Monitoring report form for CDM project activity
(Version06.0)

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

MONITORING REPORT		
Title of the project activity	LFG flaring project at Dubai, UAE	
UNFCCC reference number of the project activity	8269	
Version number of the PDD applicable to this monitoring report	8	
Version number of this monitoring report	Version # 01	
Completion date of this monitoring report	22/04/2019	
Monitoring period number	Monitoring Period Number # 06	
Duration of this monitoring period	01/09/2017 to 31/08/2018(both dates inclusive)	
Monitoring report number for this monitoring report	1	
Project participants	• Green Energy Solutions & Sustainability LLC • Dubai Municipality • Ministry of climate & Environment, Norway.	
Host Party	**United Arab Emirates**	
Sectoral scopes	Sectoral Scope: 13: Waste Handling & Disposal	
Applied methodologies and standardized baselines	Applied Methodology: ACM0001 (Version 12)- Flaring or use of landfill gas	
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
	0	312,715

Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring periodin the PDD	244,049[1]

[1]As per registered PDD the Estimated ER for 2017, annual average, is 253,634 tCO2 and the Estimated ER for 2018, annual average is 239,258 tCO2. The same when extrapolated for the period 1st Sep 2017 till 31st Dec 2017 comes to 84,544 tCO2 and for the period 1St Jan 2018 till 31St Aug 2018 comes to 159, 505 The aggregated value of 244,049

SECTION A. Description of project activity

A.1. General description of project activity

The purpose of the project activity is to replace the pre-project passive venting system (where the landfill gas is released into the atmosphere without any collection, recovery or combustion) with a landfill gas recovery system in order to collect and destroy the landfill gas generated at the Al Qusais Landfill site. The captured landfill gas is being partly flared by closed type flaring systems and part of the gas is being used onsite for power generation to the tune that is needed to run the 1 MW plant. The project includes installation of 2 identical trains of landfill gas flaring setups. The Gas collection system is common to both the flare units. Project also has a standby DG set for emergency power during outage of the gas based power generating system. The project has been commissioned by Hofstetter Umwelttechnik AG (which is one of the leading companies in the world in flaring and degassing technologies.

The flaring project was commissioned in Nov’12 and the gas based power generation unit in Jan’13.

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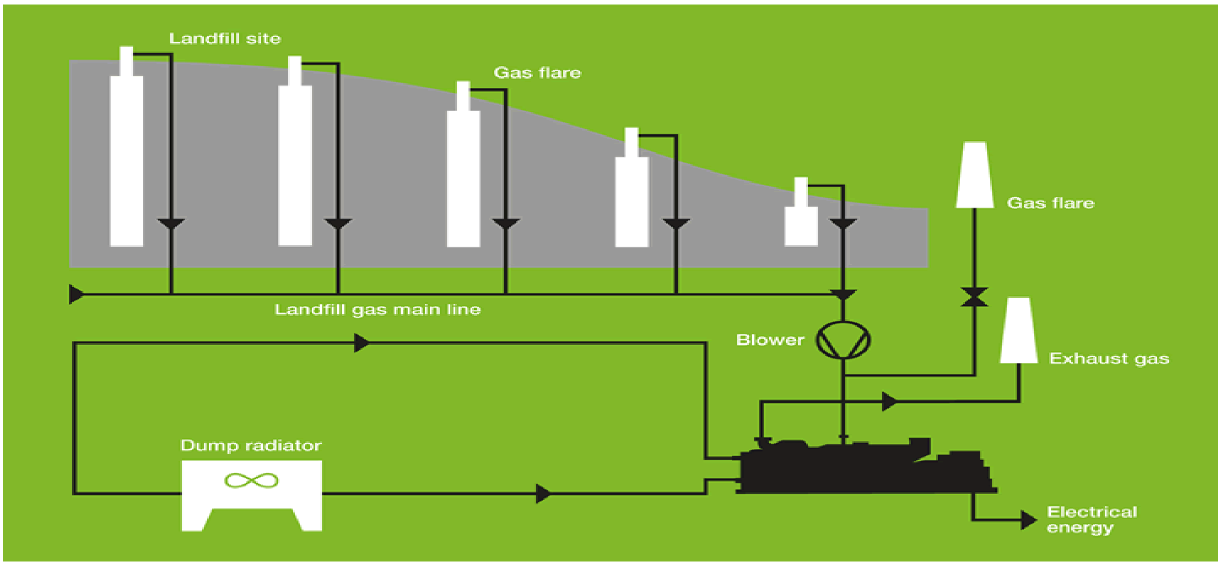


The technology helps the local welfare as well as helps in reducing safety hazards like fire on site. The project helps in improving the local ambient air quality and helps the local occupants’ methane free air for healthy life.

The total emission reduction achieved during the period under verification is 312,715 tCO_2e

A.2. Location of project activity

Location: Al Qusais landfill
City: Dubai
Country: UAE (United Arab Emirates)
Longitude: 55^{0}26’14” East
Latitude: 25^{0}16’47” North

The Arial view of the landfill and an indicative map of the landfill site are provided below:

A.3. Parties and project participants

Parties involved	Project participants	Indicate ifthe Party involved wishes to be considered as project participant (Yes/No)
United Arab Emirates (host Party)	Public Entity: Dubai Municipality Private Entity: Green Energy Solutions & Sustainability LLC	Yes Yes
Norway	Public Entity : Ministry of Climate & Environment, Norway	No

A.4. Reference to applied methodologies and standardized baselines

The approved baseline and monitoring methodology applied to the aforesaid project activity is Approved Consolidated Methodology ACM0001 “Flaring or use of landfill gas” (Version 12.0.0, EB 65). The other tools and methodologies applicable are provided in tabular format below:

Methodology	*Approved Consolidated Methodology*
Title	ACM0001- Flaring or use of Landfill gas
Version	12.0.0
EB#	65
Weblink	https://cdm.unfccc.int/methodologies/DB/RNAKK7JRFWIKCFT3YSNKGPC1FR2DVA

Following tools were also referred by the applied methodology and by the project activity

Tool	*Tool to determine project emissions from flaring gases containing methane*
Annex	13
Version	1
EB#	28
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

Tool	*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*
Annex	7
Version	01
EB#	39
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf

Tool	Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion
Annex	11
Version	2
EB#	41

Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

Tool	**Combined tool to identify the baseline scenario and demonstrate additionality**
Annex	48
Version	4.0.0
EB#	66
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v4.0.0.pdf

Tool	**Emissions from solid waste disposal sites**
Annex	46
Version	06.0.1
EB#	66
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.1.pdf

Tool	**Tool to determine the remaining lifetime of equipment**
Annex	15
Version	1
EB#	50
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-10-v1.pdf/history_view

Tool	**Tool to determine the baseline efficiency of thermal or electric energy generation systems**
Annex	12
Version	1
EB#	48
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-09-v1.pdf

Tool	**Tool to determine the mass flow of a greenhouse gas in a gaseous stream**
Annex	11
Version	02.0.0
EB#	61
Weblink	http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf

A.5. Crediting period type and duration

Type of Crediting Period	Start Date of the crediting period	Length of the crediting period	End Date of the crediting period
Renewable	19/11/2012	7 years (1st period)	18/11/2019

