electricity generated for Gas Engine No.2 and No.3. From the comparison of EL12 and EL13 (main meter), the lower value between the two is taken for the calculation of net amount of electricity generated for Gas Engine No.4. The detailed calculation was shown in the CER calculation sheet under each monthly 'ELPJ' tab.

Months	**Net electricity generated (MWh) $EG_{PJ,y}$**			**Total amount of electricity generated (MWh)**
	$EL_{LFG,GE\ No.1,y}$	**$EL_{LFG,GE\ No.2,y}$ & $EL_{LFG,GE\ No.3,y}$**	**$EL_{LFG,GE\ No.4,y}$**	
January 2018	37.59	883.35	1,082.76	2,003.70
February 2018	0.00	971.59	883.77	1,855.35
March 2018	0.00	1,244.51	913.33	2,157.84
April 2018	0.00	913.90	919.66	1,833.55
May 2018	0.00	826.86	1,015.67	1,842.53
June 2018	0.00	579.99	124.49	704.47
July 2018	0.00	661.03	726.98	1,388.01
August 2018	0.00	1,004.82	956.41	1,961.23
September 2018	285.96	721.01	840.36	1,847.32
October 2018	267.08	316.47	362.31	945.87
November 2018	0.00	64.87	0.00	64.87
December 2018	258.42	1,453.15	0.00	1,711.57
Total	**849.06**	**9,641.54**	**7,825.72**	**18,316.32**

Monitoring equipment

Item	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.1,y}$) Description (EL4)	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.1,y}$) Description (EL5)	
	01/01/2018 – 31/12/2018	01/01/2018 – 31/12/2018	
		Main energy meter	Check energy meter
Type	EDMI Limited (Mk6E) Power Meter	Itron (SL761A071) Power Meter	
Accuracy class	Class 0.5S	Class 0.20	
Serial No.	210225256	53099690	53099691
Calibration frequency	24 months	5 years	
Date of last calibration	06/01/2017	01/04/2011	
Validity	24 months	5 years (Type 2 according to the Malaysian Grid Code, version 1/2010)	

EL 5 (Itron, serial no.: 53099690) – The meter is owned by the grid operator, TNB and thus, it is not within the control of the project. However, due to delay in calibration, the maximum permissible error of ±0.2% which is the equipment accuracy error was applied to EL5 from 01/01/2018 – 31/12/2018 as a conservative approach.

Item	$EG_{PJ,y}$ ($EL_{LFG,GE\ No.2,y}$) Description (EL9)		$EG_{PJ,y}$ ($EL_{LFG,GE\ No.3,y}$) Description (EL10)	
	01/01/2018 – 31/12/2018		01/01/2018 – 31/12/2018	
Type	EDMI Limited (Genius) Power Meter		EDMI Limited (Genius) Power Meter	
Accuracy class	Class 0.5S		Class 0.5S	
Serial No.	211516862		211516863	
Calibration frequency	24 months		24 months	
Date of last calibration	13/05/2015	25/01/2018	13/05/2015	25/01/2018
Validity	24 months		24 months	

EL9 and EL 10 – Due to delay in calibration, the maximum permissible error of ±2.08% and ±1.14% respectively which is the equipment calibration error was applied to EL9 and EL10 from 01/01/2018 – 24/01/2018 as a conservative approach.

Item	$EG_{PJ,y}$ ($EL_{LFG,y}$) Description (EL11)	
	01/01/2018 – 31/12/2018	
	Main energy meter	Check energy meter
Type	EDMI (Mk6E) Power Meter	
Accuracy class	Class 0.5S	
Serial No.	908705152	908705154
Calibration frequency	5 years	
Date of last calibration	06/12/2009	

	Validity: 5 years (Type 2 according to the Malaysian Grid Code, version 1/2010) EL 11 (EDMI Limited, serial no.: 908705152) – The meter is owned by the grid operator, TNB and thus, it is not within the control of the project. However, due to delay in calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to EL11 from 01/01/2018 – 31/12/2018 as a conservative approach. **Item** / **$EG_{PJ,y}$ ($EL_{LFG,GE\ No.4,y}$) Description (EL12)**: 01/01/2018 – 31/12/2018: Type: EDMI Limited (2000-6N00-30A31-04-L00-02A2-1D) Power Meter; Accuracy class: Class 0.5S; Serial No.: 213545834; Calibration frequency: 24 months; Date of last calibration: 04/02/2016, 08/08/2018; Validity: 24 months **$EG_{PJ,y}$ ($EL_{LFG,y}$) Description (EL13)**: 01/01/2018 – 31/12/2018: Main energy meter: Itron (SL761W071) Power Meter; Class 0.2S; 81480576; 14/06/2016; Check energy meter: 81480578; 5 years (Type 2 according to the Malaysian Grid Code, version 1/2010) EL12 - Due to delay in calibration, the maximum permissible error of ±1.17% which is the equipment calibration error was applied to EL12 from 04/02/2018 – 07/08/2018 as a conservative approach.
Measuring/reading/recording frequency	Measured continuously with electricity meter installed
Calculation method (if applicable)	NA
QA/QC procedures	As a quality control procedure, the amount of electricity actually uploaded to grid will be measured by other electricity meters (EL5, EL11 and EL13) and compared with the net amount derived from above. Lower value of the amount will be taken as the net amount for emission reduction calculations. Electricity meters (except the meters owned by the grid operator, i.e. EL5, EL11 and EL13) will be checked and calibrated regularly according to manufacturer's recommendations. The meters EL5, EL11 and EL13 are owned by the grid operator and thus, they are not within the control of the project. The calibration of these meters will be based on the grid operator's requirement and standard practice.
Purpose of data/parameter	Baseline emissions calculation
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>$EG_{EC,y}$ ($EL_{PJ,y}$)</td></tr>
<tr><td>Unit</td><td>MWh</td></tr>
<tr><td>Description</td><td>Amount of electricity consumed by the project activity in year y</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Based on continuous measurement by sealed electricity meter installed.

The quantity of electricity consumed by project activity will be recorded by installed electricity meter EL6 which measured the total electricity consumed by the project activity (Flare 2, Gas Engine No.1, Gas Engine No.2, Gas Engine No.3, Gas Engine No.4, GSS No.1, GSS No.2 and GSS F1).

In case of temporary situation such as the installed electricity meter mal-functioned (EL6) leading to no readings captured, $EG_{EC,y}$ shall be estimated or calculated as described as below:

1. Using the backup meter EL1 which recorded the actual power consumption for Flare 2 and GSS F1;
2. For Gas Engine No. 2, Gas Engine No.3, Gas Engine No.4, GSS No.1 and GSS No.2, the power consumption will be estimated using the power rating (technical specifications) of the system involved during the power generation. The power consumed will be calculated based on the operating maximum capacity for the full period, including the 10% addition to account for transmission and distribution losses, according to PRC-2467-02.

In the case, temporary situation where EL1 is mal-functioned leading to no reading captured, the power consumption for Flare 1, Flare 2 and Gas Engine No.1 will be using the estimated historical data (September 2014 to August 2016) of 56.93 MWh and compared with the calculated future 24 months' data prior the malfunction period and, whichever higher will be applied for the project emission calculation.

The higher power consumption selected for the project emission calculation shall be derived based on 95% confidence interval principles (source: "IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", page 6.6). The upper bound of 95% confidence interval with reference to the above-mentioned guideline to be applied.

Additional 10% will be added to the upper bound of the interval boundaries calculated to account for transmission and distribution losses, according to PRC-2467-02.</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Months</th><th>Electricity consumed $EG_{EC,y}$ ($EL_{PJ,y}$) (EL6) (MWh)</th></tr>
<tr><td>January 2018</td><td>123.85</td></tr>
<tr><td>February 2018</td><td>126.06</td></tr>
<tr><td>March 2018</td><td>152.45</td></tr>
<tr><td>April 2018</td><td>125.79</td></tr>
<tr><td>May 2018</td><td>132.45</td></tr>
<tr><td>June 2018</td><td>76.92</td></tr>
<tr><td>July 2018</td><td>116.72</td></tr>
<tr><td>August 2018</td><td>156.36</td></tr>
<tr><td>September 2018</td><td>146.55</td></tr>
<tr><td>October 2018</td><td>98.74</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td>November 2018</td><td>33.13</td></tr>
<tr><td>December 2018</td><td>137.63</td></tr>
<tr><td>Total</td><td>1,426.65</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th rowspan="2">Item</th><th colspan="2">Electricity consumed from grid for project activity
$EG_{EC,y}$ ($EL_{PJ,y}$) (EL6) (MWh)</th></tr>
<tr><th colspan="2">01/01/2018 – 31/12/2018</th></tr>
<tr><td>Type</td><td colspan="2">IME NEMO 96HDL
Power Meter</td></tr>
<tr><td>Accuracy class</td><td colspan="2">Class 1 (± 1%)</td></tr>
<tr><td>Serial No.</td><td colspan="2">2661930098</td></tr>
<tr><td>Calibration frequency</td><td colspan="2">36 months</td></tr>
<tr><td>Date of last calibration</td><td>23/07/2014</td><td>25/01/2018</td></tr>
<tr><td>Validity</td><td colspan="2">3 years according to manufacturer’s recommendation</td></tr>
</table>

EL 6 – Due to delay in calibration, the maximum permissible error of ±1% which is the equipment accuracy error was applied to EL6 from 01/01/2018 – 24/01/2018 as a conservative approach.
</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>Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings will be double-checked by the electricity distribution company</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculation</td></tr>
<tr><td>Additional comment</td><td>This parameter is required for calculating project emissions from electricity consumption due to an alternative waste treatment process t ($\boldsymbol{PE_{EC,y}}$) using the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”</td></tr>
</table>

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

Data / Parameter	f_y
Unit	-
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
Measured/calculated/default	
Source of data	Onsite records of the gas analyzers.
Value(s) of monitored parameter	

