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	Gwangju metropolitan city sanitary landfill LFG power plant CDM project	
UNFCCC reference number of the project activity	4294	
Version number of the PDD applicable to this monitoring report	6.0	
Version number of this monitoring report	1.0	
Completion date of this monitoring report	19/04/2018	
Monitoring period number	4th Monitoring period	
Duration of this monitoring period	01/01/2017 - 31/12/2017	
Monitoring report number for this monitoring report	N/A	
Project participants	Environmental Corporation of Gwangju PANAX ENERGY Co.,Ltd Gwangju Metropolitan City Ecoeye Co.,Ltd	
Host Party	Republic of Korea	
Sectoral scopes	1: Energy industries (Renewable - / non-renewable sources) 13: Waste handling and disposal	
Applied methodologies and standardized baselines	AMS-III.G. ver.06 (Landfill methane recovery) AMS-I.D. ver.16 (Grid connected renewable electricity generation)	
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	36,819
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	33,777	

SECTION A. Description of project activity

A.1. General description of project activity

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・ Purpose of the project activity and the measures taken for GHG emission reductions

The proposed project includes LFG(landfill gas) collection and electricity generation with grid connection. The main purpose of this project is to recover landfill gas generated from landfill site and use it to generate electricity. It does not include LFG flaring. The second purpose of this project is to prevent global warming by combusting methane which is emitted to the atmosphere. Moreover, the project activity improves environmental quality and contributes to green domestic electricity supply.

・ Brief description of the installed technology and equipment

The project facilities consist of three systems which are LFG collection system, LFG pre-treatment system, and electricity generation system. Generator was installed total 2MW[1] in this project site.

Item	Gwangju
Generator capacity	2MW(1MW x 2EA)
Manufacturer	JES AG
Engine type	J 320 GS-C81
Working principle	4-Stroke

・ Relevant dates for the project activity

In the beginning stage of project design, total capacity was planned to 2MW installation. Plant capacity of 1MW has been operated from 2010 and another 1MW was added in 2013.

Item		Completion of Construction	Electricity equipment test period	Starting Date of Operation
Date	1# generator	28/01/2010	25/01/2010	15/01/2010
	2# generator	31/07/2013	31/07/2013	25/07/2013

・ Total emission reductions achieved in this monitoring period

Total emission reductions by the project is calculated as 36,819tCO_2e

A.2. Location of project activity

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Project activity landfill site is located in #26, Yanggwa-Dong, Nam-Gu, Gwangju Metropolitan City, which is the province located in the south-western part of Korea. 35˚ 05’ 18.84” N / 126˚ 53’ 10. 79” E (35.088567°/126.886331°)

[1] Refer to the IRR, the generator capacity was written as respectively 1,060kW by plant and economic evaluation was performed reflecting 1,060kW. But when PP registered PDD, PP simply marked generator capacity as 1MW.

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (Host)	Public entity: Environmental Corporation of Gwangju	NO
	Private entity: PANAX ENERGY Co.,Ltd	
	Public entity: Gwangju Metropolitan City	
	Private entity: Ecoeye Co. Ltd	

A.4. Reference to applied methodologies and standardized baselines

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・ **The applied methodology(ies):**

The version 06 of AMS III.G. “Landfill methane recovery”
The version 16 of AMS I.D. “Grid connected renewable electricity generation”

・ **The applied tools:**

“Tool to calculate the emission factor for an electricity system Ver.2”
”Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site Ver.4”
“Tools for the demonstration and assessment of additionality” Ver.5.2”

A.5. Crediting period type and duration

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・ Type : Fixed
・ Start date : 21/02/2011
・ Length of the crediting period : 10y(21/02/2011 ~ 20/02/2021)
・ 4th monitoring period : 01/01/2017 ~ 31/12/2017