SECTION B. Implementation of project activity

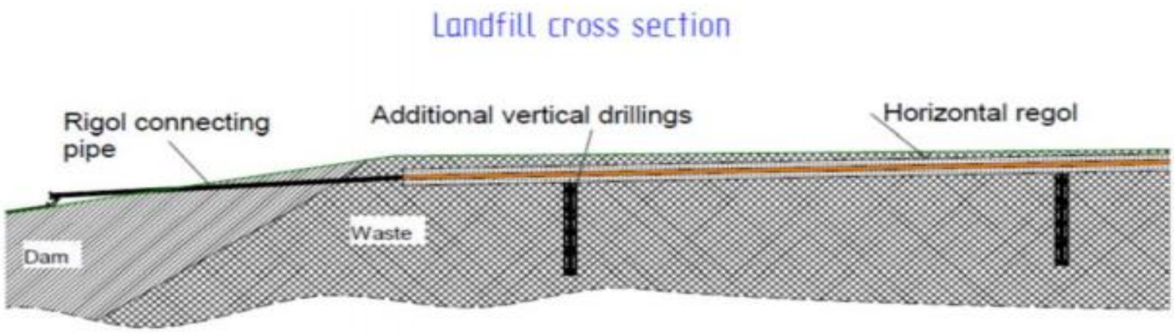
B.1. Description of implemented project activity

The project activity involves replacement of existing passive venting system with a landfill gas based recovery system in order to collect and destroy landfill gas generated at the Al-Qusais landfill site. The captured gas is being completely flared using closed type flares and partly utilised for power generation onsite.The site includes 2 identical trains of flaring units. The intention of LFG flaring is disposal of flammable constituents (mainly methane) and to control odour, nuisance, health risks and adverse environmental impacts.

The equipments include efficient gas collection system and requisite flaring equipment. The gas collection and flaring equipment has been supplied by Hofstetter Umwelttechnik AG which is one of the world's leading companies in flaring technology and degassing systems.

Description of Gas Collection System

The gas collection system is a combination of horizontal and vertical wells. The horizontal gas collection system in combination with verticals wells consist of gas trenches and implemented with a defined gradient from the centre of the landfill towards the sides. Vertical wells have been drilled at adequate distance. The vertical gas wells have been directly interconnected with the gas trenches and are underground and not piercing the surface in order to facilitate movement of waste dumping machinery on the landfill. The pictorial depiction of the setup is given below



Description of Compact Degassing Plant

The gas collection network consists of pipes that connect groups of gas wells to manifolds. These manifolds are connected to a main pipe and then to the main header pipe, which delivers the gas to the extraction plant and the flare. The system operates at pressure slightly lower than atmospheric, as blowers draw the gas from the wells through the collection system and delivers it to the flare.

Gas Collection System

Specifications of Major components

1. Blower Units

Gas flow rate of flare (Nm³/hour)	*Max: 1500* *Min: 300*
Number of blowers per flare	*2*
Rating of motors (KW)	*2x30*
No. of skids	*02*

2. High Temperature Flare

Type	*Closed*
Number of flares	*2*
Gas flow rate of flare (Nm³/hour)	*Max:3000* *Min: 300*
Flare temperature (⁰C)	*1000-1600*
Residence time (second)	*0.3*

3. Gas Filter Unit

During De-gassing small amount of sand, pieces of plastics and debris get transported through the piping into the gas pumping unit. These impurities might get in to the gas blowers and thus detrimental to the project. Gas filter units of around 200 µm has been installed at the inlet of gas pumping station to prevent the same

4. Onsite Gas Based power generation system :

The project has installed an on site 1 MW power generation unit which includes installation of a 1 MW GE-Jenbacher(JFC-320-GS-B.l) whose technical parameters are given below.:

		Full Load	:Part Load (50%)
Energy Input	KW	2655	1436
Gas volume	NM3/hr	279	151
Electrical output	KW	1063	529
Electrical efficiency		40%	36.8%

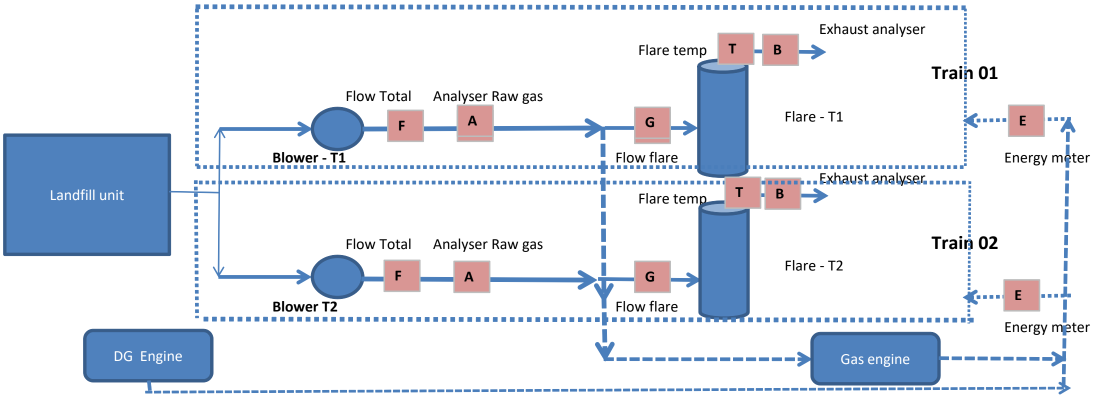
This power is used to run the blowers and the flares of the gas capture project. In case of breakdown of the generation, system a diesel generator is kept as backup and the same provides power for running the unit.

The other major components of the project include:

- Suction piping and discharge piping for blower system
- Gas collection stations
- High temperature flare unit
- Blower skid for conveying gas from landfill to flare
- Dewatering Unit
- Electrical Control Cabinet
- Instrumentation systems for blower and flare operations
- Monitoring equipment for landfill gas capture and utilization systems
- Onsite DG for Auxiliary power and
- Onsite 1 MW biogas based power project.

In the registered project activity, the power consumed onsite was being generated from Diesel based generator sets. There were 2 Nos. Diesel Gensets (one with each line of blower and flare assembly) for the entire plant. Post project implementation PP decided to install a 1 MW landfill gas based power generation unit as this would be the “first of its kind” in the region and would help in showcasing the potential of landfill gas usage to other stakeholders. For conservativeness, no change in the monitoring plan is done and the entire amount of power-consumed onsite (both from the landfill gas based generation system as well as the DG set) is used to calculate the project emissions and credits for gas-based generation are not claimed in the project.

The diagram showing the project boundary has been depicted below:



Parameters	Notation	*Instrument*
$FV_{RG,h}$	G	Gas Flow Meter. The data is then transferred to software based monitoring system (The software used is "readwin 2000version", an Endress+Hauser proprietary software for data conversion.) (as implemented in the site).
$F_{CH4,h}$,, $fv_{CO2,h}$,, $fv_{O2,h}$	A	Methane content ,CO_2 content and O_2 content of raw gas, measured by online raw gas analyser- data logged in memograph.
T_{flare}	T	Temperature of combustion chamber in flare by Thermocouple. The data is then transferred to software based monitoring system (as implemented in the site).
$fv_{CH4,FG,h}$, $T_{o2,h}$	B	Methane and oxygen concentration in the exhaust gas measured online by exhaust analyser logged in memograph.
$EC_{PJ,j,y}$	E	Energy supplied by the DG set and onsite Gas based Gensets. This is measured by Energy meters. The data is then transferred to software based monitoring system (as implemented in the site).