Months	Flare No.2 Value (%)	GSS1 Value (%)	GSS2 Value (%)	GSSF1 Value (%)
January 2018	0.60	0.68	0.54	0.59
February 2018	0.58	0.68	0.52	0.00
March 2018	0.57	0.64	0.54	0.00
April 2018	0.58	0.63	0.55	0.00
May 2018	0.63	0.54	0.60	0.00
June 2018	0.62	0.54	0.60	0.00
July 2018	0.62	0.67	0.60	0.00
August 2018	0.59	0.60	0.57	0.00
September 2018	0.59	0.62	0.58	0.55
October 2018	0.61	0.62	0.58	0.59
November 2018	0.63	0.58	0.00	0.00
December 2018	0.60	0.41	0.00	0.59
Average	**0.60**	**0.60**	**0.57**	**0.58**

Monitoring equipment	
Measuring/reading/recording frequency	For application A: Once for the crediting period ($f_y = f$)
Calculation method (if applicable)	NA
QA/QC procedures	-
Purpose of data/parameter	Baseline emissions calculation
Additional comment	This is for reporting purposes, and not applied in the ER calculation

"Project emissions from flaring" (Version 02.0.0)

Data / Parameter	$T_{EG,m}$ ($T_{Flare,F2}$)
Unit	°C
Description	Temperature in the exhaust gas of the enclosed flare in minute *m*
Measured/calculated/default	Measured
Source of data	Project participant
Value(s) of monitored parameter	

Months	$T_{EG,m}$ ($T_{Flare,F2}$) (°C)
January 2018	708.89
February 2018	659.86
March 2018	572.48
April 2018	609.54
May 2018	611.08
June 2018	706.66

	<table><tr><td>July 2018</td><td>621.19</td></tr><tr><td>August 2018</td><td>561.82</td></tr><tr><td>September 2018</td><td>593.52</td></tr><tr><td>October 2018</td><td>686.10</td></tr><tr><td>November 2018</td><td>718.43</td></tr><tr><td>December 2018</td><td>548.36</td></tr><tr><td>Average</td><td>633.16</td></tr></table>
Monitoring equipment	<table><tr><th rowspan="2">Item</th><th colspan="2">$T_{EG,m}$ ($T_{Flare,F2}$) Description 01/01/2018 – 31/12/2018</th></tr><tr><td>Type</td><td colspan="2">Honeywell (STT25M-0-EN0-000-000-000-00 3D) Temperature Transmitter</td></tr><tr><td>Accuracy class</td><td colspan="2">± 0.5% of span</td></tr><tr><td>Serial No.</td><td colspan="2">B838901937</td></tr><tr><td>Calibration frequency</td><td colspan="2">Annually</td></tr><tr><td>Date of last calibration</td><td>13/09/2017</td><td>11/10/2018</td></tr><tr><td>Validity</td><td colspan="2">1 year</td></tr></table> **Flare No.2** Due to delay in calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT3 from 13/09/2018 – 10/10/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.
Measuring/reading/recording frequency	Once per minute
Calculation method (if applicable)	Measure the temperature of the exhaust gas in the flare by an appropriate temperature measurement equipment. The temperature of the exhaust gas in the flares is measured by temperature transmitters. The exhaust gas from the enclosed flares is expected to be in the range of 800 – 1,200°C. Temperatures above 500°C indicate that the flare is operated in a reliable way where the default value of destruction efficiency of 90% is valid. Minimum operational temperature in the exhaust gas of the enclosed flare is 500°C.
QA/QC procedures	Temperature measurement equipment is calibrated in accordance with the maintenance schedule
Purpose of data/parameter	Baseline emissions calculation
Additional comment	Any unexpected changes such as a sudden increase/drop in temperature will be noted in the site records along with any corrective action that was implemented to correct the issue. Monitoring of this parameter is applicable in case of enclosed flares. Measurements are required to determine if manufacturer's flare specifications for operating temperature are met

Data / Parameter	**$Flame_m$**
Unit	Flame on or Flame off
Description	Flame detection of flare in the minute *m*

Measured/calculated/default	Measured
Source of data	Project participant
Value(s) of monitored parameter	On or Off, refer to $V_{t,wb}$
Monitoring equipment	Fixed installation optical flame detector: Ultra-violet detector
Measuring/reading/recording frequency	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off.
Calculation method (if applicable)	The flame detection will be monitored and cross checked with the amount of gas sent to flare (FT2) and gas engine (FT3). If there is data for FT2 and FT3, means the flame is on. Equipment will be maintained and calibrated in accordance with manufacturer's recommendations
QA/QC procedures	Baseline emissions calculation
Purpose of data/parameter	Applicable to all flares
Additional comment	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off.

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

Data / Parameter	**$V_{t,wb}$ ($LFG_{Flare,\ Flare\ No.2,y}$, $LFG_{electrcity,GSS1,y}$, $LFG_{electrcity,GSS2,y}$ $LFG_{electrcity,GSSF1,y}$)**
Unit	m^3 wet gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a wet basis
Measured/calculated/default	Measured
Source of data	Onsite records of the flow meters. There is an independent flow meter to measure the gas sent to Flare No.2, ($FT2_{Flare\ No.2}$), GSS1 ($FT3_{GSS1}$), GSS2 ($FT3_{GSS2}$), and GSS F1 ($FT3_{GSSF1}$).
Value(s) of monitored parameter	***LGF_{total} - Total amount of LFG sent to flare/captured during the project at normal temperature and pressure:*** **Flare No.2** According to ACM 0001, version 18, page 15, if the LFG is used for multiple purposes (e.g. flaring or energy generation), and all methane destruction devices are verified to be operational (e.g. by means of flame detector records, energy generated), a single flow meter may be used to record the flow into multiple destruction devices. However, as Gas Engine No.1 is being converted to GSS F1 which starts to operate on 01/06/2017, only one flow meter (FT2) remained for Flare No. 2, therefore, no comparison was done started from June 17 onwards.

Months	**$V_{t,wb}$ ($LFG_{Flare,Flare\ No.2,y}$) $FT_{2,\ Flare\ No.2}$ (Nm^3)**
January 2018	715,924
February 2018	704,088
March 2018	594,801
April 2018	457,176

May 2018	145,649
June 2018	754,175
July 2018	682,316
August 2018	616,134
September 2018	588,162
October 2018	699,829
November 2018	820,156
December 2018	681,167
Total	**7,459,579**

GSSF1 (Gas Engine No.1), GSS1 (Gas Engine No.2 and 3) and GSS2 (Gas Engine No.4)

According to ACM 0001, version 18, page 15, if the LFG is used for multiple purposes (e.g. flaring or energy generation), and all methane destruction devices are verified to be operational (e.g. by means of flame detector records, energy generated), a single flow meter may be used to record the flow into multiple destruction devices. In the case where LFG is just sent to the power plants (gas engines) for electricity generation, one flow meter 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 sent to the gas engines for GSS F1, GSS1 and GSS2 respectively during the monitoring period as total LFG captured in GSSF1 was only sent to Gas Engine No.1, total LFG captured in GSS1 was only sent to Gas Engine No.2 and No.3, and total LFG captured in GSS2 was sent to Gas Engine No.4.

Months	$V_{t, wb}$ ($LFG_{electrcity,GSS1,y}$) $FT_{3, GSS1}$ (Nm^3)	$V_{t, wb}$ ($LFG_{electrcity,GSS2,y}$) $FT_{3, GSS2}$ (Nm^3)	$V_{t, wb}$ ($LFG_{electrcity,GSSF1,y}$) $FT_{3, GSSF1}$ (Nm^3)
January 2018	456,609	493,543	24,044
February 2018	527,447	427,416	0
March 2018	722,906	452,279	0
April 2018	506,303	407,593	0
May 2018	445,452	465,138	0
June 2018	323,748	67,381	0
July 2018	381,939	343,948	0
August 2018	593,927	458,609	0
September 2018	432,984	395,182	197,248
October 2018	187,090	192,640	188,136
November 2018	27,991	0	0
December 2018	807,411	0	175,663
Total	**5,413,807**	**3,703,730**	**585,091**

Monitoring equipment

Item	Flare No.2, $LFG_{flare,Flare\ No.2,y}$ ($FT_{2,\ Flare\ No.2}$)
	01/01/2018 – 31/12/2018
Type	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone
Accuracy class	± 0.5%
Serial No.	5476627 (Rosemount) / FT140 (10031701) (Kingways)
Calibration frequency	24 months
Date of last calibration	13/09/2017
Validity	24 months

Item	GSS1, $LFG_{electricity,GSS1,y}$ ($FT_{3,\ GSS1}$)	
	01/01/2018 – 31/12/2018	
Type	Flow transmitter – Rosemount	
Accuracy class	± 0.5%	
Serial No.	5988022	
Calibration frequency	24 months	
Date of last calibration	07/06/2016	11/10/2018
Validity	24 months	

Item	GSS2, $LFG_{electricity,GSS2,y}$ ($FT_{3,\ GSS2}$)	
	01/01/2018 – 31/12/2018	
Type	Flow transmitter – Binder	
Accuracy class	± 2.5% of reading + 0.2% of full scale	
Serial No.	C150327	
Calibration frequency	24 months	
Date of last calibration	23/06/2015	10/12/2018
Validity	24 months	

Item	GSSF1, $LFG_{electricity,GSSF1,y}$ ($FT_{3,\ GSSF1}$)
	01/01/2018 – 31/12/2018
Type	Flow transmitter – Rosemount Differential Pressure Transmitter – Kingways Control Vcone
Accuracy class	± 0.5%
Serial No.	02768007 (Rosemount) / FT161 (11011001) (Kingways)
Calibration frequency	24 months
Date of last calibration	05/01/2017
Validity	24 months

GSS1 (Gas Engine No.2 & 3)

FT3 – Due to delay in calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to FT3 from 07/06/2018 – 10/10/2018 as a conservative approach.