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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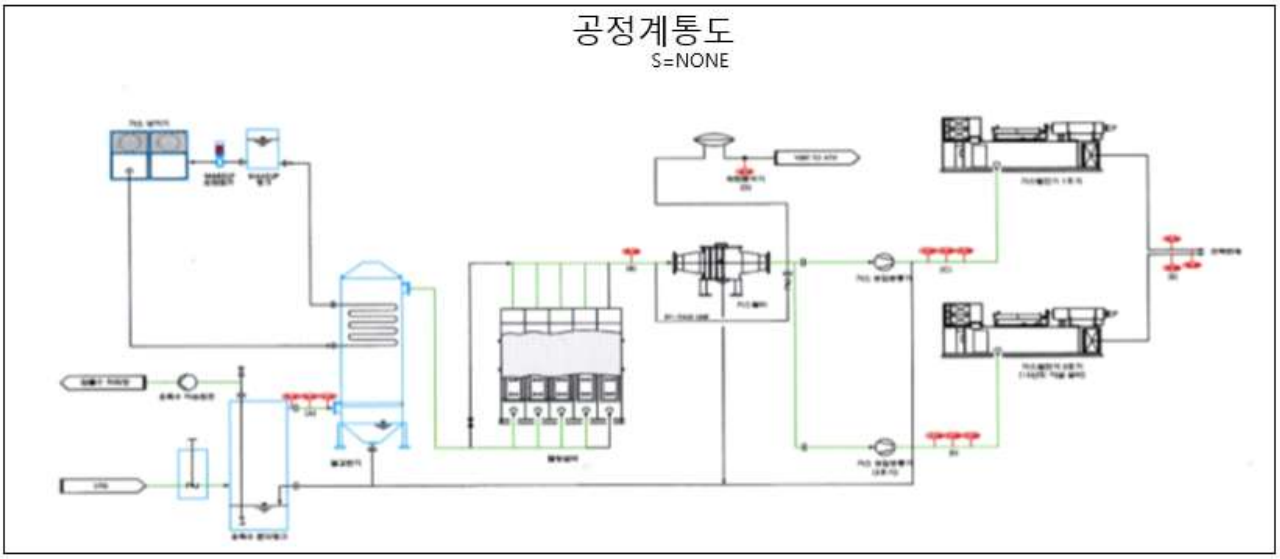
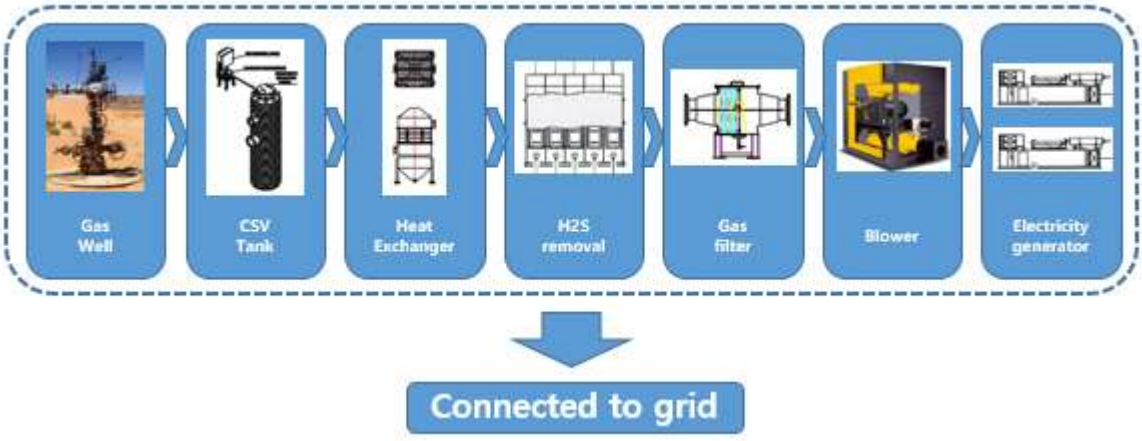
· Technical process

The proposed project includes LFG(landfill gas) collection and electricity generation with grid connection. The project facilities consist of three systems, which are LFG collection system, LFG pre-treatment system, and electricity generation system. The project activity does not include LFG flaring system and existing flaring tips have not been operated since the project began. Therefore, the whole amount of captured LFG is used for electricity generation only. For preventing methane leakage from LFG collection pipes and power generation system, a block system is installed.





· Installed technology

Type	Details	Quantity
Gas Well	· material : PE pipe · main pipe : 100A(3EA), 150A(3EA), ,200A(3EA), 250A(3EA) · Pipe connection : 50A · Gas collection extract tablet : 150A(204EA)	204well
CSV Tank	· material : High Density Poly Ethylene · weight : Approx 1450kg · size : DIA/L : 1,000/4,215mm · pump type: Positive Displacement · flow operating of pump: 80L/min	1

Heat Exchanger	· material : STS304, STC302 · weight : 815kg · size : 1,835x1,635x3,652 · volume : 2,000m^3/h · design pressure : -15Kpa/MAX	1
H_2S removal set	· type : dry process · H_2S density of input gas : 500ppm · H_2S density of exhaust gas : 50ppm · size : 2,500x1,600x2700mm · volume : 1,200Nm^3/hr · max internal pressure : -20kpa	1
Gas Filter	· material : STS304, STC302 · weight : 250kg · size : 1,600x1210x949 · fluid flow : methane · capacity : 1,000m^3/h · design pressure : 150KGF/CM2G	1
Blower	· type : SP 125 IM · no : 3099418 · capacity : 17m^3/min · speed : 1770RPM · discharge pressure : 0.1kg/cm^2	2
Generator	· manufacturer : STAMFORD · type : HCI 634 K2 · volume : 1,060kW · voltage : 480v · speed : 1,800rpm	2

- **Information on the implementation and actual operation of the project activity**

<table>
<tr><th>Item</th><th>Gwangju</th></tr>
<tr><td>Overhaul</td><td>- 1# Generator
<table>
<tr><th>Date</th><th>details</th></tr>
<tr><td>01/05/2017 ~ 03/05/2017</td><td>Emergency maintenance</td></tr>
<tr><td>16/05/2017 ~ 23/05/2017</td><td>Emergency maintenance</td></tr>
</table>
- 2# Generator
<table>
<tr><th>Date</th><th>details</th></tr>
<tr><td>06/02/2017 ~ 10/02/2017</td><td>Emergency maintenance</td></tr>
<tr><td>14/12/2017~26/03/2018</td><td>Semi-overhaul</td></tr>
</table></td></tr>
<tr><td>Downtime</td><td>- CH content analyser
<table>
<tr><th>Date</th><th>details</th></tr>
<tr><td>14/08/2017 ~ 04/11/2017</td><td>Failure of CH4 content analyser</td></tr>
</table>
- 1# Generator
<table>
<tr><th>Date</th><th>details</th></tr>
<tr><td>19/08/2017 ~ 06/09/2017</td><td>Leakage of jacket water pump</td></tr>
<tr><td>31/10/2017 ~ 15/12/2017</td><td>Damage of diaphragm pumps</td></tr>
</table>
- 2# Generator
<table>
<tr><th>Date</th><th>details</th></tr>
<tr><td>08/06/2017 ~ 17/07/2017</td><td>Generator trip of reverse power</td></tr>
<tr><td>19/07/2017 ~ 26/07/2017</td><td>Abnormal combustion of exhaust temperature</td></tr>
<tr><td>27/07/2017 ~ 01/08/2017</td><td>Generator loss of excitation trip</td></tr>
<tr><td>04/08/2017 ~ 14/08/2017</td><td>Leanox Control of deviation exceeded</td></tr>
<tr><td>15/08/2017 ~ 19/08/2017</td><td>Generator trip of reverse power</td></tr>
</table></td></tr>
</table>