B.2. Post-registration changes

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

None

B.2.2. Corrections

None

B.2.3. Changes to the start date of the crediting period

None

B.2.4. Inclusion of monitoring plan

None

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

None

B.2.6. Changes to project design

Reference: Revised PDD version 08 dated 18/07/2016 approved on 29/09/2016.Reference No. of PRC is PRC-8269-002

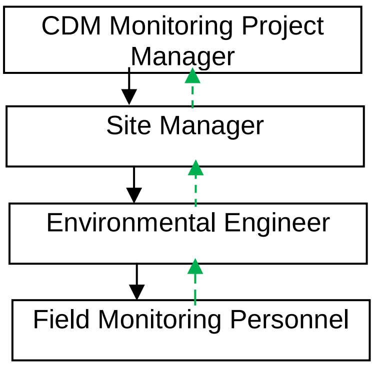
SECTION C. Description of monitoring system

The data monitoring involves all the parameters mentioned in the section B.7.1 of the registered PDD. In the project plant the entire CDM related data is logged in a data logger which is integral to the unit. The data is downloaded through a dedicate interface using an external hard disk or storage. This data is then exported using the Proprietary software of Endress and Hauser and exported to excel format for use. . Proper training has been imparted to concerned personnel for accurate measurement and collection of data for each parameter.

The roles and responsibilities have been tabulated as below:

Designation	Role
Field Monitoring Personnel	Responsible for performing the monitoring activity (viz. Recording of monitored data)
Environmental Engineer	Specific responsibilities include: • Verification of monitored data (consistency & completeness) • Ensuring adequate maintenance • Ensuring timely calibration of monitoring instruments • Taking actions related to emergency preparedness
Site Manager	Responsible for the overall QA/QC of the monitoring activity. Specific responsibilities include: • Training of the staff involved in the monitoring of the project activity • Ensuring proper data archiving & adequate storage of data monitored (integrity and backup) • Identification of non-conformance and corrective/preventive actions and monitoring plan improvement • Also responsible for the management review (internal audit) of the monitoring report
CDM Monitoring Report Project Manager	Responsible for entire monitoring of the project activity.

The hierarchy and data flow has been provided below:



Emergency Preparedness and Instrument Failure

In the event of instrument failure, Field Monitoring Personnel to Site Manager would report the same. The instrument would be sent for repaired/calibrated. In case, calibration of the concerned instrument is not possible, the instrument would be repaired and the same would be replaced. In case the replacement is not available, the emission reductions (for the period of unavailability of the instrument) will not be considered

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**GWP_{CH4}**
Unit	tCO_2e/tCH_4
Description	Global warming potential of CH_4
Source of data	IPCC
Value(s) applied	*All monitoring, verifications and requests for issuance of CERs in respect of GHG emission reductions and net anthropogenic GHG removals achieved by CDM project activities in the second commitment period (from 1 January 2013) shall be calculated using the GWPs as applied by decision 4/CMP.7 in accordance with section 6.3 above."* *https://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf*
Choice of data or measurement methods and procedures	This data is has been considered from https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf and is considered as an authentic source of data
Purpose of data/parameter	This data has been used to determine baseline emissions
Additional comments	-

Data/parameter:	**$\rho_{i,n}$**
Unit	kg/Nm^3
Description	Density of greenhouse gas i (i.e. CH_4) in the gaseous stream at normal Conditions
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"
Value(s) applied)	0.716 (Methane density at normal temperature and pressure (273.15 K and 101325 Pa))
Choice of data or measurement methods and procedures	The data has been sourced from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and is considered as an authentic source of data
Purpose of data	This data has been used to determine baseline emissions
Additional comments	-

Data/parameter:	**$EF_{ELj,y}$**
Unit	tCO_2/MWh
Description	Emission factor for electricity generation for source j in year y
Source of data	"Tool to calculate baseline, project and/or leakage emission from electricity consumption", version 1
Value(s) applied)	1.3 (Default value as per Option B2 of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", version 1).
Choice of data or measurement methods and procedures	This data has been considered sourced from Tool to calculate baseline, project and/or leakage emission from electricity consumption", version 1 and is considered as an authentic source of data.
Purpose of data	This data has been used to determine project emissions
Additional comments	This data is fixed *ex-ante*

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"	10%
0.1 Default value as per the tool "("Emissions from solid waste disposal sites")[2]	Choice of data
or measurement methods and procedures	This value has been sourced from the methodological tool "Emissions from solid waste disposal sites".
Purpose of data	This data has been used to determine baseline emissions

D.2. Data and parameters monitored

Data/Parameter	**$V_{t,wb,n}$(same as $FV_{RG,h}$)**
Unit	Nm^3 LFG/hour
Description	Volumetric flow of the gaseous stream going to flare unit per hour on a wet basis at normal conditions
Measured/calculated/ default	Measured
Source of data	On site measurement (This data has been taken from excel based spreadsheets as provided by the software installed on site)
Value(s) of monitored parameter	The aforesaid parameter has been measured continuously and has been recorded on minute basis. Average value for both lines is given below.

Months (2017)	**Line 01**	**Line 02**
September	2143	2241
October	2224	2237
November	2237	2254
December	2226	2241
Months (2018)	**Line 01**	**Line 02**
January	2140	2249
February	2131	2241
March	2131	2248
April	2213	2246
May	2244	2245
June	2219	2245
July	2253	2255
August	2247	2235

[2] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.0.pdf

<table>
<tr><td>Monitoring equipment</td><td>Flow has been measured by flow meter. The flow meter details have been provided below:
<table>
<tr><td>Instrument Name</td><td>Flow Transmitter</td></tr>
<tr><td>Manufacturer</td><td>Endress Hauser</td></tr>
<tr><td>Serial Number</td><td>EC07090109D</td></tr>
<tr><td>Range</td><td>0-3300Nm^3/hour</td></tr>
<tr><td>Location</td><td>Flare-1 Flow Flare Side</td></tr>
<tr><td>Accuracy Class</td><td>+/-1.5%</td></tr>
</table>
<table>
<tr><td>Instrument Name</td><td>Flow Transmitter</td></tr>
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<tr><td>Location</td><td>Flare-2 Flow Flare Side</td></tr>
<tr><td>Accuracy Class</td><td>+/-1.5%</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Monitoring Frequency: Continuous
Recording Frequency : recorded on minute basis and averaged on Hourly Basis</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>NA</td></tr>
<tr><td>QA/QC procedures</td><td>The QA/QC has been ensured by yearly calibration of the flow meter. The calibration details have been provided below:
<table>
<tr><td>Calibration Entity</td><td>PROCAL</td></tr>
<tr><td>Prev. Calibration dates</td><td>6th December 2016</td></tr>
<tr><td>Calibration Date</td><td>3rd December 2017</td></tr>
<tr><td>Next Calibration Due</td><td>2nd December 2018</td></tr>
<tr><td>Location</td><td>Flare-1 Flow Flare Side</td></tr>
</table>
<table>
<tr><td>Calibration Entity</td><td>PROCAL</td></tr>
<tr><td>Prev. Calibration dates</td><td>14th December 2016</td></tr>
<tr><td>Calibration Date</td><td>3rd December 2017</td></tr>
<tr><td>Next Calibration Due</td><td>2nd December 2018</td></tr>
<tr><td>Location</td><td>Flare-2 Flow Flare Side</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data/parameter</td><td>This data has been used to calculate baseline emission</td></tr>
<tr><td>Additional comments</td><td>Data Archiving Policy: Paper/ Electronic for crediting period + 2 years</td></tr>
</table>

Data/parameter:	$\mathbf{F_{CH4,sent\_flare,y}}$
Unit	tCH_4
Description	Amount of methane in the LFG which is sent to the flare in year *y*
Measured/calculated/default	Calculated. This data have been Calculated based on the measured data of Volumetric flow of the gaseous stream delivered to the flare averaged out on per hour basis in Nm3 / Hr. and methane concentration in the LFG.
Source of data	This parameter has been calculated based on volumetric flow of gaseous flow to the methane. , methane concentration and the density of methane gas at normal conditions (0.716kg/Nm^3) in LFG. Both the parameters are measured on site.