	GSS2 (Gas Engine No. 4) FT3 - Due to delay in calibration, the maximum permissible error of ±2.7% which is the equipment accuracy error was applied to FT3 from 01/01/2018 – 09/12/2018 as a conservative approach.
Measuring/reading/recording frequency	Continuous if not specified in the underlying methodology/tool
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory for all projects applying large scale methodology(ies). Calibration and frequency of calibration is according to manufacturer's specifications
Purpose of data/parameter	Baseline emissions calculation
Additional comment	This parameter is monitored in Option B

Data / Parameter	**$V_{CH4,m,db}$ ($W_{CH4,Flare\ No.2,y}$, $W_{CH4,GSS1,y}$, $W_{CH4,GSS2,y}$, $W_{CH4,GSSF1,y}$)**
Unit	m^3 CH_4 / m^3 dry gas
Description	Volumetric fraction of greenhouse gas CH_4 in minute *m* on a dry basis
Measured/calculated/default	Measured
Source of data	Onsite records of the gas analyzers. In case of temporary situation such as the installed CH_4 gas analyser mal-functioned or giving unrepresentative results due to data logging problem, the V_{CH4} shall be measured manually with portable gas analyser. For any affected day, the calculation of the values measured using the portable analyser will be based on the Guidelines to calculate the fraction of methane in the landfill gas from periodical measurements (Version 01). As conservative approach, the lower bound of the 95% Confidence Interval will be applied as per guideline.
Value(s) of monitored parameter	

Months	**Methane Fraction of LFG (%), $V_{CH4,m,db}$**			
	Flare No.2, $W_{CH4,Flare\ No.2,y}$	**GSS1, $W_{CH4,GSS1,y}$**	**GSS2, $W_{CH4,GSS2,y}$**	**GSSF1, $W_{CH4,GSSF1,y}$**
January 2018	0.60	0.68	0.54	0.59
February 2018	0.58	0.68	0.52	0.00
March 2018	0.57	0.64	0.54	0.00
April 2018	0.58	0.63	0.55	0.00
May 2018	0.63	0.54	0.60	0.00
June 2018	0.62	0.54	0.60	0.00
July 2018	0.62	0.67	0.60	0.00
August 2018	0.59	0.60	0.57	0.00
September 2018	0.59	0.62	0.57	0.55
October 2018	0.61	0.62	0.57	0.59
November 2018	0.63	0.57	0.00	0.00
December 2018	0.60	0.41	0.00	0.59
Average	**0.60**	**0.60**	**0.57**	**0.58**

Monitoring equipment

Item	Flare No.2, $W_{CH4,Flare\ No.2,y}$ ($CH_{4,\ Flare\ No.2}$) 01/01/2018 – 31/12/2018	
Type	Guardian Plus (97460) Infra-Red Gas Monitor	
Accuracy class	± 2%	
Serial No.	31453	
Calibration frequency	Annually	
Date of last calibration	05/01/2017	04/06/2018
Validity	1 year	

Flare 2

CH4 – Due to delay in calibration, the maximum permissible error of which is the equipment accuracy error was applied to CH4 from 05/01/2018 – 03/06/2018 as a conservative approach.

Item	GSS1, $W_{CH4,GSS1,y}$ ($CH_{4,\ GSS1}$) 01/01/2018 – 31/12/2018	
Type	Guardian Plus (97460) Infra-Red Gas Monitor	
Accuracy class	± 2%	
Serial No.	34140	
Calibration frequency	Annually	
Date of last calibration	09/11/2017	
Validity	1 year	

GSS1 (Gas Engine No. 2 & 3)

CH4 – Due to delay in calibration, the maximum permissible error of ±2.0% which is the equipment accuracy error was applied to CH4 from 09/11/2018 – 31/12/2018 as a conservative approach.

Item	GSS2, $W_{CH4,GSS2,y}$ ($CH_{4,\ GSS2}$) 01/01/2018 – 31/12/2018	
Type	Guardian Plus (97460)	
Accuracy class	± 2%	
Serial No.	33542	
Calibration frequency	Annually	
Date of last calibration	13/09/2017	11/10/2018
Validity	1 year	

GSS2 (Gas Engine No.4)

CH4 - Due to delay in calibration, the maximum permissible error of ±2.0% which is the equipment accuracy error was applied to CH4 13/09/2018 – 10/10/2018 as a conservative approach.

	<table><tr><th>Item</th><th>GSSF1, $W_{CH4,GSSF1,y}$ ($CH_{4, GSSF1}$) 01/01/2018 – 31/12/2018</th></tr><tr><td>Type</td><td>Guardian Plus (97460)</td></tr><tr><td>Accuracy class</td><td>± 2%</td></tr><tr><td>Serial No.</td><td>33436</td></tr><tr><td>Calibration frequency</td><td>Annually</td></tr><tr><td>Date of last calibration</td><td>13/09/2017</td></tr><tr><td>Validity</td><td>1 year</td></tr></table> **GSSF1 (Gas Engine No.1)** CH4 – Due to delay in calibration, the maximum permissible error of ±2.0% which is the equipment accuracy error was applied to CH4 from 13/09/2018 – 31/12/2018 as a conservative approach.
Measuring/reading/recording frequency	The CH_4 fraction were measured continuously with certified equipment or measured manually with a portable gas analyser during emergency cases
Calculation method (if applicable)	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures	The CH_4 gas analyser was checked and calibrated regularly according to the manual given by the manufacturer
Purpose of data/parameter	Baseline emission calculation
Additional comment	-

Data / Parameter	**T_t ($T_{TT1,F2}$, $T_{TT1,GSS1}$, $T_{TT1,GSS2}$, $T_{TT1,GSSF1}$)**
Unit	°C
Description	Temperature of the gaseous stream in time interval *t*
Measured/calculated/default	Measured
Source of data	Continuous measurement by temperature meter. This parameter was measured separately for both flare and the gas engines, i.e. Flare No.2 (1 meter), Gas Engine No.1 (1 meter), Gas Engine No.2 and No.3 (1 meter) and Gas Engine No.4 (1 meter). Therefore, 4 sets of equipment have to be used for the monitoring period.
Value(s) of monitored parameter	

Months	T_t (°C)			
	$T_{TT1,F2}$	$T_{TT1,GSS1}$	$T_{TT1,GSS2}$	$T_{TT1,GSSF1}$
January 2018	36.73	42.52	41.85	33.68
February 2018	39.84	45.15	42.92	33.23
March 2018	36.93	46.40	41.32	33.39
April 2018	37.32	47.65	40.93	33.44
May 2018	37.46	55.30	40.94	0.00
June 2018	39.56	53.80	31.57	0.00
July 2018	37.55	53.97	38.90	0.00
August 2018	37.72	53.45	43.00	0.00
September 2018	36.45	47.38	40.18	39.62
October 2018	39.45	38.66	35.00	39.20
November 2018	44.10	33.10	30.34	33.25
December 2018	37.94	47.50	29.33	40.88
Average	**38.42**	**47.07**	**38.02**	**35.84**

Monitoring equipment

Item	Flare No.2, T_t ($T_{TT1,F2}$)	
	01/01/2018 -31/12/2018	
Type	Honeywell (STT25M-0-EN0-000-000-000-00-3D) Temperature Transmitter	
Accuracy class	± 0.5% of span	
Serial No.	B839917437	
Calibration frequency	Annually	
Date of last calibration	13/09/2017	11/10/2018
Validity	1 year	

Flare No.2

TT1 - Due to delay in calibration, the maximum permissible error of ±0.5% which is the equipment accuracy error was applied to TT1 from 13/09/2018 – 10/10/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Item	GSS1, T_t ($T_{TT1,GSS1}$)	
	01/01/2018 – 31/12/2018	
Type	Honeywell (STT25M-0-ENS-000-000-000-00-3H) Temperature Transmitter	
Accuracy class	± 1%	
Serial No.	b527143837	
Calibration frequency	Annually	
Date of last calibration	13/09/2017	11/10/2018
Validity	1 year	

GSS1 (Gas Engine No. 2 & 3)

TT1 - Due to delay in calibration, the maximum permissible error of ±1% which is the equipment accuracy error was applied to TT1 from 13/09/2018 – 10/10/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Item	GSS2, T_t ($T_{TT1,GSS2}$)	
	01/01/2018 – 31/12/2018	
Type	Autrol (ATT2100-S11HA3E1-M1) Temperature Transmitter	
Accuracy class	± 0.1%	
Serial No.	ATT21004151000	
Calibration frequency	Annually	
Date of last calibration	05/01/2017	04/06/2018
Validity	1 year	

GSS2 (Gas Engine No. 4)

TT1 - Due to delay in calibration, the maximum permissible error of ±0.2% which is the equipment accuracy error was applied to TT1 from 05/01/2018 – 03/06/2018 as a conservative approach.

	<table><tr><th rowspan="2">Item</th><th colspan="2">GSSF1, T_t ($T_{TT1,GSSF1}$) 01/01/2018</th></tr><tr><td>Type</td><td colspan="2">PR Electronics (5335A) Temperature Transmitter</td></tr><tr><td>Accuracy class</td><td colspan="2">≤ ± 0.05% of span</td></tr><tr><td>Serial No.</td><td colspan="2">100944768</td></tr><tr><td>Calibration frequency</td><td colspan="2">Annually</td></tr><tr><td>Date of last calibration</td><td>05/01/2017</td><td>04/06/2018</td></tr><tr><td>Validity</td><td colspan="2">1 year</td></tr></table> **GSS F1 (Gas Engine No. 1)** TT1 - Due to delay in calibration, the maximum permissible error of ±0.3% which is the equipment accuracy error was applied to TT1 from 05/01/2018 – 03/06/2018 as a conservative approach.
Measuring/reading/recording frequency	Measured continuously by temperature meter
Calculation method (if applicable)	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures	The temperature transmitter was calibrated regularly according to the manual given by the manufacturer
Purpose of data/parameter	Baseline emission calculation
Additional comment	-