	12/09/2017 ~ 16/09/2017 | Soaring of bearing temperature 23/10/2017 ~ 31/10/2017 | Leanox Control of deviation exceeded
Equipment exchange	-

・ Events of situations which may impact on the applicability of the methodology

There are no events of situations that occurred during the monitoring period that may impact the applicability of the applied methodology.

B.2. Post-registration changes

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

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There is one temporary deviation found in this monitoring period as below;

1. Failure of Gas analyser

* Reason of temporary deviation
CH4 content was not measured and archived continuously because of Gas analyser of failure
PP measured to CH4 content once a day during failure periods.
Measured data was daily confirmed to headquarter of PANAX

* Duration of temporary deviation
From 14/08/2017 to 04/11/2017

* Application of conservative approach
As portable gas analyser is new in 2017, that was complied with calibration frequency.
Measured CH4 content were accurate value, CH4 content was conservatively adjusted by reflecting allowable error 1% of original gas analyser because of monitoring plan of nonfulfillment.

Portable gas analyser of allow error is 0.5% and original gas analyser of allow error is 1.0%
PP was applied to 1.0% of allow error as conservative manner.

B.2.2. Corrections

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N/A

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

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N/A

B.2.4. Inclusion of monitoring plan

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N/A

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

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N/A

B.2.6. Changes to project design

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The following changes have been made in the registered PDD ver.6.0 and the request for approval submitted with the 1st monitoring report.

1. Technical specifications of installed equipment
2. Unit of measurement of a monitored parameter, $LFG_{burnt,y}$
3. Information of PP in the registered PDD

The request for post-registration changes was approved on 06 Jan 16, and can be found by reference number PRC-4294-001.

SECTION C. Description of monitoring system

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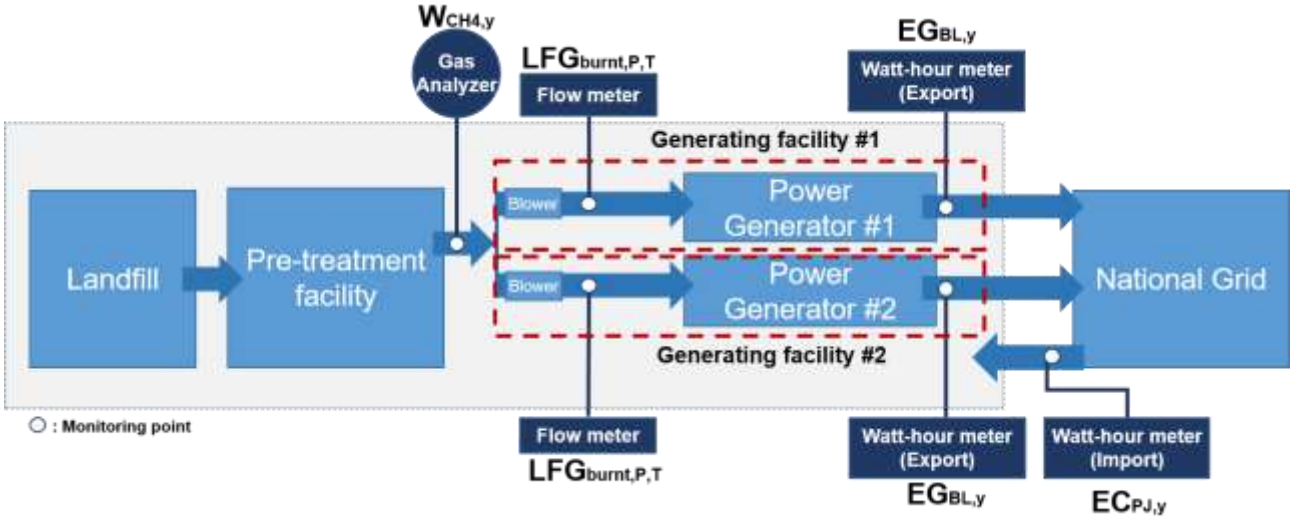
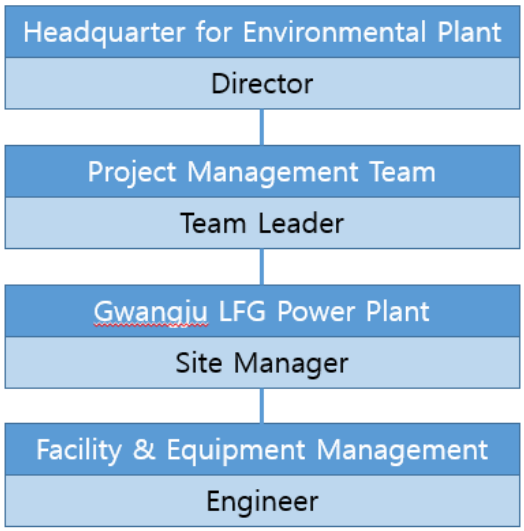
・ Date collection procedure and Monitoring Point for the project

There are 2 monitoring points located between the blower and the generator of each generating facility. Mainly 2 gas flow meters installed at each monitoring point and measuring LFG flow rate and one spare meter is used when either of meters have been through calibration or broken down. The gas flow meter measures the temperature, pressure, and the amount of collected LFG automatically and displays normalized volume in standard cubic meter.