<table>
<tr><td>Value(s) of monitored parameter</td><td>Amount of methane in the LFG which is sent to the flare has been provided in the spreadsheet format
<table>
<tr><td>Month (2017)</td><td>Line 1</td><td>Line 2</td></tr>
<tr><td>September</td><td>0.81</td><td>0.93</td></tr>
<tr><td>October</td><td>0.84</td><td>0.88</td></tr>
<tr><td>November</td><td>0.84</td><td>0.84</td></tr>
<tr><td>December</td><td>0.90</td><td>0.85</td></tr>
</table>
<table>
<tr><td>Months (2018)</td><td>Line 1</td><td>Line 2</td></tr>
<tr><td>January</td><td>0.81</td><td>0.84</td></tr>
<tr><td>February</td><td>0.79</td><td>0.85</td></tr>
<tr><td>March</td><td>0.80</td><td>0.84</td></tr>
<tr><td>April</td><td>0.86</td><td>0.88</td></tr>
<tr><td>May</td><td>0.87</td><td>0.84</td></tr>
<tr><td>June</td><td>0.83</td><td>0.84</td></tr>
<tr><td>July</td><td>0.84</td><td>0.86</td></tr>
<tr><td>August</td><td>0.84</td><td>0.86</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>Not applicable</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Monitoring Frequency: Continuous
Recording Frequency: (Methane Concentration): Averaged Hourly and consolidated on a monthly basis.</td></tr>
<tr><td>Calculation method (if applicable):</td><td>The gas flow rate has been measured on continuous basis using gas flow meters and the average value calculated based on minute by minute value. The methane concentration has been measured continuously through online analyser and recorded on hourly basis and average value used for determination of amount of methane gas sent to flare on annual basis</td></tr>
<tr><td>QA/QC procedures:</td><td>-</td></tr>
<tr><td>Purpose of data:</td><td>This data has been used to calculate baseline emissions</td></tr>
<tr><td>Additional comments:</td><td>Data Archiving Policy: Paper/ Electronic for crediting period + 2 years</td></tr>
</table>

Data/parameter:	**$PE_{flare,y}$**
Unit	tCO_2e
Description	Project emissions from flaring of the residual gas stream in year y.
Measured/calculated/default	Calculated. This parameter has been calculated as per the “Tool to determine project emissions from flaring gases containing methane”[3]
Source of data	This is a calculated value.

[3]http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

Value(s) of monitored parameter	Project Emissions from flaring of the residual gas stream has been provided in spreadsheet form: **2017:** Monthly (2017) — Line1 / Line 2 September — 86 / 78.96 October — 21.87 / 1.55 November — 0 / 0 December — 4.63 / 0 **2018:** Monthly (2018) — Line1 / Line 2 January — 13.62 / 20.91 February — 512.59 / 0 March — 31.71 / 21.19 April — 127.621 / 0 May — 29.37 / 40.63 June — 42.70 / 21.04 July — 18.68 / 21.75 August — 0 / 0
Monitoring equipment	The project emissions are based on the monitored flare temperature using the thermocouple mentioned under parameter $\mathbf{T_{flare}}$
Measuring/reading/recording frequency:	This is a calculated value.
Calculation method (if applicable):	Project Emission has been calculated using the following equation: $\mathbf{PE_{flare,y}=\sum TM_{RG,h}*(1-\eta_{flare,h})*(GWP_{CH4}/1000)}$, where $\mathbf{\sum TM_{RG,h}}$=Mass flow rate of methane in the residual gas in the hour h $\mathbf{\eta_{flare,h}}$= Flare efficiency in hour h $\mathbf{GWP_{CH4}}$= Global Warming potential of methane
QA/QC procedures:	-
Purpose of data:	This data has been used to calculate the project emission from flaring
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years

Values of monitored parameter (tables above):

Monthly (2017)	Line1	Line 2
September	86	78.96
October	21.87	1.55
November	0	0
December	4.63	0

Monthly (2018)	Line1	Line 2
January	13.62	20.91
February	512.59	0
March	31.71	21.19
April	127.621	0
May	29.37	40.63
June	42.70	21.04
July	18.68	21.75
August	0	0

Data/parameter:	$\mathbf{fv_{i,h}}$
Unit	-
Description	Volumetric fraction of component i (i represents CH_4, CO_2, O_2, N_2) in the landfill gas in the hour h
Measured/calculated/default	This is a measured parameter
Source of data	On-site measurements (This data has been taken from excel based spreadsheets as provided by the software installed on site)
Value(s) of monitored parameter	The average volumetric fractions of the gas components for the monitoring period are provided in spreadsheet form.

Months (2017) O_2	**Line 01**	**Line 02**
September	0.00	0
October	0.00	0
November	0.01	0.01
December	0.00	0.01
Months (2018) O_2	**Line 01**	**Line 02**
January	0	0.01
February	0	0.01

	(continued tables below)

March	0.00	0
April	0.01	0
May	0.00	0.01
June	0.01	0.01
July	0.01	0.02
August	0	0.01

Months (2017) CO2	**Line 01**	**Line 02**
September	0.41	0.39
October	0.38	0.38
November	0.43	0.42
December	0.45	0.42
Months (2018) CO2	**Line 01**	**Line 02**
January	0.42	0.42
February	0.42	0.42
March	0.37	0.42
April	0.41	0.41
May	0.38	0.42
June	0.42	0.42
July	0.42	0.43
August	0.42	0.36

Months (2017) CH4	**Line 01**	**Line 02**
September	0.52	0.58
October	0.57	0.57
November	0.53	0.52
December	0.56	0.52
Months (2018) CH4	**Line 01**	**Line 02**
January	0.53	0.52
February	0.52	0.52
March	0.52	0.52
April	0.53	0.54
May	0.54	0.52
June	0.52	0.52
July	0.53	0.52
August	0.52	0.53

Monitoring equipment

The volumetric fraction of component i has been measured by continuous gas quality analyser. The instrument details have been provided below:

Flare Unit-1

Instrument Name	Continuous Gas Quality Analyzer-GAE CH_4
Manufacturer	NUK NENNING UND KRUMM GmbH
Measuring Range	0-100 Vol % CH_4
Serial Number	A1715
Accuracy Class	±1%

Instrument Name	Continuous Gas Quality Analyzer-GAE CO_2
Make	NUK NENNING UND KRUMM GmbH
Measuring Range	0-100 Vol % CO_2
Old Serial Number	A1757
New Serial Number	A2200 (From Jan 2017)
Accuracy Class	±1%

Instrument Name	Continuous Gas Quality Analyzer-GAE O_2
Manufacturer	NUK NENNING UND KRUMM GmbH
Measuring Range	0-25 Vol % O_2

Old Serial Number	A1744
New Serial Number	A1739(From Jan 2017)
Accuracy Class	±2%

Flare Unit-2

Instrument Name	Continuous Gas Quality Analyzer-GAE O_2
Manufacturer	NUK NENNING UND KRUMM GmbH
Measuring Range	0-25 Vol % O_2
Old Serial Number	A1738
New Serial Number	A2106(From Jan 2017)
Accuracy Class	±1%

Instrument Name	Continuous Gas Quality Analyzer-GAE CH_4
Manufacturer	NUK NENNING UND KRUMM GmbH
Measuring Range	0-100 Vol % CH_4
Old Serial Number	A1721
New Serial Number	A2149(From Jan 2017)
Accuracy Class	±1%