Data / Parameter	**P_t ($P_{PT2,F1}$, $P_{PT2,F2}$, $P_{PT2,GSS1}$, $P_{PT2,GSS2}$, $P_{PT2,GSSF1}$)**
Unit	kPa
Description	Pressure of the gaseous stream in time interval *t*
Measured/calculated/default	Measured
Source of data	Continuous measurement by pressure transmitter. This parameter was measured separately for both flares and the gas engines, i.e. Flare No.2 (1 meter), Gas Engine No.1 (1 meter), Gas Engine No.2 and No.3 (1 meter) and Gas Engine No.4 (1 meter). Therefore, 4 sets of equipment have to be used for the monitoring period.
Value(s) of monitored parameter	<table><tr><th rowspan="2">Average Gauge Pressure (Months)</th><th colspan="4">P_t (kPa)</th></tr><tr><th>$PT_{PT2,F2}$</th><th>$PT_{PT2,GSS1}$</th><th>$PT_{PT2,GSS2}$</th><th>$PT_{PT2,GSSF1}$</th></tr><tr><td>January 2018</td><td>5.32</td><td>16.70</td><td>16.76</td><td>2.47</td></tr><tr><td>February 2018</td><td>6.23</td><td>17.01</td><td>16.72</td><td>1.01</td></tr><tr><td>March 2018</td><td>4.01</td><td>16.41</td><td>15.82</td><td>1.02</td></tr><tr><td>April 2018</td><td>5.05</td><td>16.15</td><td>15.45</td><td>1.02</td></tr><tr><td>May 2018</td><td>7.13</td><td>16.76</td><td>16.24</td><td>0.00</td></tr><tr><td>June 2018</td><td>8.39</td><td>16.56</td><td>4.62</td><td>0.00</td></tr><tr><td>July 2018</td><td>6.38</td><td>16.80</td><td>12.81</td><td>0.00</td></tr><tr><td>August 2018</td><td>5.92</td><td>16.17</td><td>16.22</td><td>0.00</td></tr><tr><td>September 2018</td><td>6.72</td><td>16.98</td><td>15.16</td><td>11.00</td></tr></table>

October 2018	10.20	10.32	9.28	10.36
November 2018	14.66	5.37	4.01	1.59
December 2018	8.09	16.99	3.12	12.27
Average	**7.34**	**15.18**	**12.18**	**5.09**

Average Absolute Pressure (Months)	**P_t (kPa)**			
	$PT_{PT2,F2}$	**$PT_{PT2,GSS1}$**	**$PT_{PT2,GSS2}$**	**$PT_{PT2,GSSF1}$**
January 2018	106.64	118.02	118.08	103.80
February 2018	107.55	118.33	118.05	102.34
March 2018	105.33	117.74	117.15	102.34
April 2018	106.38	117.47	116.78	102.34
May 2018	108.46	118.08	117.56	101.33
June 2018	109.71	117.88	105.95	101.33
July 2018	107.71	118.13	114.14	101.33
August 2018	107.25	117.49	117.55	101.33
September 2018	108.04	118.30	116.48	112.33
October 2018	111.53	111.65	110.60	111.69
November 2018	115.98	106.69	105.34	102.92
December 2018	109.41	118.32	104.45	113.59
Average	**108.67**	**116.51**	**113.51**	**104.72**

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

Monitoring equipment

Item	Flare No.2, P_t ($PT_{PT2,F2}$)	
	01/01/2018 – 31/12/2018	
Type	Rosemount (3051TG1A2B21AB4E5Q4) Pressure Transmitter	
Accuracy class	± 0.25%	
Serial No.	5584784	
Calibration frequency	Annually	
Date of last calibration	13/09/2017	11/10/2018
Validity	1 year	

Flare No. 2

PT2 - Due to delay in calibration, the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 13/09/2018 – 10/10/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Item	GSS1, P_t ($PT_{PT2,GSS1}$)	
	01/01/2018 – 31/12/2018	
Type	Rosemount (3051TG1A2B21AB4K5M5) Pressure Transmitter	
Accuracy class	± 0.1%	
Serial No.	5916057	
Calibration frequency	Annually	
Date of last calibration	13/09/2017	11/10/2018
Validity	1 year	

GSS1 (Gas Engine No. 2 & 3)

PT2 - Due to delay in calibration, the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 13/09/2018 – 10/10/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Item	GSS2, P_t ($PT_{PT2,GSS2}$)	
	01/01/2018 – 31/12/2018	
Type	Autrol (APT3200-G4M11E11S1-M1) Pressure Transmitter	
Accuracy class	± 0.075% of span	
Serial No.	APT3200-4150998	
Calibration frequency	Annually	
Date of last calibration	05/01/2017	04/06/2018
Validity	1 year	

GSS2 (Gas Engine No. 4)

PT2 - Due to delay in calibration, the maximum permissible error of ±0.4% which is the equipment accuracy error was applied to PT2 from 05/01/2018 – 03/06/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.

Item	GSSF1, P_t ($PT_{PT2,GSSF1}$)

	<table><tr><th></th><th colspan="2">01/01/2018 – 31/12/2018</th></tr><tr><td>Type</td><td colspan="2">Rosemount (3051TG1A2B21AB4E5M5Q4) Pressure Transmitter</td></tr><tr><td>Accuracy class</td><td colspan="2">± 0.25%</td></tr><tr><td>Serial No.</td><td colspan="2">02492864</td></tr><tr><td>Calibration frequency</td><td colspan="2">Annually</td></tr><tr><td>Date of last calibration</td><td>05/01/2017</td><td>04/06/2018</td></tr><tr><td>Validity</td><td colspan="2">1 year</td></tr></table> **GSS F1 (Gas Engine No. 1)** PT2 - Due to delay in calibration, the maximum permissible error of ±0.25% which is the equipment accuracy error was applied to PT2 from 05/01/2018 – 03/06/2018 as a conservative approach. The impact of applying this error to the flow normalisation is negligible.
Measuring/reading/recording frequency	Measured continuously by a pressure transmitter
Calculation method (if applicable)	Raw data logged at 1 minute's interval was used to compute the daily average readings
QA/QC procedures	The meter was checked and calibrated regularly according to the manual given by the manufacturer
Purpose of data/parameter	Baseline emission calculation
Additional comment	-

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

Data / Parameter	**$V_{CO2,t,db}$**
Unit	m^3 gas CO_2 / m^3 dry gas
Description	Volumetric fraction of greenhouse gas CO_2 in the gaseous stream in time interval *t* on a dry basis
Measured/calculated/default	Measured

Source of data	The V_{CO2} shall be measured manually with portable gas analyser. A minimum sampling frequency of one sample per week to be conducted. As conservative approach, the lower bound of the 95% Confidence Interval will be applied for the data collected.
Value(s) of monitored parameter	36.8%
Monitoring equipment	Portable gas analyser
Measuring/reading/recording frequency	Continuous if not specified in the underlying methodology/tool
Calculation method (if applicable)	Continuous gas analyser operating in dry-basis
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Purpose of data/parameter	Baseline emissions calculation
Additional comment	-

Data / Parameter	**$V_{O2,t,db}$**
Unit	m^3 gas O_2 / m^3 dry gas
Description	Volumetric fraction of greenhouse gas O_2 in the gaseous stream in time interval *t* on a dry basis
Measured/calculated/default	Measured
Source of data	On site measurement
Value(s) of monitored parameter	
Monitoring equipment	Continuous gas analyser operating in dry-basis
Measuring/reading/recording frequency	Continuous if not specified in the underlying methodology/tool
Calculation method (if applicable)	-

Oxygen (Months)	**Flare No.2 Value (%)**
January 2018	0.60
February 2018	1.06
March 2018	2.08
April 2018	1.78
May 2018	0.10
June 2018	0.32
July 2018	0.18
August 2018	1.26
September 2018	1.67
October 2018	0.70
November 2018	0.25
December 2018	1.22
Average	**0.93**

QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period
Purpose of data/parameter	Baseline emissions calculation
Additional comment	-

Data / Parameter	**Status of biogas destruction device**
Unit	-
Description	Operational status of biogas destruction devices
Measured/calculated/default	Measured
Source of data	On-site measurement
Value(s) of monitored parameter	On or Off, refer to $V_{t,wb}$ and operating hour of Gas engines ($\mathbf{Op_{j,h}}$).
Monitoring equipment	Monitoring and documenting may be undertaken by recording the energy production from methane captured or the operation of the flare by means of a flame detector to demonstrate the actual destruction of methane, unless a different method is specified in the underlying methodology/tool. Emission reductions will not accrue for periods in which the destruction device is not operational
Measuring/reading/recording frequency	Continuous if not specified in the underlying methodology/tool
Calculation method (if applicable)	NA
QA/QC procedures	The operational status will be monitored and cross checked with the amount of gas sent to flare (FT2), and also the operating hour for Gas Engines.
Purpose of data/parameter	Baseline emissions calculation
Additional comment	For flame detector devices, refer to the methodological tool “Project emissions from flaring”

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

Data / Parameter	**$FC_{i,j,y}$**
Unit	ton/yr
Description	Quantity of fuel type i combusted in process j during the year y
Measured/calculated/default	Measured
Source of data	Onsite measurements
Value(s) of monitored parameter	0 ton/yr (No diesel usage during this monitoring period)
Monitoring equipment	Fuel meter
Measuring/reading/recording frequency	Continuously
Calculation method (if applicable)	The measurement from fuel meter is in litre, for the calculation, the amount of diesel in litre will be convert to tonne/year by multiply the density of diesel (kg/l)
QA/QC procedures	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records

Purpose of data/parameter	Project emissions calculation
Additional comment	-

Data / Parameter	**$EFCO_{2,i,y}$**
Unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type i in year y
Measured/calculated/default	Default (Option D was applied in the calculation)
Source of data	Option A will be used if the value is available from the fuel supplier in invoices; Option D will be used if there is no data available from the fuel supplier.
Value(s) of monitored parameter	0.0741
Monitoring equipment	-
Measuring/reading/recording frequency	If the values are provided by fuel supplier, the measurements should be undertaken in line with national or international fuel standards. If the value is according to IPCC default value, any future revision of the IPCC Guidelines should be taken into account.
Calculation method (if applicable)	For a): The CO_2 emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated For d): Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures	-
Purpose of data/parameter	Project emissions calculation
Additional comment	-

Data / Parameter	**$NCV_{i,y}$**
Unit	GJ/ton
Description	Weighted average net calorific value of fuel type i in year y
Measured/calculated/default	Default (Option D was applied in the calculation)
Source of data	Option A will be used if the value is available from the fuel supplier in invoices; Option D will be used if there is no data available from the fuel supplier.
Value(s) of monitored parameter	43
Monitoring equipment	-
Measuring/reading/recording frequency	For a): The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For d): Any future revision of the IPCC Guidelines should be taken into account
Calculation method (if applicable)	For a): The NCV emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For d): Any future revision of the IPCC Guidelines should be taken into account