A continuous methane analyzer is used to measure the fraction of methane in LFG fed into the gas engine. Watthour meters were installed for measuring the electricity export and electricity import separately.



・ Operational and management structure



・ Quality Control(QC) / Quality Assurance(QA) and Emergency procedure

1. Monitoring equipment

1-1. Electricity measuring meters were set up transparently in accordance with “Measures Act” and “Rules on the operation of the electricity market” and sealed after the affirmation of Korea Power Exchange(hereinafter referred to as KPX).
1-2. Other monitoring equipments were installed and operated in accordance with AMS I.D and AMS III.G.
1-3. The monitoring equipments were certified when they were produced. Since then, periodic calibration has been implemented as stated in B.7.1 of the registered PDD. Calibration frequency is determined in accordance with domestic and UNFCCC regulations. If any monitoring equipment were considered to be performing abnormally, appropriate actions should be made immediately.

2. Electricity monitoring

2-1. The amount of electricity exported to the grid is measured automatically by established meter. The measured data are also checked by central control system of KPX.
2-2. The measured data of the electricity export are collected electronically in daily, weekly, and monthly basis. The measured data of the electricity import are collected by monthly bill issued by Korea Electric Power Corporation (hereinafter referred to as KEPCO).
2-3. The collected electricity production data as in article 2-2 are compared with those of KPX.
2-4. If the collected data differ from the data provided by KPX, when the data were being compared as stated in article 2-3, project site manager shall identify the reason for the difference. As the source of issue identified, monitoring report shall specify how to treat the concern data in calculation of the amount of emission reduction. In case of errors to meters internal investigation and correction procedure shall be followed by the site manager.

3. Other parameters monitoring

3-1. The major parameters measured automatically by metering equipment ($LFG_{burnt,y}$, $W_{CH4,y}$ etc.) are monitoring continuously and recorded automatically in computer.
3-2 Other monitoring parameters are monitoring in accordance with B.7.1 of the registered PDD.

4. Training & guideline for CDM monitoring

4-1. All employees directly involved in the monitoring process are training for monitoring and managing its data and equipment. The engineers at the project site is in touch with the CDM consultants to get proper guideline for monitoring activity. In addition, the separate monitoring manual is prepared for the engineers to implement monitoring and managing monitoring equipment appropriately.

The monitored data will be archived until 2 years after the end of the period of the project activity.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/parameter:	ε_{BL}
Unit	%
Description	Destruction efficiency of the baseline system(fraction)
Source of data	Survey for estimating GHG emission and establishing statistics in landfill, August 2006, Ministry of Environment
Value(s) applied)	5.2%
Choice of data or measurement methods and procedures	Sourced from the research document.
Purpose of data	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	CE
Unit	%
Description	LFG capturing efficiency of the proposed project LFG collection system
Source of data	Seohee Construction Co. Ltd.
Value(s) applied)	55%
Choice of data or measurement methods and procedures	Technological survey of Seohee Construction Co. Ltd.
Purpose of data	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	D_{CH4}
Unit	$tCH_4/m^3 CH_4$
Description	Methane density
Source of data	ACM0001 version 05
Value(s) applied)	$0.0007168 tCH_4/m^3 CH_4$
Choice of data or measurement methods and procedures	At standard temperature and pressure(0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 $tCH_4/m^3 CH_4$
Purpose of data	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	$EF_{Grid,CM,y}$
Unit	tCO_2e/MWh
Description	CO_2 emission factor for electricity grid in baseline
Source of data	Calculated
Value(s) applied)	0.6018 tCO_2e/MWh
Choice of data or measurement methods and procedures	This value was calculated according to "Tool for calculation of emission factor for electricity system ". Applied value was calculated using Statistics of Electric Power in KOREA (2006,2007,2008, KEPCO) and Status of Generation facility(2008) (Korea Power Exchange)
Purpose of data	Calculation of baseline emissions
Additional comments	This value corresponds to EF_{CO2} in ER calculation.

Data / Parameter:	$EF_{Grid,OM,y}$
Unit:	tCO_2e/MWh
Description:	CO_2 Operating Margin emission factor of the grid
Source of data:	Calculated
Value(s) applied):	0.6816 tCO_2e/MWh
Choice of data or measurement methods and procedures	This value was calculated according to "Tool for calculation of emission factor for electricity system". Applied value was calculated using Statistics of Electric Power in KOREA (2006,2007,2008, KEPCO) and Status of Generation facility(2008) (Korea Power Exchange).
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	$EF_{Grid,BM,y}$
Unit:	tCO_2e/MWh
Description:	CO_2 Build Margin emission factor of the grid