Instrument Name	Continuous Gas Quality Analyzer-GAE CO_2
Manufacturer	NUK NENNING UND KRUMM GmbH
Measuring Range	0-100 Vol % CO_2
Old Serial Number	A1705
New Serial Number	A2198
Accuracy Class	±2%

Measuring/reading/recording frequency:	**Monitoring Frequency: Continuous** **Recording Frequency : recorded on minute basis and averaged on Hourly Basis** **Recording Frequency of CH4%, O_2 % and CO_2 %: Hourly**
Calculation method (if applicable):	The values have been consolidated on a hourly basis and the same has been averaged monthly.
QA/QC procedures:	The calibration has been carried in house by GESS/ The QA/QC has been ensured by weekly calibration of the gas quality analyser:

Calibration Type	Weekly calibration done through standard gas sample Traceability certificate of the sample gas- as per certificate SOC/QC-6353/12/13 dt 17th December 2015, valid upto 24 months from calibration. The latest certificate of the sample gas as per certificate SOC/QC-7720/10/16 dt 20th October 2016, valid upto 24 months from calibration.
Calibration Dates	**Weekly**

Purpose of data:	This data has been used to determine baseline emissions from flaring
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years

<table>
<tr><td>**Data/parameter:**</td><td>$t_{O2,h}$</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>On site measurement (This data has been taken from excel based spreadsheets as provided by the software installed on site)</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>The average value for the monitoring period is provided in spreadsheet format.
<table><tr><td>**Months (2017) exh O2**</td><td>**Line 01**</td><td>**Line 02**</td></tr><tr><td>September</td><td>0.04</td><td>0.05</td></tr><tr><td>October</td><td>0.04</td><td>0.04</td></tr><tr><td>November</td><td>0.05</td><td>0.05</td></tr><tr><td>December</td><td>0.04</td><td>0.05</td></tr><tr><td>**Months (2018) exh O2**</td><td>**Line 01**</td><td>**Line 02**</td></tr><tr><td>January</td><td>0.05</td><td>0.05</td></tr><tr><td>February</td><td>0.04</td><td>0.05</td></tr><tr><td>March</td><td>0.04</td><td>0.05</td></tr><tr><td>April</td><td>0.19</td><td>0.07</td></tr><tr><td>May</td><td>0.03</td><td>0.04</td></tr><tr><td>June</td><td>0.04</td><td>0.06</td></tr><tr><td>July</td><td>0.04</td><td>0.02</td></tr><tr><td>August</td><td>0.04</td><td>0.02</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>The volumetric fraction of O_2 in the exhaust gas of the flare has been measured by continuous gas quality analyser. The instrument details has been provided below:
Flare 1
<table><tr><td>Instrument Name</td><td>Continuous Gas Quality Analyser</td></tr><tr><td>Manufacturer</td><td>NUK NENNING UND KRUMM GmbH</td></tr><tr><td>Measuring Range</td><td>0-21 Vol% O_2</td></tr><tr><td>Old Serial Number</td><td>A1739</td></tr><tr><td>New Serial Number</td><td>A1732(From Jan 2017)</td></tr><tr><td>Accuracy Class</td><td>±2%</td></tr></table>
Flare 2
<table><tr><td>Instrument Name</td><td>Continuous Gas Quality Analyser</td></tr><tr><td>Manufacturer</td><td>NUK NENNING UND KRUMM GmbH</td></tr><tr><td>Measuring Range</td><td>0-21 Vol% O_2</td></tr><tr><td>Old Serial Number</td><td>A1732</td></tr><tr><td>NewSerial Number</td><td>A2177 (From Jan 2017)</td></tr><tr><td>Accuracy Class</td><td>±2%</td></tr></table></td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>**Monitoring Frequency: Continuous**
Recording Frequency :recorded on minute basis and averaged on Hourly Basis</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N.A (This parameter has been measured directly)</td></tr>
<tr><td>QA/QC procedures:</td><td>The QA/QC has been ensured by weekly calibration of the gas quality analyser. The calibration has been carried out in house by GESS.</td></tr>
</table>

	Calibration Type	Weekly calibration has been done through standard sample Traceability of the standard gas sample as per certificate number SOC/QC-6352/12/15 dated 17/12/2015 with a Valid upto for 24 months. The New Certificate number is dated and is valid for 24 months.
	Calibration Dates	**Weekly :**
Purpose of data:	This data has been used to calculate project emissions	
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years	

Data/parameter:	**T_{flare}**
Unit	^0C
Description	Temperature in the exhaust gas of the flare
Measured/calculated/default	Measured
Source of data	On-site measurement (This data has been taken from excel based spreadsheets as provided by the software installed on site)
Value(s) of monitored parameter	The values have been monitored continuously. The detailed measured hourly values have been provided to the verifier. The range of monitored values for both locations are provided in excel format.
Monitoring equipment	This parameter has been measured using S type thermocouples. The technical details of the thermocouple have been provided below:

Months (2017) Temperature	**Line 01**	**Line 02**
September	1035	1024
October	1047	1036
November	1038	1051
December	1049	1057
Months (2018) Temperature	**Line 01**	**Line 02**
January	1041	1055
February	1007	1061
March	1038	1055
April	1032	1056
May	1045	1053
June	1041	1053
July	1056	1031
August	1047	1054

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

Thermocouple (Flare 1)

Equipment Description	Thermocouple
Serial Number	
Manufacturer	JOMO
Range	0-1600^{0}C
Location	Flare-1- (At Combustion Tank)
Thermocouple type	Type S
Installation date	
Accuracy Class	±1.5%

Thermocouple (Flare 2)

Equipment Description	Thermocouple
Serial Number	
Manufacturer	JOMO
Range	0-1600^{0}C
Location	Flare-2- (At Combustion Tank)
Thermocouple type	Type S
Installation Date	
Accuracy Class	±1.5%

</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Monitoring Frequency: Continuous
Recording Frequency recorded on minute basis and averaged on Hourly Basis</td></tr>
<tr><td>Calculation method (if applicable):</td><td>This parameter has been directly measured</td></tr>
<tr><td>QA/QC procedures:</td><td>The QA/QC has been ensured by replacement annually</td></tr>
</table>

<table>
<tr><td>Data/parameter:</td><td>$fv_{CH4,FG,h}$</td></tr>
<tr><td>Unit</td><td>mg/Nm^3</td></tr>
<tr><td>Description</td><td>Concentration of methane in the exhaust gas of the flare</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>On site measurement (This data has been taken from excel based spreadsheets as provided by the software installed on site)</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>

Month (2017)	Line 1	Line 2
September	0	0
October	0	0
November	0	0
December	0	0

Month (2018)	Line 1	Line 2
January	0	0
February	0	0
March	0	0
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0