QA/QC procedures	If option A value is used for the calculation, verify if the values under a) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data/parameter	Project emissions calculation
Additional comment	-

D.3 Implementation of sampling plan

Not applicable

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

The total baseline emissions according to ACM0001 (Version 18.0) were calculated according to the equations below:

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

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

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

$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
OX_{top_layer}	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

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

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

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

$BE_{CH4,SWDS,y}$ $PE_{CH4,SWDS,y}$ $LE_{CH4,SWDS,y}$	=	Baseline, project or leakage methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year *y* (t CO_2e/yr)
x	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year *y* (x = *y*)
y	=	Year of the crediting period for which methane emissions are calculated (*y* is a consecutive period of 12 months)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)
$W_{j,x}$	=	Amount of solid waste type *j* disposed or prevented from disposal in the SWDS in the year *x* (t)

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}}$$

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

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

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

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

Determination of $BE_{CH4,y}$

Flare No.2

Month	$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - \frac{PE_{flare,y}}{GWP_{CH4}}$							$F_{CH4,PJ,y} = F_{CH4,flared,y}$	$BE_{CH4} = \left((1 - OX_{top\_layer}) \times F_{CH4,PJ,y} - F_{CH,BL,y}\right) \times GWP_{CH4}$	
	Quantity of LFG to Flare No.2 FT2 Flare No.2,y (Nm^3)	Methane average fraction Flare No.2 WCH4	Density of Methane Flare No.2 DCH4 (t/Nm^3)	Amount of methane in LFG sent to Flare No.2 FCH4,sent_flare (t_{CH4})	Project emissions from flaring of residual gas stream PEflare (tCO_2e)	Global Warming Potential Flare No.2 GWPCH4 (tCO_2e/tCH_4)	Amount of methane in LFG destroyed by flaring FCH4,flared (tCH_4)	Amount of methane in LFG flared/used in project activity FCH4, PJ (tCH_4)	Fraction of oxidised methane in LFG in top layer of SWDS in baseline OX_{top_layer}	Baseline emissions of methane from SWDS BE_{CH4} (tCO_2e)
Jan-18	715,924.06	0.60	0.0007157	309.10	788.11	25	277.58	277.58	0.10	6,245.55
Feb-18	704,088.43	0.58	0.0007157	291.76	732.14	25	262.47	262.47	0.10	5,905.69
Mar-18	594,801.31	0.57	0.0007157	242.04	686.50	25	214.58	214.58	0.10	4,828.15
Apr-18	457,177.60	0.58	0.0007157	190.11	546.98	25	168.23	168.23	0.10	3,785.11
May-18	145,648.65	0.63	0.0007157	65.98	167.66	25	59.28	59.28	0.10	1,333.71
Jun-18	754,175.04	0.62	0.0007157	333.02	832.25	25	299.73	299.73	0.10	6,743.83
Jul-18	682,316.27	0.62	0.0007157	303.94	759.88	25	273.54	273.54	0.10	6,154.71
Aug-18	616,133.98	0.59	0.0007157	261.84	745.09	25	232.04	232.04	0.10	5,220.81
Sep-18	588,162.02	0.59	0.0007157	248.51	681.32	25	221.26	221.26	0.10	4,978.33
Oct-18	699,829.39	0.61	0.0007157	303.56	816.53	25	270.90	270.90	0.10	6,095.22
Nov-18	820,155.51	0.63	0.0007157	368.33	993.05	25	328.61	328.61	0.10	7,393.66
Dec-18	681,167.24	0.60	0.0007157	291.73	776.95	25	260.65	260.65	0.10	5,864.59

GSS1

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

Month	Density of Methane GSS1 DCH4 (t/Nm3)	Quantity of Landfill Gas Fed into GSS1 FT3 LFG electricity,y (m^3 LFG)	Average methane fraction of the Landfill Gas Fed into GSS1 W_{CH_4}	Amount of methane in LFG used for electricity generation GSS1 $F_{CH4,EL}$ (tCH_4)	Amount of methane in LFG flared/used in project activity GSS1 $F_{CH4,PJ}$ (tCH_4)	Global Warming Potential GSS1 GWP_{CH4} (tCO_2e/tCH_4)	Fraction of oxidised methane in LFG in top layer of SWDS in baseline, GSS1 OX_{top_layer}	Baseline emissions of methane from SWDS GSS1 BE_{CH4} (tCO_2e)
Jan-18	0.0007157	456,609.00	0.68	222.73	222.73	25	0.10	5,011.37
Feb-18	0.0007157	527,446.97	0.68	255.72	255.72	25	0.10	5,753.78
Mar-18	0.0007157	722,905.50	0.64	333.42	333.42	25	0.10	7,501.98
Apr-18	0.0007157	506,302.59	0.63	229.49	229.49	25	0.10	5,163.62
May-18	0.0007157	445,452.15	0.54	173.59	173.59	25	0.10	3,905.73
Jun-18	0.0007157	323,748.41	0.54	125.75	125.75	25	0.10	2,829.31
Jul-18	0.0007157	381,938.75	0.67	181.94	181.94	25	0.10	4,093.73
Aug-18	0.0007157	593,926.63	0.60	256.76	256.76	25	0.10	5,777.00
Sep-18	0.0007157	432,983.61	0.62	192.12	192.12	25	0.10	4,322.69
Oct-18	0.0007157	187,090.08	0.62	83.16	83.16	25	0.10	1,871.11
Nov-18	0.0007157	27,991.37	0.57	11.44	11.44	25	0.10	257.34
Dec-18	0.0007157	807,411.50	0.41	234.79	234.79	25	0.10	5,282.79

GSS2

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

Month	Density of Methane GSS2 DCH4 (t/Nm3)	Quantity of Landfill Gas Fed into the GSS2 FT3 LFG electricity,y (m^3 LFG)	Average methane fraction of the Landfill Gas Fed into the GSS2 WCH4	Amount of methane in LFG used for electricity generation GSS2 FCH4,EL (tCH_4)	Amount of methane in LFG flared/used in project activity GSS2 FCH4, PJ (tCH_4)	Global Warming Potential GSS2 GWPCH4 (tCO_2e/tCH_4)	Fraction of oxidised methane in LFG in top layer of SWDS in baseline GSS2 OX_{top_layer}	Baseline emissions of methane from SWDS GSS2 BE_{CH4} (tCO_2e)
Jan-18	0.0007157	481,179.61	0.54	185.10	185.10	25	0.1	4,164.70
Feb-18	0.0007157	416,709.43	0.52	155.55	155.55	25	0.1	3,499.96
Mar-18	0.0007157	440,949.22	0.54	171.96	171.96	25	0.1	3,869.08
Apr-18	0.0007157	397,382.61	0.55	156.81	156.81	25	0.1	3,528.29
May-18	0.0007157	453,486.01	0.60	193.71	193.71	25	0.1	4,358.45
Jun-18	0.0007157	65,693.54	0.60	28.32	28.32	25	0.1	637.29
Jul-18	0.0007157	335,332.30	0.60	144.89	144.89	25	0.1	3,260.04
Aug-18	0.0007157	447,121.08	0.57	182.88	182.88	25	0.1	4,114.70
Sep-18	0.0007157	385,282.50	0.57	157.45	157.45	25	0.1	3,542.62
Oct-18	0.0007157	187,814.47	0.57	76.50	76.50	25	0.1	1,721.30
Nov-18	0.0007157	0.00	0.00	0.00	0.00	25	0.1	0.00
Dec-18	0.0007157	0.00	0.00	0.00	0.00	25	0.1	0.00

GSSF1

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

Month	Density of Methane GSSF1 DCH4 (t/Nm3)	Quantity of Landfill Gas Fed into GSSF1 FT3 LFG electricity,y (m^3 LFG)	Average methane fraction of the Landfill Gas Fed into GSSF1 W_{CH_4}	Amount of methane in LFG used for electricity generation GSSF1 $F_{CH4,EL}$ (tCH_4)	Amount of methane in LFG flared/used in project activity GSSF1 $F_{CH4,PJ}$ (tCH_4)	Global Warming Potential GSSF1 GWP_{CH4} (tCO_2e/tCH_4)	Fraction of oxidised methane in LFG in top layer of SWDS in baseline, GSSF1 OX_{top_layer}	Baseline emissions of methane from SWDS GSSF1 BE_{CH4} (tCO_2e)
Jan-18	0.0007157	24,043.79	0.59	10.14	10.14	25	0.10	228.20
Feb-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Mar-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Apr-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
May-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Jun-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Jul-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Aug-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Sep-18	0.0007157	197,247.75	0.55	77.86	77.86	25	0.10	1,751.90
Oct-18	0.0007157	188,135.98	0.59	79.17	79.17	25	0.10	1,781.32
Nov-18	0.0007157	0.00	0.00	0.00	0.00	25	0.10	0.00
Dec-18	0.0007157	175,663.22	0.59	73.92	73.92	25	0.10	1,663.22

Determination of $BE_{EC, y}$

GSS1

Month	$BE_{EC,y} = \sum_k EC_{BL,k,y} \times EF_{EF,k,y} \times (1 + TDL_{k,y})$			
	Quantity of electricity generated GSS 1 $EC_{BL,k}$ (MWh)	Emission factor for electricity generation GSS1 $FE_{EL,k}$ (tCO_2/MWh)	Average technical transmission and distribution losses GSS1 TDL_k	Baseline emission for electricity GSS1 $BE_{EC,y}$ (tCO_2)
Jan-18	883.35	0.7146	0.0739	677.89
Feb-18	971.59	0.7146	0.0739	745.60
Mar-18	1,244.51	0.7146	0.0739	955.04
Apr-18	913.90	0.7146	0.0739	701.33
May-18	826.86	0.7146	0.0739	634.54
Jun-18	579.99	0.7146	0.0774	446.54
Jul-18	661.03	0.7146	0.0774	508.93
Aug-18	1,004.82	0.7146	0.0774	773.62
Sep-18	721.01	0.7146	0.0774	555.11
Oct-18	316.47	0.7146	0.0774	243.65
Nov-18	64.87	0.7146	0.0774	49.95
Dec-18	1,453.15	0.7146	0.0774	1,118.80