Source of data:	Calculated
Value(s) applied):	0.5221 tCO_2e/MWh
Choice of data or measurement methods and procedures	This value was calculated according to "Tool for calculation of emission factor for electricity system ".Applied value was calculated using Statistics of Electric Power in KOREA (2006,2007,2008, KEPCO) and Status of Generation facility(2008) (Korea Power Exchange).
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	ø
Unit:	N/A
Description:	Model correction factor to account for model uncertainties
Source of data:	"Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site Ver.4"
Value(s) applied):	0.9
Choice of data or measurement methods and procedures	The above default value is suggested in "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site Ver.4"
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	OX
Unit:	N/A
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:	Use the IPCC 2006 Guidelines for National Greenhouse Gas Inventories for the choice of the value to be applied.
Value(s) applied):	0.1
Choice of data or measurement methods and procedures	For managed solid waste disposal sites which are covered with oxidizing material such as soil or compost. As Gwangju landfill has daily soil cover, OX is 0.1
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	DOC_i
Unit:	%
Description:	Fraction of degradable organic carbon (by weight) in the waste type j
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4, and 2.5)
Value(s) applied):	

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

Choice of data or measurement methods and procedures	The above default value is suggested in "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site Ver.4".
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	DOC_f
Unit:	%
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied):	0.5
Choice of data or measurement methods and procedures	The above default value is suggested in "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site Ver.4".
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	MCF
Unit:	N/A
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	The project site is categorized as „anaerobic managed solid waste disposal site".
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	$W_{j,x}$
Unit:	%
Description:	Amount of organic waste type j prevented from disposal in the SWDS in the year *x* (tons)
Source of data:	The project site(Gwangju landfill)-specific data collected by Gwangju Environmental Installations Co.
Value(s) applied):	Refer to the separate calculation sheet.
Choice of data or measurement methods and procedures	Since the landfill operation started, Gwangju Environmental Installations Co. has collected the waste amount and composition data by monitoring and analyzing the waste received.
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	K_i
Unit:	N/A
Description:	Decay rate for the waste type j
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 3.3)
Value(s) applied):	

Waste type j		K_j Dry (MAP/PET < 1)
Slowly Degrading	Pulp, paper, cardboard(other than sludge), textiles	0.04
	Wood, wood products and straw	0.02
Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.05
Rapidly degrading	Food, food waste, beverages and tobacco (other than sludge)	0.06

Choice of data or measurement methods and procedures	The above default values applicable for the region where Mean Annual Temperature (MAT) is below 20°C and mean annual precipitation(MAP) is less than Potential evapo-transpiration(PET), according to the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site." The MAT of Gwangju city is 13.9°C which is consistent with the above condition. It is assumed that MAP is less than PET in conservative manner because there is no information about PET in Gwangju.
Purpose of data:	Calculation of baseline emissions
Additional comment:	10 years mean value (1996~2005) MAT(Mean Annual Temperature) : 13.9 MAP(Mean Annual Precipitation): 1524.6 mm PET(Potential evapo-transpiration): N/A Based on data observed at meteorological observatory in Gwangju Data source :Korea Meteorological Association

Data / Parameter:	F
Unit:	N/A
Description:	Fraction of methane in the SWDS gas (volume faction)
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied):	0.5
Choice of data or measurement methods and procedures	This factor reflects the fact that some degradable organic carbon doesn't degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	f
Unit:	N/A
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Source of data:	Written information from the operator of the solid waste disposal site and/or site visits at the solid waste disposal site
Value(s) applied):	0
Choice of data or measurement methods and procedures	According to the AMS.III.G, this value corresponds to zero. $MD_{reg,y}$ is considered in the ER calculation.
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

D.2. Data and parameters monitored

Data/parameter:	$MG_{PR,1}$
Unit	tCH_4
Description	Amount of methane generated during the first year of the project activity estimated using the actual amount of waste disposed in the landfill
Measured/ calculated/ default	Calculated using "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site Ver.4"
Source of data	Calculated from the data collected by the Environmental Corporation of Gwangju
Value(s) of monitored parameter	1,276.31tCH_4
Monitoring equipment	N/A
Measuring/ reading/ recording frequency:	Continuous measuring and reading, hourly recording

Calculation method (if applicable):	N/A
QA/QC procedures:	As per "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site Ver.4"
Purpose of data:	Calculation of baseline emissions
Additional comments:	This parameter was measured at 1st monitoring period to calculate $\varepsilon_{PR,1}$.

Data/parameter:	$MD_{PR,1}$
Unit	tCH_4
Description	Amount of methane destroyed by the project activity during the first year of the project activity
Measured/ calculated/ default	Calculated from the monitoring data.
Source of data	Using the value of the first year collected through the monitoring equipment(flow meter & gas analyser)
Value(s) of monitored parameter	$958.43tCH_4$
Monitoring equipment	N/A
Measuring/ reading/ recording frequency:	Continuous measuring and reading, hourly recording
Calculation method (if applicable):	N/A
QA/QC procedures:	Related monitoring equipments (flow meter & gas analyser) are subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of baseline emissions
Additional comments:	This parameter was measured at 1st monitoring period to calculate $\varepsilon_{PR,1}$.

Data/parameter:	$LFG_{burnt,y}$
Unit	Nm^3
Description	Landfill gas flared or used as fuel in the year *y*
Measured/ calculated/ default	Measured by flow meter Measured and archived continuously in form of electronic data file Calibrated every two years
Source of data	Data of acquisition for Flow meter
Value(s) of monitored parameter	

Date	#1	#2	total
01/Jan/17 ~ 31/Dec/17	2,450,220Nm^3	2,426,510Nm^3	4,876,730Nm^3
total	2,450,220Nm^3	2,426,510Nm^3	4,876,730Nm^3

Total $LFG_{burnt,y}$ is the sum of the data measured from 2 monitoring points(details are below) and each of data is the amount of LFG used in each power generating facilitiy in this project.