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

<table>
<tr><td>Monitoring equipment</td><td>Continuous gas quality analyser has measured concentration of methane in the exhaust gas of the flare. The instrument details has been provided below:
Flare 1
<table>
<tr><td>Instrument Name</td><td>Continuous Gas Quality Analyser</td></tr>
<tr><td>Manufacturer</td><td>NUK NENNING UND KRUMM GmbH</td></tr>
<tr><td>Measuring Range</td><td>0-2 Vol% CH_4</td></tr>
<tr><td>Old Serial Number</td><td>A1729</td></tr>
<tr><td>New Serial Number</td><td>A1731</td></tr>
<tr><td>Accuracy Class</td><td>±2%</td></tr>
</table>
Flare 2
<table>
<tr><td>Instrument Name</td><td>Continuous Gas Quality Analyser</td></tr>
<tr><td>Manufacturer</td><td>NUK NENNING UND KRUMM GmbH</td></tr>
<tr><td>Measuring Range</td><td>0-2 Vol% CH_4</td></tr>
<tr><td>Old Serial Number</td><td>A1731</td></tr>
<tr><td>New Serial Number</td><td>A1729</td></tr>
<tr><td>Accuracy Class</td><td>±2%</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Monitoring Frequency: Continuous
Recording Frequency :recorded on minute basis and averaged on Hourly Basis</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N.A (This parameter has been measured directly)</td></tr>
<tr><td>QA/QC procedures:</td><td>The QA/QC has been ensured by weekly calibration of the gas quality analyser. The gas quality analyser has been calibrated in house by GESS. The calibration details have been provided below:
<table>
<tr><td>Calibration Type</td><td>Weekly calibration has been done through standard sample. Traceability of the Calibrating gas as per certificate number SOC/QC-6353/12/15 dated 17/12/2015 with a valid upto 24 months. The new traceability certificate number is dated and valid upto 24 months.</td></tr>
<tr><td>Calibration Dates</td><td>Weekly:</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data:</td><td>This data has been used to determine project emissions from flaring</td></tr>
<tr><td>Additional comments:</td><td>Paper/ Electronic for crediting period + 2 years</td></tr>
</table>

Data/parameter:	**$EC_{PJ,j,y}$**
Unit	MWh
Description	Quantity of electricity consumed by the project electricity in year *y.*
Measured/calculated/default	Measured
Source of data	On-site measurement via Energy meter
Value(s) of monitored parameter	The calculated project emission value for this monitoring period is as provided spreadsheet format.

	<table><tr><th>Months (2017)</th><th>Line 01</th><th>Line 02</th></tr><tr><td>September</td><td>149.75</td><td>151</td></tr><tr><td>October</td><td>156</td><td>162</td></tr><tr><td>November</td><td>151</td><td>151</td></tr><tr><td>December</td><td>155</td><td>152</td></tr><tr><td>**Months (2018)**</td><td>**Line 01**</td><td>**Line 02**</td></tr><tr><td>January</td><td>156</td><td>156</td></tr><tr><td>February</td><td>141</td><td>141</td></tr><tr><td>March</td><td>150</td><td>156</td></tr><tr><td>April</td><td>134</td><td>151</td></tr><tr><td>May</td><td>151</td><td>152</td></tr><tr><td>June</td><td>147</td><td>122</td></tr><tr><td>July</td><td>151</td><td>168</td></tr><tr><td>August</td><td>156</td><td>156</td></tr></table>
Monitoring equipment	Energy meter has been used to measure the amount of electricity supplied to the landfill gas recovery and flaring system. Post implementation of project the electricity is also been supplied to the project activity by a 1MW landfill Gas Engine. For conservativeness the entire amount of power as measured under the common energy meter is being used for project emission calculation. The details for the energy meters have been provided below for both the flare units: <table><tr><td>Equipment Description</td><td>Power Consumption Meter</td></tr><tr><td>Serial Number</td><td></td></tr><tr><td>Manufacturer</td><td>EMU</td></tr><tr><td>Location</td><td>**Flare Unit -1**</td></tr><tr><td>Accuracy Class</td><td>1</td></tr><tr><td>Installation Month</td><td></td></tr><tr><td>Old Meter Serial Number</td><td>135513/01</td></tr></table> <table><tr><td>Equipment Description</td><td>Power Consumption Meter</td></tr><tr><td>Serial Number</td><td></td></tr><tr><td>Manufacturer</td><td>EMU</td></tr><tr><td>Location</td><td>**Flare Unit -2**</td></tr><tr><td>Accuracy Class</td><td>1</td></tr><tr><td>Installation Month</td><td></td></tr><tr><td>Old Meter Serial Number</td><td>135513/02</td></tr></table>
Measuring/reading/recording frequency:	**Monitoring Frequency: Continuous** **Recording Frequency : recorded on minute basis and Summed on Hourly Basis**
Calculation method (if applicable):	N.A (This is a measured parameter)
QA/QC procedures:	Calibrated Energy meter is used for monitoring purpose.
Purpose of data:	This data has been used to calculate project emission from electricity consumption.
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years

Data/parameter:	**$PE_{EC,y}$**
Unit	tCO_2e

Description	Emissions from consumption of electricity due to the project activity in year y
Measured/calculated/default	Calculated
Source of data	On-site measurement via Energy meter and default emission factor
Value(s) of monitored parameter	The values are given in spreadsheet format
Monitoring equipment	Calculated from energy meter readings
Measuring/reading/recording frequency:	The project emission is calculated on Monthly basis
Calculation method (if applicable):	It is product of total amount of Power consumed and the emission factor for power (Default)
QA/QC procedures:	Calculated value
Purpose of data:	This data has been used to calculate project emission from electricity consumption.
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years

Data/parameter:	$\eta_{flare,h}$
Unit	%
Description	Flare efficiency in hour h
Measured/calculated/default	Calculated
Source of data	This parameter has been calculated based on steps mentioned in “Tool to determine project emissions from flaring gases containing methane”. Version 1[4],
Value(s) of monitored parameter	The average flare efficiency during this monitoring period for operational hours of the flares are provided in the spreadsheet form.
Monitoring equipment	-
Measuring/reading/recording frequency:	Flare efficiency is calculated on an hourly basis.
Calculation method (if applicable):	As per the tool, the efficiency has been calculated using the formula: $\eta_{flare,h} = 1-(TM_{FG,h}/TM_{RG,h})$, where: $\eta_{flare,h}$= Flare efficiency in hour h $TM_{FG,h}$=Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h $TM_{RG,h}$= Mass flow rate of methane in the residual gas in the hour h T The above mentioned formula has been used to calculate the efficiency, where the temperature of exhaust has been 500DegC or more for more than 40 minutes.
QA/QC procedures:	Calculated value.
Purpose of data:	This data has been used to calculate project emissions from flaring
Additional comments:	Data Archiving Policy: Paper/ Electronic for crediting period + 2 years

D.3. Implementation of sampling plan

Not Applicable

[4] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

As per the steps and guidance provided in the approved methodology ACM0001 (Version 12.0.0) the baseline emissions have been calculated as follows5

$BE_y = BE_{CH4,y} + BE_{ECy} + BE_{HGy} + BE_{NG,y}$ ________________ Equation 1

Where

BE_y	Baseline emissions in year y	tCO_2e
$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year y	tCO_2e
BE_{ECy}	Baseline emissions associated with electricity generation in year y	tCO_2e
BE_{HGy}	Baseline emissions associated with heat generation in year y	tCO_2e
$BE_{NG,y}$	Baseline emissions associated with natural gas use in year y	tCO_2e

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

$BE_{CH4} = (1 - OX_{top\_layer})(F_{CH4,PJ,y} - F_{CH4,BL,y})GWP_{CH4}$ __________ Equation 2

Where

$BE_{CH4,y}$	Baseline emissions of methane from the SWDS in year y	tCO_2e
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*	tCH_4
$F_{CH4,BL,y}$	Amount of methane in the LFG that would be flared in the baseline in year y	tCH_4
GWP_{CH4}	Global warming potential of CH_4	tCO_2e/ tCH_4

Sample calculation:

Sample calculation timeline :1st August 2018- 01:00 Hrs (for Flare 1)
Calculation : 0.835*(1-0.1)*25 = 21.04 tCO_2e