GSS2

Month	$BE_{EC,y} = \sum_k EC_{BL,k,y} \times EF_{EF,k,y} \times (1 + TDL_{k,y})$			
	Quantity of electricity generated **GSS 2** **ECBL,k (MWh)**	**Emission factor for electricity generation** **GSS2** **EFEL,k (tCO_2/MWh)**	**Average technical transmission and distribution losses** **GSS2** **TDLk**	**Baseline emission for electricity** **GSS2** **$BE_{EC,y}$ (tCO_2)**
Jan-18	1,082.76	0.7146	0.0739	830.92
Feb-18	883.77	0.7146	0.0739	678.21
Mar-18	913.33	0.7146	0.0739	700.90
Apr-18	919.66	0.7146	0.0739	705.75
May-18	1,015.67	0.7146	0.0739	779.43
Jun-18	124.49	0.7146	0.0774	95.84
Jul-18	726.98	0.7146	0.0774	559.71
Aug-18	956.41	0.7146	0.0774	736.35
Sep-18	840.36	0.7146	0.0774	647.00
Oct-18	362.31	0.7146	0.0774	278.95
Nov-18	0.00	0.7146	0.0774	0.00
Dec-18	0.00	0.7146	0.0774	0.00

GSSF1

Month	$BE_{EC,y} = \sum_k EC_{BL,k,y} \times EF_{EF,k,y} \times (1 + TDL_{k,y})$			
	Quantity of electricity generated GSSF1 $EC_{BL,k}$ (MWh)	Emission factor for electricity generation GSSF1 $EF_{EL,k}$ (tCO_2/MWh)	Average technical transmission and distribution losses GSSF1 TDL_k	Baseline emission for electricity GSSF1 $BE_{EC,y}$ (tCO_2)
Jan-18	37.59	0.7146	0.0774	28.94
Feb-18	0.00	0.7146	0.0774	0.00
Mar-18	0.00	0.7146	0.0774	0.00
Apr-18	0.00	0.7146	0.0774	0.00
May-18	0.00	0.7146	0.0774	0.00
Jun-18	0.00	0.7146	0.0774	0.00
Jul-18	0.00	0.7146	0.0774	0.00
Aug-18	0.00	0.7146	0.0774	0.00
Sep-18	285.96	0.7146	0.0774	220.17
Oct-18	267.08	0.7146	0.0774	205.63
Nov-18	0.00	0.7146	0.0774	0.00
Dec-18	258.42	0.7146	0.0774	198.96

For this project, the following applies:

1. The grid connected baseline 2014 for Peninsula Malaysia was applied to this project and the $EF_{EF,k,y}$ was recalculated to be 0.7146tCO_2/MWh (applied from 01/01/2018 – 31/12/2018) using the latest release of grid emission factor published by Green Tech Centre (GTC) CDM Secretariat, based on the "Tool to calculate the emission factor for an electricity system" (Version 5.0).
2. With reference to ACM0001, Version 18.0, page 21, $\boldsymbol{EC_{BL,k,y}}$ is equivalent to the net amount of electricity generated using LFG in year *y* ($\boldsymbol{EG_{PJ,y}}$). $\boldsymbol{EF_{EL,k,y} = EF_{grid,CM,y}}$ *and therefore*, $\boldsymbol{BE_{EC,y} = \sum EG_{PJ,y} \times EF_{grid,CM,y} \times (1 + TDL_{k,y})}$.
3. The total electricity generated ($EL_{LFG,y}$) is the amount based on the monthly invoices to the grid operator (Tenaga National Berhad (TNB)) which is also the lower reading from the comparison between (EL4 + EL9 + EL10 + EL12) and (EL5 + EL11 + EL13).

Total Baseline Emissions

$BE_y = BE_{CH4,y} + BE_{EC,y}$

Month	$BE_{CH4,y}$				$BE_{EC,y}$			Total B_{Ey}
	Flare No.2	GSS1	GSS2	GSSF1	GSS1	GSS2	GSSF1	
Jan-18	6,245	5,011	4,164	228	677	830	28	17,183
Feb-18	5,905	5,753	3,499	0	745	678	0	16,580
Mar-18	4,828	7,501	3,869	0	955	700	0	17,853
Apr-18	3,785	5,163	3,528	0	701	705	0	13,882
May-18	1,333	3,905	4,358	0	634	779	0	11,009
Jun-18	6,743	2,829	637	0	446	95	0	10,750
Jul-18	6,154	4,093	3,260	0	508	559	0	14,574
Aug-18	5,220	5,776	4,114	0	773	736	0	16,619
Sep-18	4,978	4,322	3,542	1,751	555	646	220	16,014
Oct-18	6,095	1,871	1,721	1,781	243	278	205	12,194
Nov-18	7,393	257	0	0	49	0	0	7,699
Dec-18	5,864	5,282	0	1,663	1,118	0	198	14,125
Total	**64,543**	**51,763**	**32,692**	**5,423**	**7,404**	**6,006**	**651**	**168,482**

Note: The Baseline Emission figure has been rounded down for conservativeness

E.2. Calculation of project emissions or actual net removals

The total project emissions according to ACM0001 (Version 18.0) were estimated according to the equations below:

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} + PE_{SP,y}$$

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

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

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

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-18	122.62	0.7146	0.0739	94.10
Feb-18	126.06	0.7146	0.0739	96.74
Mar-18	152.45	0.7146	0.0739	116.99
Apr-18	125.79	0.7146	0.0739	96.54
May-18	132.45	0.7146	0.0739	101.64
Jun-18	76.92	0.7146	0.0774	59.22
Jul-18	116.72	0.7146	0.0774	89.86
Aug-18	156.36	0.7146	0.0774	120.39
Sep-18	146.55	0.7146	0.0774	112.83
Oct-18	98.74	0.7146	0.0774	76.02
Nov-18	33.13	0.7146	0.0774	25.51
Dec-18	137.63	0.7146	0.0774	105.96

For this project, the following applies:

1. The grid connected baseline 2014 for Peninsula Malaysia was applied to this project and the $EF_{EF,j,y}$ was recalculated to be 0.7146tCO_2/MWh (applied from 01/01/2018 – 31/12/2018) using the latest release of

grid emission factor published by Green Tech Centre (GTC) CDM Secretariat, based on the "Tool to calculate the emission factor for an electricity system" (Version 5.0).

2. TDL = 7.39% adopted as stated in the registered PDD, version 20.5 page 54 (TNB annual report 2016[7]).

$PE_{FC,j,y}$, for this project, is the emission from diesel backup generators. During the monitoring period, there is no diesel consumption.

Project emissions from Fossil fuel Combustion by Project Activity

Month	Quantity of diesel combusted (Liter)	Diesel Density (kg/l)	Quantity of diesel combusted (t/month)	$COEF_{diesel,y} = NCV_{diesel,j} \times EF_{CO2,diesel,y}$			Total Project Emission from project activity
				Weighted average net calorific value of diesel (GJ/t)	Weighted average CO_2 emission factor of diesel	CO_2 emission coefficient of diesel (tCO_2/mass of volume unit)	
			FC_{diesel}	$NCV_{diesel,j}$	$EF_{CO2,diesel,y}$	$COEF_{diesel,y}$	(tCO2e)
Jan-18	0	0.84	0.00	43	0.0741	3.19	0.00
Feb-18	0	0.84	0.00	43	0.0741	3.19	0.00
Mar-18	0	0.84	0.00	43	0.0741	3.19	0.00
Apr-18	0	0.84	0.00	43	0.0741	3.19	0.00
May-18	0	0.84	0.00	43	0.0741	3.19	0.00
Jun-18	0	0.84	0.00	43	0.0741	3.19	0.00
Jul-18	0	0.84	0.00	43	0.0741	3.19	0.00
Aug-18	0	0.84	0.00	43	0.0741	3.19	0.00
Sep-18	0	0.84	0.00	43	0.0741	3.19	0.00
Oct-18	0	0.84	0.00	43	0.0741	3.19	0.00
Nov-18	0	0.84	0.00	43	0.0741	3.19	0.00
Dec-18	0	0.84	0.00	43	0.0741	3.19	0.00

Total Project Emissions

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

Month	PE_{EC}	PE_{FC}	Total P_{Ey}
Jan-18	95	0	95
Feb-18	97	0	97
Mar-18	117	0	117
Apr-18	97	0	97
May-18	102	0	102
Jun-18	60	0	60
Jul-18	90	0	90
Aug-18	121	0	121
Sep-18	113	0	113
Oct-18	77	0	77
Nov-18	26	0	26
Dec-18	106	0	106
Total	**1,101**	**0**	**1,101**

Note: The project emission has been rounded up for conservativeness

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

E.3. Calculation of leakage emissions

No leakage emissions.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	**168,482**	**1,101**	**0**	**Not applicable**	**167,381**	**167,381**

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante (t CO_2e)
167,381	**269,207**[8]

E.6. Remarks on increase in achieved emission reductions

The total CERs claimed in the 2nd monitoring period of 2nd crediting period was 37.8% lower as compared to the value reported in the ex-ante calculations.

The total decrease of 37.8% is due to the following reasons:

1. Several shutdowns to Flare No.2 due to lightning strike in April and May 2018.
2. Major overhaul for GSSF1 (Gas Engine No.1) from February 2018 – August 2018, October 2018 – December 2018.
3. Several shutdowns to Gas Engine No.2 and Gas Engine No.3 of GSS1 in April, May and November 2018 due to lightning strike and upgrading works.
4. Gas Engine No.4 of GSS2 shutdown in June, November and December 2018 for maintenance and upgrading work at DG room.

[8] Obtained from PDD version 20.5 dated 02/03/2018.