<table>
<tr><td>Monitoring equipment</td><td>
- Equipment: Flow meter
- Quantity: 3
(Main-flow meter: 2, Sub-flow meter: 1)
- Details:
There are 2 monitoring points located at the front of each power generator (#1, 2) to measuring the amount of landfill gas used by each of the generating facility. There are 3 flow meters used in rotation (2 main meters and 1 spare meter) and normally 2 flow meters are installed to each monitoring point and 1 flow meter is kept for maintenance or calibration in rotation. The specific date which meter used for each monitoring point during the monitoring period is below.

a) LFG #1
<table>
<tr><th>Used period</th><th>Serial number</th></tr>
<tr><td>26/10/2016 ~ 02/02/2018</td><td>23082001</td></tr>
<tr><td>02/02/2018 ~ present</td><td>13121202</td></tr>
</table>
b) LFG #2
<table>
<tr><th>Used period</th><th>Serial number</th></tr>
<tr><td>26/10/2016 ~ Present</td><td>28041404</td></tr>
</table>
Detailed specification for each flow meter is below.
* Main flow meter 1
<table>
<tr><td>Model</td><td>8840MP-SSS-133-DC24-6”-LFG</td></tr>
<tr><td>Accuracy class</td><td>± 1.0%</td></tr>
<tr><td>Serial number</td><td>28041404</td></tr>
<tr><td>Calibration frequency</td><td>2years</td></tr>
<tr><td>Date of the latest calibration</td><td>10/06/2016</td></tr>
<tr><td>Used period</td><td>26/10/2016 ~ present (LFG #2)</td></tr>
<tr><td>Validity period</td><td>10/06/2016 ~ 09/06/2018</td></tr>
</table>
* Main flow meter 2
<table>
<tr><td>Type</td><td>8840MP-SSS-133-DC24-6”-LFG</td></tr>
<tr><td>Accuracy class</td><td>± 1.0%</td></tr>
<tr><td>Serial number</td><td>23082001</td></tr>
<tr><td>Calibration frequency</td><td>2years</td></tr>
<tr><td>Date of the latest calibration</td><td>29/01/2016</td></tr>
<tr><td>Used period</td><td>26/10/2016 ~ 02/02/2018 (LFG #1)</td></tr>
<tr><td>Validity period</td><td>29/01/2016 ~ 28/01/2018</td></tr>
</table>
* Sub-flow meter 1
<table>
<tr><td>Type</td><td>8840MP-SSS-DC24-6”-LFG</td></tr>
<tr><td>Accuracy class</td><td>± 1.0%</td></tr>
<tr><td>Serial number</td><td>13121202</td></tr>
<tr><td>Calibration frequency</td><td>2years</td></tr>
<tr><td>Date of the latest calibration</td><td>02/02/2018</td></tr>
<tr><td>Used period</td><td>02/02/2018 ~ Present (LFG #1)</td></tr>
<tr><td>Validity period</td><td>02/02/2018 ~ 01/02/2020</td></tr>
</table>
</td></tr>
<tr><td>Measuring/
reading/
recording frequency:</td><td>Continuous measuring and reading, hourly recording</td></tr>
<tr><td>Calculation method
(if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments:</td><td>N/A</td></tr>
</table>

Data/parameter:	$W_{CH4,y}$
Unit	m^3 CH_4/m^3 LFG
Description	Methane content in landfill gas in the year *y*
Measured/ calculated/ default	Measured by gas analyser Measured and archived continuously in form of electronic data file Calibrate the meter every three years
Source of data	Data of acquisition for Gas analyser
Value(s) of monitored parameter	<table><tr><th>Date</th><th>Average</th><th>#1</th><th>#2</th></tr><tr><td>01/Jan/16 ~ 31/Dec/16</td><td>41.9%</td><td>42.1%</td><td>41.7%</td></tr><tr><td>total</td><td>41.9%</td><td>42.1%</td><td>41.7%</td></tr></table> For calculating of baseline emission, each generating facility used daily value of $W_{CH4,y}$ considering the operation of generating facility. $W_{CH4,y}$ #1, 2 in the upper table is the representative value calculated backward from $LFG_{burnt,y}$ of each facility.
Monitoring equipment	- Equipment: Gas analyser - Quantity: 2 (one is original analyser another is potable analyser) - Details: * Main analyser <table><tr><td>Tag</td><td>AN-101</td></tr><tr><td>Type</td><td>ZRJF4C15-BUXRX-RYYLVAY-A</td></tr><tr><td>Accuracy class</td><td>± 1.0%</td></tr><tr><td>Serial number</td><td>A9K5306T</td></tr><tr><td>Calibration frequency</td><td>3years</td></tr><tr><td>Date of previous calibration</td><td>06/01/2015</td></tr><tr><td>Date of the latest calibration</td><td>10/01/2018</td></tr><tr><td>Validity period</td><td>06/01/2015 ~ 05/01/2018 10/01/2018 ~ 09/01/2021</td></tr></table> * Portable analyser <table><tr><td>Tag</td><td>Portable analyser</td></tr><tr><td>Type</td><td>Biogas 5000</td></tr><tr><td>Accuracy class</td><td>± 0.5%</td></tr><tr><td>Serial number</td><td>G504526</td></tr><tr><td>Calibration frequency</td><td>3years</td></tr><tr><td>Date of previous calibration</td><td>02/03/2017</td></tr><tr><td>Validity period</td><td>02/03/2017 ~ 01/03/2020</td></tr></table>Using date: From 14/08/2017 to 04/11/2017
Measuring/ reading/ recording frequency:	Continuous measuring and reading, hourly recording
Calculation method (if applicable):	N/A
QA/QC procedures:	The gas analyzer is subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of baseline emissions
Additional comments:	N/A