Step A.1 Amount of methane in the LFG which is flared and/or used in the project activity in year y

$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$[6] __________ Equation 3

Where

$F_{CH4PJ,y}$	Amount of methane in the LFG which is flared and/or used in the project activity in year *y*	tCH_4
$F_{CH4,flared,y}$	Amount of methane in the LFG which is destroyed by flaring in year y	tCH_4
$F_{CH4,EL,y}$	Amount of methane in the LFG which is used for electricity generation in year y	tCH_4

5

ol-06-v1.pdf" http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

electricity generation, heat generation and neither it is sent to the natural gas distribution network

$F_{CH4,HG,y}$	Amount of methane in the LFG which is used for heat generation in year *y*	tCH_4
$F_{CH4,NG,y}$	Amount of methane in the LFG which is sent to the natural gas distribution network in year y	tCH_4

Sample calculation:

Sample calculation timeline :1st August 2018- 01:00 Hrs (for Flare 1)
Calculation: $F_{CH4, PJ,y}=F_{CH4,flared,y}$ as others are not relevant in the project . So $F_{CH4,flared,y}$ = 0.835 tCH_4

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

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

Where

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

Sample calculation

Sample calculation timeline : 1st August 2018, 01:00 hrs
Calculation : 0.7972 –(0/28) = 0.797 tCH_4

Mass flow of greenhouse gas i in the gaseous stream per hour $F_{i,t}$

$F_{i,t}=V_{t,wb,n}*v_{i,t,wb}*\rho_{i,n}$

With

$\rho_{i,n}=P_n*MM_i/R_u*T_n$ __________________ **Equation 5**

Where:

$F_{i,t}$	Mass flow of greenhouse gas i in the gaseous stream per hour	Kg gas/h
$V_{t,wb,n}$	Volumetric flow of the gaseous stream per hour on a wet basis at normal conditions	m^3 wet gas/h
$v_{i,t,wb}$	Volumetric fraction of greenhouse gas i (CH_4 in this case) in the gaseous stream per hour on a wet basis	m^3 gas i/m^3 wet gas
$\rho_{i,n}$	Density of greenhouse gas i (CH_4) in the gaseous stream at normal conditions	kg gas i/m^3 wet gas i
P_n	Absolute pressure at normal conditions	Pa
T_n	Temperature at normal conditions	K
MM_i	Molecular mass of greenhouse gas I (CH_4)	Kg/kmol
R_u	Universal ideal gas constant	Pa.m^3/kmol. K

Density of greenhouse gas (CH_4)$\rho_{i,n}$has been calculated as

follows: $\rho_{i,n}$=101325*16.04/8314.47*273.15=**0.716 kg CH_4/Nm^3 CH_4**

Step 1: Determination of the mass flow rate of the residual gas that is flared

$FM_{RG,h}=\rho_{RG,n,h}*FV_{RG,h}$ _________________ **Equation 7**

Where:

$FM_{RG,h}$	Mass flow rate of the residual gas in hour h	Kg/h
$\rho_{RG,n,h}$	Density of the residual gas at normal conditions in hour h	Kg/Nm^3
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h	Nm^3/h

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)
Calculation : 2224.46*1.27=2825.06 Kg/h

Molecular mass of the residual gas in hour h

$MM_{RG,h}=\sum(fv_{i,h}*MM_i)$ ________________________ **Equation 9**

Where:

$MM_{RG,h}$	Molecular mass of the residual gas in hour h	Kg/kmol
$fv_{i,h}$	Volumetric fraction of component i in the residual gas in the hour h	-
MM_i	Molecular mass of residual gas component i	Kg/kmol
I	The components CH_4, CO, CO_2, O_2,H_2, N_2	-

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)
Calculation: ∑ (0.52 * 16.04) (0.42*44.01) (0* 32) (0.05 * 28.02) = 28.466 Kg/kmol

Step 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas $fm_{j,h}=\sum_I fv_{I,h}*AM_j*NA_{j,i}/ MM_{RG,h}$ __________________ **Equation 10**

Where:

$fm_{j,h}$	Mass fraction of element j in the residual gas in hour h	-
$fv_{I,h}$	Volumetric fraction of component i in the residual gas in the hour h	-
AM_j	Atomic mass of element j	kg/kmol
$NA_{j,i}$	Number of atoms of element j in component i	-
$MM_{RG,h}$	Molecular mass of the residual gas in hour h	Kg/kmol
j	The elements carbon, hydrogen, oxygen and nitrogen	-
i	The components CH4, CO, CO2, O2,H2, N2	-

Step 3 Determination of the volumetric flow rate of the exhaust gas on a dry basis

$TV_{n,FG,h}=V_{n,FG,h}*FM_{RG,h}$ ________________________ **Equation 11**

Where:

$TV_{n,FG,h}$	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour h	Nm^3/hour
$V_{n,FG,h}$	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour h	Nm^3/kg residual gas
$FM_{RG,h}$	Mass flow rate of the residual gas at normal conditions in the hour h	kg residual gas/h

Sample calculation:

Sample calculation timeline : 1st August 2018- 01:00 Hrs (for Flare 1)
Calculation: 4.82 * 2825.07= 13633.80 Nm^3/hour

Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour h

$V_{n,FG,h}= V_{n,CO2,h}+ V_{n,O2,h}+ V_{n,N2,h}$ ___________________ **Equation 12**

Where:

$V_{n,FG,h}$	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour h	Nm^3/kg of residual gas
$V_{n,CO2,h}$	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg of residual gas
$V_{n,O2,h}$	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg of residual gas

$V_{n,N2,h}$	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg of residual gas

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)
Calculation: 0.745+3.879+0.20 =4.826 Nm^3/kg of residual gas

Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h

$$V_{n,O2,h}=n_{O2,h} * MV_n \qquad \text{Equation 13}$$

Where:

$V_{n,O2,h}$	Quantity of O2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg residual gas
$n_{O2,h}$	Quantity of moles O2 in the exhaust gas of the flare per kg residual gas flared in hour h	kmol/kg residual gas
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure	$Nm^3/kmol$

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)
Calculation : 0.009 * 22.414= 0.20 Nm^3/kg residual gas

Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h

$$V_{n,N2,h}=MV_n*\{fm_{N,h}/200AM_N +(1-MF_{O2}/ MF_{O2})*[F_h +n_{O2}]\} \qquad \text{Equation 14}$$

Where:

$V_{n,N2,h}$	Quantity of N2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg residual gas
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure	$Nm^3/kmol$
$fm_{N,h}$	Mass fraction of nitrogen in the residual gas in the hour h	-
AM_N	Atomic mass of nitrogen	Kg/mol
MF_{O2}	O_2 volumetric fraction of air	-
F_h	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h	kmol/kg residual gas
n_{O2}	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h	kmol/kg residual gas

Sample calculation:

Sample calculation timeline :1st August 2018, 01:00 Hrs (for Flare 1)
Calculation: 22.414 *(0.054/ (200 * 14.01) + (1-0.21)/0.21)*(0.037 +0.009)) = 3.879 Nm^3/kg residual gas

Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h.

$$V_{n,CO2,h}=(f_{mC,h}/AM_c)*MV_n \qquad \text{Equation 15}$$

Where:

$V_{n,CO2,h}$	Quantity of CO2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h	Nm^3/kg residual gas
$f_{mC,h}$	Mass fraction of carbon in the residual gas in the hour h	-
AM_c	Atomic mass of carbon	kg/kmol
MV_n	Volume of one mole of any ideal gas at normal temperature and pressure	Nm^3/kmol