Appendix 1: Details on the downtime of Flare No.2

Date	Time		Problem Description
	Shutdown	Restart	
24/01/2018	14:46	17:42	Proper shutdown -to install blower, repaired unit by Hydrocare
25/01/2018	10:28	14:56	Unify to install pressure gauge at main pipe (450 mm)
28/01/2018	18:49	19:19	TNB Power failure - few minutes
03/03/2018	14:33	19:31	TNB power surge few seconds
05/03/2018	11:11	06/03/2018 17:59	O2 above danger set point. Main pipe leaking - found damage at main pipe Ph2B
06/04/2018	16:22	16:29	TNB Power failure few second. Blower #2 trip (overcurrent)
24/04/2018	9:17	30/04/2018 23:59	Proper shutdown. PLC problem - modules 1x Network/ 2x PLC 1/0 module - install test at GSS1 - to run gas engine
01/05/2018	0:00	25/05/2018 12:57	Lightning strike at RE Center. Major all system tripped. Unable to restart. Major components to check for damages.
04/06/2018	11:42	13:01	Proper shutdown - for CDM Equipment calibration by Nectar CH4, FT1 and FT2.
08/08/2018	10:52	11:42	Proper shutdown - to service HT VCB at SSU LTP - Site total shutdown. • Mechanical service grease on mechanical parts • Re-tightening all the bolts and nuts • Cleaning on mechanical parts • Vacuum test, Insulation test and Trip test
25/09/2018	16:22	17:25	O2 above danger set point.
29/09/2018	10:41	17:09	Proper shutdown - requested by TNB for repairing work (VCB) at Pencawang Elektrik Pelupusan Sampah
02/10/2018	2:50	4:15	TNB works to normalize power at PE Pelupusan for the consumer panel change, together with generation panel.
06/10/2018	14:54	15:03	TNB install export meter (new) at PE Pelupusan sampah.
05/11/2018	10:32	19:31	GSS3 pipe connection (new) to existing main pipe
06/11/2018	8:32	9:00	Electrical works - Chen Guan. New MSB panel for GSS3 power supply/ new building extension
	20:03	20:12	Electrical works - Chen Guan. New MSB panel for GSS3 power supply/ new building extension
01/12/2018	8:11	8:42	CH4 Low-Low
	9:01	10:12	CH4 Low-Low
16/12/2018	15:15	15:58	GBS trip - O2 above danger set point

Appendix 2: Details on the downtime of Gas Engine No.1, No.2, No.3 and No.4

Gas Engine No. 1

Date	Gas Engine No. 1		Problem Description
	Shutdown	Restart	
02/01/2018	10:15	14:52	Proper shutdown. For service at 1,500 hrs interval
04/01/2018	2:55	31/01/2018 23:59	Main fault - to check generation cable to TNB substation/termination.
01/02/2018	0:00	28/02/2018 23:59	Main fault - to check generation cable to TNB substation/termination.
01/03/2018	0:00	31/03/2018 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/04/2018	0:00	30/04/2018 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/05/2018	0:00	31/05/2018 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/06/2018	0:00	0:00 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/07/2018	0:00	31/07/2018 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/08/2018	0:00	31/08/2018 23:59	Shutdown for major overhaul works at 45,000 hours interval by SPE
01/09/2018	0:00	12/09/2018 16:14	Shutdown for major overhaul works at 45,000 hours interval by SPE
07/10/2018	14:37	14:50	Combustion chamber A6
08/10/2018	9:45	11:30	GSSF1 trip. Reset OK.
	14:24	14:31	Combustion chamber A6, A5, B6. Restart OK.
01/11/2018	0:00	30/11/2018 23:59	Critical fault. Check Engine. A5
01/12/2018	0:00	07/12/2018 19:46	Critical fault B5, check engine
13/12/2018	9:49	22:13	Proper shutdown. For normal service at 50 hrs interval by SPE

Gas Engine No. 2

Date	Gas Engine No. 2		Problem Description
	Shutdown	Restart	
05/01/2018	3:07	10:26	Proper shutdown - knocking sensor
15/01/2018	14:52	15:01	Proper shutdown to rack out ACB GE 3 - overhaul by SPE
03/02/2018	13:28	13:34	Jacket water engine outlet
12/02/2018	17:06	18:12	Safety chain
03/03/2018	14:33	20:12	TNB Power surge few seconds
04/03/2018	10:58	11:21	Combustion chamber average
	12:56	13:08	Combustion chamber B4
05/04/2018	11:20	11:31	Combustion chamber B6. After change to new spark plug, restart OK.
06/04/2018	14:16	14:32	Jacket water engine outlet (HT Fan #2 trip)
	16:05	16:19	TNB power failure few second
04/05/2018	9:19	12:31	Proper shutdown - to install blower #2 at GSS1 by Hydrocare
08/05/2018	0:32	0:43	Combustion chamber A2
	7:44	8:12	Combustion chamber A2 changed new spark plug
03/06/2018	12:15	12:30	Combustion chamber B5 faulty - change with spare unit
09/06/2018	5:41	5:59	Jacket water engine outlet
	12:56	13:06	Proper shutdown - to check on intake ON sensor. Restart OK.
01/07/2018	0:00	31/07/2018	ZA error code. Unable to restart immediately due to HT radiator fan faulty.
		23:59	
01/08/2018	0:00	07/08/2018	ZA error code. Unable to restart immediately due to HT radiator fan faulty.
		0:32	
08/08/2018	10:52	13:49	Proper shutdown - to service HT VCB at SSU LTP - Site total shutdown. • Mechanical service grease on mechanical parts • Re-tightening all the bolts and nuts • Cleaning on mechanical parts • Vacuum test, Insulation test and Trip test
05/09/2018	15:11	30/09/2018	Proper shutdown - to swap AGCM PLC with GE1. Unable to restart immediately due to short number of fan for radiator
		23:59	
01/10/2019	0:00	31/102018	Proper shutdown - to swap AGCM PLC with GE1. Unable to restart immediately due to short number of fan for radiator (HT)
		23:59	
01/11/2018	0:00	28/11/2018	Shutdown for GE5/GE6 electrical works at DG Building/ PPU Bukit Tagar. Parts of upgrading works.
		18:50	
29/11/2018	18:28	18:33	TNB power surge - engine trip
01/12/2018	3:09	3:12	Deviation power control
	5:59	8:06	Deviation power control
	12:19	13:02	Knocking sensor error bank B (B3)

Gas Engine No. 3

Date	Gas Engine No. 3		Problem Description
	Shutdown	Restart	
01/01/2018	0:00	31/01/2018 23:59	Major overhaul maintenance works - 30,000 hours. weeks
01/02/2018	0:00	15/02/2018 3:02	Major overhaul maintenance works - 30,000 hours. weeks
16/02/2018	14:15	15:11	Low water intercooler circuit
03/03/2018	14:33	20:29	TNB power surge few seconds
04/03/2018	0:52	8:03	Engine water level low. After release air lock OK.
	10:58	11:24	Combustion chamber average
04/04/2018	13:57	14:01	T206 jacket water engine cutlet
	17:34	17:45	Jacket water engine outlet. Safety chain
06/04/2018	16:05	16:32	TNB power failure few second
12/04/2018	16:42	17:00:00	Gas pressure gas control system
01/05/2018	0:00	08/05/2018 15:03	Lightning strike at RE Center. Major all system tripped. Unable to restart. Major components to check for damages.
09/05/2018	5:39	14/05/2018 19:39	Jacket water engine outlet. HT pump leaking
11/06/2018	17:32	17:42	Combustion chamber B3 faulty - change with spare unit
14/06/2018	3:27	11:19	Proper shutdown for TNB overhead line 33 kV repairing works.
04/07/2018	17:35	17:45	Combustion chamber B2 changed spark plug (spare)
24/07/2018	22:41	22:50	Combustion chamber A6
30/07/2018	16:20	16:36	Combustion chamber A6 changed spark plug (spare)
02/08/2018	13:18	03/08/2018 23:34	Proper shutdown for pre-treatment service by SPE • GDU • Radiator Fan • Scrubber tank
04/08/2018	12:58	16:34	Proper shutdown for pre-treatment service by SPE • GDU • Radiator Fan • Scrubber tank
08/08/2018	10:53	13:52	Proper shutdown - to service HT VCB at SSU LTP - Site total shutdown. • Mechanical service grease on mechanical parts • Re-tightening all the bolts and nuts • Cleaning on mechanical parts • Vacuum test, Insulation test and Trip test
19/09/2018	13:29	14:47	Gas pressure gas control system
25/09/2018	10:25	10:55	GSS1 trip. Pneumatic valve failure. Gas pressure gas control system.
01/10/2018	10:47	11:29	Proper shutdown - O2 flare 2 high. Unable to restart GBS due to TNB power shutdown
	13:35	21:26	
02/10/2018	1:59	4:24	TNB works to normalize power at PE Pelupusan for the consumer panel change, together with generation panel.
01/11/2018	0:00	30/11/2018 16:48	Shutdown for GE5/GE6 electrical works at DG Building/ PPU Bukit Tagar. Parts of upgrading works.
04/12/2018	9:05	9:15	Combustion chamber A5. Change spark plug

Gas Engine No. 4

Date	Gas Engine No. 4		Problem Description
	Shutdown	Restart	
19/01/2018	13:44	14:40	GSS2 trip
20/01/2018	15:15	15:20	Module faulty
02/02/2018	8:07	16:19	Proper shutdown - service by MTU
09/02/2018	15:55	16:19	Proper shutdown to check engine. MIP air cond problem/faulty
03/03/2018	14:33	04/03/2018 9:32	TNB power surge for few seconds. Unable to restart immediately due to voltage unstable.
04/03/2018	13:25	13:56	LoLo T-exhaust A9
	16:07	17:00	LoLo T-exhaust A9
	23:38	05/03/2018 0:51	Combustion chamber average
05/04/2018	10:43	16:24	Proper shutdown to service at 1,250 hours interval by WZS
06/04/2018	16:05	16:49	TNB power failure few second
	18:25	18:35	Power surge
02/05/2018	9:48	14:55	Proper shutdown - to do radiator fan wiring modification (trip alarm) by WZS
08/05/2018	9:11	10:12	Open MCB. Safety sensor reserve 3.
13/05/2018	1:44	1:49	TNB power surge
01/06/2018	10:23	16:09	Proper shutdown for normal service at 1,250 hours interval by WZS
03/06/2018	15:57	17:51	X20 module faulty, LoLo A3, SM 97 -undervoltage - change A3 spark plug
04/06/2018	10:27	11:53	Proper shutdown for CDM equipment calibration by Nectar 1) TT1 2) PT2
01/07/2018	0:00	09/07/2018 16:59	Proper shutdown - to adjust valve clearance, mapping and check head condition. Unable to restart immediately due to AVR card faulty.
15/07/2018	7:27	8:25	GSS2 trip. Air compressor trip. Restart OK.
22/07/2018	20:17	22:00	GSS2 trip. Air compressor trip. Restart OK.
01/08/2018	3:00	4:07	X20 module faulty. Restart OK.
06/08/2018	14:22	14:31	PRD ACT B
01/09/2018	0:00	04/09/2018 17:08	GSS2 trip. Compressor faulty. Unable to restart immediately due to starter problem.
07/09/2018	12:49	12:57	TNB power surge -few seconds
	16:13	16:38	TNB power surge -few seconds
01/10/2018	0:00	7:46	Proper shutdown for GSS3 cable installation work from MSB to GSS3 Feeder Pillar. Unable to restart, gas unstable (CH4)
02/10/2018	2:55	4:22	TNB works to normalize power at PE Pelupusan for the consumer panel change, together with generation panel.
01/11/2018	0:00	30/11/2018 23:59	Shutdown for GE5/GE6 electrical works at DG Building/ PPU Bukit Tagar. Parts of upgrading works.
04/12/2018	0:00	31/12/2018 23:59	Shutdown for GE5/GE6 electrical works at DG Building/ PPU Bukit Tagar. Parts of upgrading works.