Data / Parameter:	T
Unit:	℃
Description:	Temperature of the landfill gas

Measured/ Calculated / Default:	Measured to determine the density of methane D_{CH4} No separate monitoring of temperature will be done as the project LFG flow meter automatically measures temperature and pressure, expressing LFG volumes in normalized cubic meters
Source of data:	Data of acquisition for Temperature Gauges
Value(s) of monitored parameter:	Reference data
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	Continuous measuring and reading, hourly recording
Calculation method (if applicable):	N/A
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	P
Unit:	Pa
Description:	Pressure of the landfill gas
Measured/ Calculated / Default:	Measured to determine the density of methane D_{CH4} No separate monitoring of temperature will be done as the project LFG flow meter automatically measures temperature and pressure, expressing LFG volumes in normalized cubic meters
Source of data:	Data of acquisition for Pressure Gauges
Value(s) of monitored parameter:	Reference data
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	Continuous measuring and reading, hourly recording
Calculation method (if applicable):	N/A
QA/QC procedures:	Measuring instruments should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards
Purpose of data:	Calculation of baseline emissions
Additional comment:	N/A

Data / Parameter:	$EG_{BL,y}$
Unit:	MWh
Description:	Total amount of electricity exported to the grid by the project activity
Measured/ Calculated / Default:	Measured by watt-hour meter
Source of data:	Measured by Watt-hour meters installed at the project site
Value(s) of monitored parameter:	

Date	#1	#2	total
01/Jan/17 ~ 31/Dec/17	2,309.669MWh	2,505.353MWh	4,545.022MWh
total	2,309.669MWh	2,505.353MWh	4,545.022MWh

<table>
<tr><td>Monitoring equipment:</td><td>- Equipment: watt-hour meter
- Quantity: 2
- Details:
<table>
<tr><td>Tag</td><td>WH-101(1# generator)</td></tr>
<tr><td>Type</td><td>SCE8711</td></tr>
<tr><td>Accuracy class</td><td>± 0.5%</td></tr>
<tr><td>Serial number</td><td>53048181</td></tr>
<tr><td>Calibration frequency</td><td>Within 3years</td></tr>
<tr><td>Date of the latest calibration</td><td>27/07/2015</td></tr>
<tr><td>Validity period</td><td>27/07/2015 ~ 26/07/2018</td></tr>
</table>

<table>
<tr><td>Tag</td><td>WH-201(2# generator)</td></tr>
<tr><td>Type</td><td>TWR-ALM1</td></tr>
<tr><td>Accuracy class</td><td>± 0.5%</td></tr>
<tr><td>Serial number</td><td>4349712</td></tr>
<tr><td>Calibration frequency</td><td>Within 3years</td></tr>
<tr><td>Date of the latest calibration</td><td>24/12/2015</td></tr>
<tr><td>Validity period</td><td>24/12/2015 ~ 23/12/2018</td></tr>
</table>
</td></tr>
<tr><td>Measuring/
Reading/
Recording frequency:</td><td>Continuous measuring and reading, hourly recording</td></tr>
<tr><td>Calculation method
(if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>The watt-hour meter is subject to a regular maintenance and testing regime to ensure accuracy.</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment:</td><td>N/A</td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>$EC_{PJ,y}$</td></tr>
<tr><td>Unit:</td><td>MWh</td></tr>
<tr><td>Description:</td><td>Electricity supplied from the grid by the project activity during the year y</td></tr>
<tr><td>Measured/
Calculated /
Default:</td><td>The electricity for the project activity is from the grid. If any, corresponding amount will be monitored and considered as $PE_{EC,y}$.
Measured by watt-hour meter
Calibrate the meter every three years</td></tr>
<tr><td>Source of data:</td><td>Data of acquisition for electronic bills</td></tr>
<tr><td>Value(s) of monitored parameter:</td><td>There is 1 monitoring point for measuring total amount of electricity supplied from the grid, $EC_{PJ,y.}$

Total: 18,948kWh

$EC_{PJ,y}$ #1, 2 in below tables is determined by operation of each generating facility.

Generator #1:
<table>
<tr><td>01/Jan/17 ~ 31/Dec/17</td><td>8,503kWh</td></tr>
<tr><td>Total</td><td>8,503kWh</td></tr>
</table>

Generator #2:
<table>
<tr><td>01/Jan/17 ~ 31/Dec/17</td><td>10,445kWh</td></tr>
<tr><td>Total</td><td>10,445kWh</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>Monitoring equipment:</td><td>- Equipment: watt-hour meter
- Quantity: 1
- Details:

watthour meter which collects electricity supplied from the grid was replaced by a new device on 19 Dec 2016.