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)	
Calculation: (0. 399 / 12)*22.414 = 0.745 Nm^3/kg residual gas	

Quantity of moles O2 in the exhaust gas of the flare per kg residual gas flared in hour h

$n_{02,h}=t_{O2,h}/(1-(t_{O2}/MF_{O2}))*[(f_{mc,h}/AM_c)+(fm_{N,h}/2AM_n)+((1-MF_{O2})/MF_{O2})*F_h]$____________Equation 16

Where:

$n_{02,h}$	Quantity of moles O2 in the exhaust gas of the flare per kg residual gas flared in hour h	Kmol/kg residual gas
$t_{O2,h}$	Volumetric fraction of O2 in the exhaust gas in the hour h	-
MF_{O2}	Volumetric fraction of O2 in the air	-
$fm_{N,h}$	Mass fraction of element N in the residual gas in hour h	-
AM_n	Atomic mass of carbon	Kg/kmol
F_h	Stoichiometric quantity of moles of O2 required for a complete oxidation of one kg residual gas in hour h	kmol/kg residual gas
j	The elements carbon(index C) and Nitrogen (index N)	=

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)	
Calculation:(0.04/(1-(0.04/0.21)*(0.399/12) +(0.054/(2*14.01)+0.034*((1-0.21/0.21))= 0.009Kmol/kg residual gas	

Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h

$F_h=(fm_{C,h}/AM_c)+(fm_{H,h}/4AM_H)-(fm_{O,h}/2AM_O)$____________________Equation 17

Where:

F_h	Stoichiometric quantity of moles of O2 required for a complete oxidation of one kg residual gas in hour h	kmol/kg residual gas
$Fm_{j,h}$	Mass fraction of element j in the residual gas in hour h	-
AM_j	Atomic mass of element j	Kg/kmol
J	The elements carbon (index C), hydrogen (index H) and oxygen (index O)	=

Sample calculation:

Sample calculation timeline : 1st August 2018, 01:00 Hrs (for Flare 1)	
Calculation : (0.399/12)+(0.07/4*1.01)-(0.473/2*16)= 0.034 kmol/kg residual gas	

Step 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

$TM_{FG,h}=(TV_{n,FG,h}*fv_{CH4,FG,h})/1000000$ ______________________ Equation 18

Where:

$TM_{FG,h}$	Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h	kg/h
$T_{Vn,FG,h}$	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour h	Nm^3/h exhaust gas
$fv_{CH4,FG,h}$	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour h	Mg/ Nm^3

Sample calculation :

Sample calculation timeline :1st August 2018, 01:00 Hrs (for Flare 1)
Calculation : (13896.46 * 0)/1000000= 0

Step 5 : Determination of methane mass flow rate in the residual gas on a dry basis

$TM_{RG,h}= FV_{RG,h} *fv_{CH4, RG,h}*\rho_{CH4,n}$ ____________________________ Equation 19

Where:

$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour h	kg/hour
$FV_{RG,h}$	Volumetric flow rate of the residual gas at normal conditions in the hour *h*	Nm^3/hour
$fv_{CH4, RG,h}$	Volumetric fraction of methane in the residual gas in the hour h	-
$\rho_{CH4,n}$	Density of methane at normal conditions	Kg/NM^3

Sample calculation:

Sample calculation timeline :1st August 2018, 01:00 Hrs (for Flare 1)
Calculation : 2224.46* 0.52 *0.716 = 835.38 kg/hour

Step 6: Determination of the hourly flare efficiency

$\eta_{flare,h}=1-(TM_{FG,h}/TM_{RG,h})$[7] ________________________ Equation 20

Where:

$\eta_{flare,h}$	Flare efficiency in the hour h	-
$TM_{FG,h}$	Mass flow rate of methane in the residual gas in the hour h	Kg/hour
$TM_{RG,h}$	Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h	Kg/hour

Sample calculation :

Sample calculation timeline :1st August 2018, 01:00 Hrs (for Flare 1)

[7] The efficiency has been found out using the following condition:

- 0% if the temperature of the flare is below 500 Deg C for more than 20 minutes
- Efficiency has been calculated using Equation 20 if temperature of flare is found more than 500 Deg C for more than 40 minutes

Calculation : 1- (0/835.38)= 1

Step 7: Annual Project Emissions from flaring

$PE_{flare,y}$=∑$TM_{RG,h}$*(1-$\eta_{flare,h}$)*(GWP_{CH4}/1000)____________________Equation 21

$PE_{flare,y}$	Project Emissions from flaring of the residual gas stream in the year y	tCO_2e
∑$TMRG_{,h}$	Mass flow rate of methane in the residual gas in the hour h	Kg/hour
$\eta_{flare,h}$	Flare efficiency in hour h	%
GWP_{CH4}	Global Warming Potential value for methane	tCO_2e/tCH_4

Sample calculation :

Sample calculation timeline : 1st August 2018 – 01:00 Hrs
Calculation :835.38* (1-1)* 28/1000)= 0 tCO_2e

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

<u>Project Emissions from consumption of electricity:</u>

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

Where:

PE_y	Project emissions in year y	tCO_2e
$PE_{EC,y}$	Emissions from consumption of electricity due to the project activity in year y	tCO_2e
$PE_{FC,y}$	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y	tCO_2e

The emission in the project activity due to consumption of electricity has been determined as per *“Tool to calculate baseline, project and/or leakage emissions from electricity consumption”*

The project activity consumes electricity from an onsite gas based generation system as well as Diesel Generator sets and hence the project emissions resulting from electricity consumptions has been calculated based on the following formula:

$PE_{EC,y}$=∑$EC_{PJ,j,y}$*$EF_{EL,j,y}$*(1+$TDL_{,j,y}$)

Where:

$PE_{EC,y}$	Emissions from consumption of electricity due to the project activity in year y	tCO_2e
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source j in year y	MWh
$EF_{EL,j,y}$	Emission factor for electricity generation for source j in year y	tCO_2e/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	-

Determination of emission factor for electricity generation ($EF_{EL,j,y}$)

The emission factor for electricity generation has been determined by Option B2 mentioned in “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

As per the tool,

Option B2: Use the following conservative default values:

- *A value of 1.3 tCO_2/MWh if*

a. *The electricity consumption source is a project or leakage electricity consumption source; or*

b. *The electricity consumption source is a baseline electricity consumption source; and the electricity consumption of all baseline electricity consumptions sources at the site of the captive power plant(s) is less than the electricity consumption of all project electricity consumption sources at the site of the captive power plant(s).*

Since the electricity consumption source is a project electricity consumption source, the default value of 1.3 tCO2/MWh has been applied in the project activity. Also as per scenario B, $TDL_{j,y}$ has been considered 0

Sample calculation :

Sample calculation timeline : 1st August 2018 – 01:00 Hrs
Calculation : energy consumption value recorded – 0.202 MWh

Hence as per formula

Sample calculation :

Sample calculation timeline : 1st August 2018- 01:00 Hrs
Calculation : 0.202 *1.3 = 0.262 tCO_2e

E.3. Calculation of leakage emissions

No leakage effects need to be accounted for under methodology ACM0001, version 12.0.0

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	317,362	4647	0	0	312,715	312,715

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)
312,715	244,049

E.6. Remarks on increase in achieved emission reductions

The actual amount of emission reduction achieved is 312,715 as against 244,049 tCO_2e for the corresponding period. This is around 28 % more than the estimated amount. The major reason for this change being the alteration in the GWP value of Methane. i.e 25 in place of 21 which results in a rise of 20 % of CER accounting.

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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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