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 03.0

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 60ºC, the same basis for both methane concentration and flow measurement will be considered according to the tools.

There are 6 measurement options as tabulated below:

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

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

Determination of the absolute humidity of the gaseous stream

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

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

Option 2: Simplified calculation without measurement of the moisture content

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

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

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_s – Saturation pressure of H_2O t – LFG Temperature
P_t	**Absolute Pressure** $P_a = P_g + P_{at}$ $P_a = P_g + 101325$ where, P_a = Absolute Pressure, P_g = Gauge Pressure, P_{at} = Atmospheric Pressure.
MM_{H2O}	18.0152 kg/kmol Default value from the tool
$MM_{t,db}$	$MM_{t,db} = \sum_k (v_{k,t,db} * MM_k)$ Where: $MM_{t,db}$ = Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas) $v_{k,t,db}$ = Volumetric fraction of gas *k* in the gaseous stream in time interval *t* on a dry basis (m^3 gas k/m^3 dry gas) MM_k = Molecular mass of gas *k* (kg/kmol) k = All gases, except H_2O, contained in the gaseous stream (e.g. N_2, CO_2, O2, CO, H2, CH_4, N_2O, NO, NO2, SO_2, SF_6 and PFCs). See available simplification below Default value for $MM_{i,k}$, Gases involve in the calculation are CH_4, CO_2, and O_2

Parameter	Formula / description

Data / Parameter:	MM_i
Data unit:	kg/kmol
Description:	Molecular mass of greenhouse gas *i*
Value to be applied:	

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-C_4F_8	200.03
Perfluoropentane	C_5F_{12}	288.03
Perfluorohexane	C_6F_{14}	338.04

Any comment:	

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.

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

Any comment:	

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 (m^3 H_2O/m^3 dry gas)

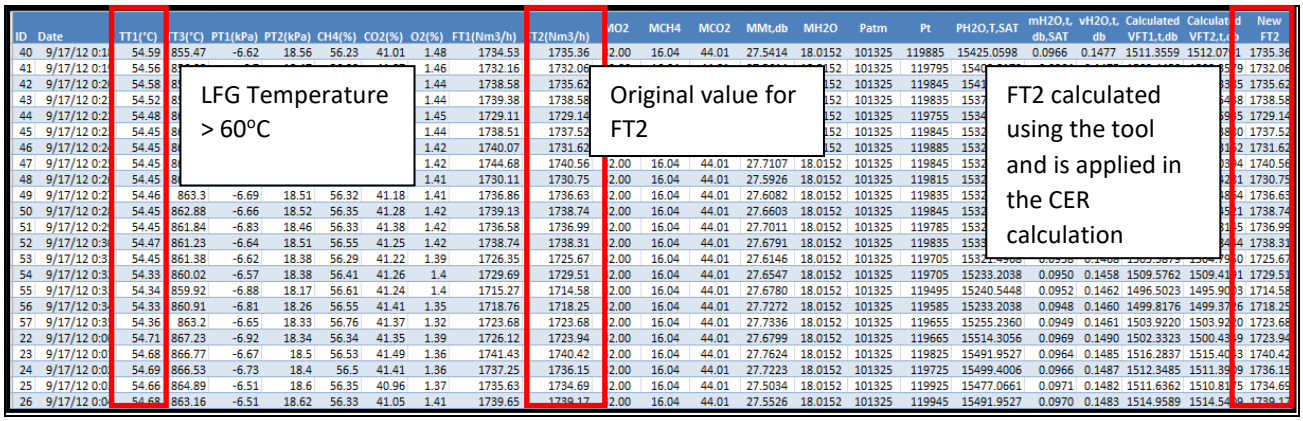
$m_{H2O,t,db}$ = Absolute humidity in the gaseous stream in time interval *t* on a dry basis (kg H_2O/kg dry gas)

$MM_{t,db}$ = Molecular mass of the gaseous stream in time interval *t* on a dry basis (kg dry gas/kmol dry gas)

MM_{H2O} = Molecular mass of H_2O (kg H_2O/kmol H_2O)

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 03.0.



ID	Date	TT1(°C)	TT3(°C)	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,db	Calculated VFT2,t,db	New FT2
40	9/17/12 0:1	54.59	855.47	-6.62	18.56	56.23	41.01	1.48	1734.53	1735.36	2.00	16.04	44.01	27.5414	18.0152	101325	119885	15425.0598	0.0966	0.1477	1511.3559	1512.07	1735.36
41	9/17/12 0:1	54.56						1.46	1732.16	1732.06					152	101325	119795	1540					1732.06
42	9/17/12 0:2	54.58						1.44	1738.58	1735.62					152	101325	119845	1541					1735.62
43	9/17/12 0:2	54.52						1.44	1739.38	1738.58					152	101325	119835	1537					1738.58
44	9/17/12 0:2	54.48						1.45	1729.11	1729.14					152	101325	119755	1534					1729.14
45	9/17/12 0:2	54.45						1.44	1738.51	1737.52					152	101325	119845	1532					1737.52
46	9/17/12 0:2	54.45						1.42	1740.07	1731.62					152	101325	119885	1532					1731.62
47	9/17/12 0:2	54.45						1.42	1744.68	1740.56	2.00	16.04	44.01	27.7107	18.0152	101325	119845	1532					1740.56
48	9/17/12 0:2	54.45						1.41	1730.11	1730.75	2.00	16.04	44.01	27.5926	18.0152	101325	119815	1532					1730.75
49	9/17/12 0:2	54.46	863.3	-6.69	18.51	56.32	41.18	1.41	1736.86	1736.63	2.00	16.04	44.01	27.6082	18.0152	101325	119835	1533					1736.63
50	9/17/12 0:2	54.45	862.88	-6.66	18.52	56.35	41.28	1.42	1739.13	1738.74	2.00	16.04	44.01	27.6603	18.0152	101325	119845	1532					1738.74
51	9/17/12 0:2	54.45	861.84	-6.83	18.46	56.33	41.38	1.42	1736.58	1736.99	2.00	16.04	44.01	27.7011	18.0152	101325	119785	1532					1736.99
52	9/17/12 0:3	54.47	861.23	-6.64	18.51	56.55	41.25	1.42	1738.74	1738.31	2.00	16.04	44.01	27.6791	18.0152	101325	119835	1533					1738.31
53	9/17/12 0:3	54.45	861.38	-6.62	18.38	56.29	41.22	1.39	1726.35	1725.67	2.00	16.04	44.01	27.6146	18.0152	101325	119705	1532					1725.67
54	9/17/12 0:3	54.33	860.02	-6.57	18.38	56.41	41.26	1.4	1729.69	1729.51	2.00	16.04	44.01	27.6547	18.0152	101325	119705	15233.2038	0.0950	0.1458	1509.5762	1509.41	1729.51
55	9/17/12 0:3	54.34	859.92	-6.88	18.17	56.61	41.24	1.4	1715.27	1714.58	2.00	16.04	44.01	27.6780	18.0152	101325	119495	15240.5448	0.0952	0.1462	1496.5023	1495.90	1714.58
56	9/17/12 0:3	54.33	860.91	-6.81	18.26	56.55	41.41	1.35	1718.76	1718.25	2.00	16.04	44.01	27.7272	18.0152	101325	119585	15233.2038	0.0948	0.1460	1499.8176	1499.37	1718.25
57	9/17/12 0:3	54.36	863.2	-6.65	18.33	56.76	41.37	1.32	1723.68	1723.68	2.00	16.04	44.01	27.7336	18.0152	101325	119655	15255.2360	0.0949	0.1461	1503.9220	1503.92	1723.68
22	9/17/12 0:0	54.71	867.23	-6.92	18.34	56.34	41.35	1.39	1726.12	1723.94	2.00	16.04	44.01	27.6799	18.0152	101325	119665	15514.3056	0.0969	0.1490	1502.3323	1500.43	1723.94
23	9/17/12 0:0	54.68	866.77	-6.67	18.5	56.53	41.49	1.36	1741.43	1740.42	2.00	16.04	44.01	27.7624	18.0152	101325	119825	15491.9527	0.0964	0.1485	1516.2837	1515.40	1740.42
24	9/17/12 0:0	54.69	866.53	-6.73	18.4	56.5	41.41	1.36	1737.25	1736.15	2.00	16.04	44.01	27.7223	18.0152	101325	119725	15499.4006	0.0966	0.1487	1512.3485	1511.39	1736.15
25	9/17/12 0:0	54.66	864.89	-6.51	18.6	56.35	40.96	1.37	1735.63	1734.69	2.00	16.04	44.01	27.5034	18.0152	101325	119925	15477.0661	0.0971	0.1482	1511.6362	1510.81	1734.69
26	9/17/12 0:0	54.68	863.16	-6.51	18.62	56.33	41.05	1.41	1739.65	1739.17	2.00	16.04	44.01	27.5526	18.0152	101325	119945	15491.9527	0.0970	0.1483	1514.9589	1514.54	1739.17

Document information

Version	*Date*	*Description*
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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