<table><tr><td></td><td>After replacement</td></tr><tr><td>Tag</td><td>WH-102</td></tr><tr><td>Type</td><td>OMWH-3405H</td></tr><tr><td>Accuracy class</td><td>± 1.0%</td></tr><tr><td>Serial number</td><td>26141004722</td></tr><tr><td>Calibration frequency</td><td>Within 3years</td></tr><tr><td>Installation date</td><td>16/12/2016</td></tr><tr><td>Date of the latest calibration</td><td>01/12/2016</td></tr><tr><td>Validity period</td><td>01/12/2016 ~ 30/11/2019</td></tr></table></td></tr>
<tr><td>Measuring/
Reading/
Recording frequency:</td><td>Real-time measurement and monthly records.</td></tr>
<tr><td>Calculation method
(if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>The watt-hour meter is subject to a regular maintenance and testing regime to ensure accuracy.</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comment:</td><td>N/A</td></tr>
</table>

Data / Parameter:	$PE_{EC,y}$
Unit:	tCO_2e/yr
Description:	Project emissions from the electricity generated by (an) off-grid fossil fuel fired captive power plant(s).
Measured/ Calculated / Default:	The project is planning to use no electricity from (an) off-grid fossil fuel fired captive power plant(s) in doing project activity. If such electricity is used, corresponding amount will be monitored and calculated according to the latest version of “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Source of data:	N/A
Value(s) of monitored parameter:	0
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	If such electricity is used, corresponding amount will be monitored and calculated according to the latest version of “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Calculation method (if applicable):	N/A
QA/QC procedures:	If applicable, related monitoring equipment are subject to regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of project emissions
Additional comment:	N/A

Data / Parameter:	$PE_{FC,i,y}$
Unit:	tCO_2e/yr

Description:	Project emissions from fossil fuel combustion in process j for the project activity during the year y
Measured/ Calculated / Default:	The project is planning to use no fossil fuel in doing project activity. If any fossil fuel is used, corresponding amount will be monitored and calculated according to the latest version of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Source of data:	N/A
Value(s) of monitored parameter:	0
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	If any fossil fuel is used, corresponding amount will be monitored and calculated according to the latest version of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Calculation method (if applicable):	N/A
QA/QC procedures:	If applicable, related monitoring equipment are subject to regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of project emissions
Additional comment:	N/A

Data/parameter:	GWP_{CH4}
Unit	tCO_2/tCH_4
Description	Global warming potential for methane (CH_4)
Source of data	Default value in IPCC & ACM0001 version 5
Value(s) applied)	25
Choice of data or measurement methods and procedures	Refer the decisions under UNFCCC and the Kyoto Protocol(Decision 24/CP.19)
Purpose of data	Calculation of baseline emissions
Additional comments	N/A

D.3. Implementation of sampling plan

>>
N/A

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>
1. Baseline emission

$BE_y = MD_y - MD_{reg,y} + BE_{electricity,y}$

Where:

MD_y	Methane captured and destroyed/gainfully used by the project activity in the year "y" (tCO_2e).
$MD_{reg,y}$	Methane emissions that would be captured and destroyed to comply with national or local safety requirement or legal regulations in the year "y" (tCO_2e).
$BE_{electricity,y}$	The baseline emission from the electricity generation in the absence of the Project activity at year y (tCO_2e). This parameter is calculated according to AMS I.D while other parameters in this equation are calculated according to AMS III.G.

・ Generator #1

Period	BE_y	MD_y	$MD_{reg,y}$	$(EG_{BL,y}-EC_{PJ,y})$	EF_{CO2}
	(tCO_2e)	(tCO_2e)	(tCO_2e)	(MWh)	(tCO_2e/MWh)
2017	18,433	18,491	1,280	2,031	0.6018
Total	18,433				

・ Generator #2

Period	BE_y	MD_y	$MD_{reg,y}$	$(EG_{BL,y}-EC_{PJ,y})$	EF_{CO2}
	(tCO_2e)	(tCO_2e)	(tCO_2e)	(MWh)	(tCO_2e/MWh)
2017	18,386	18,140	1,255	2,495	0.6018
Total	18,386				

$MD_y = LFG_{burnt,y} \times W_{CH4,y} \times D_{CH4} \times GWP_{CH4}$

Where:

$LFG_{burnt,y}$	Landfill gas flared or used as fuel in the year "y" (Nm^3)
$W_{CH4,y}$	Methane content in landfill gas in the year "y"
D_{CH4}	Density of methane at the temperature and pressure of the landfill gas[5]
GWP_{CH4}	Global warming potential of CH_4

・ Generator #1

Period	MD_y	$LFG_{burnt,y}$	$W_{CH4,y}$	D_{CH4}	GWP_{CH4}
	(tCO_2e)	(Nm^3)	(%)	($tonCH_4/Nm^3CH_4$)	
2017	18,491	2,450,220	42.1	0.0007168	25
Total	18,491				

・ Generator #2

Period	MD_y	$LFG_{burnt,y}$	$W_{CH4,y}$	D_{CH4}	GWP_{CH4}
	(tCO_2e)	(Nm^3)	(%)	($tonCH_4/Nm^3CH_4$)	
2017	18,140	2,426,510	41.7	0.0007168	25
Total	18,140				

$MD_{reg,y} = MD_y \times AF_y$

Where:

AF_y	Adjustment factor for year y

Period	$MD_{reg,y}$	MD_y	AF
	(tCO_2e)	(tCO_2e)	(%)
2017	2,535	36,630	6.92%
Total	2,535		

$AF_y = \varepsilon_{BL} / \varepsilon_{PR,1}$

Where;

ε_{BL}	Destruction efficiency of the baseline system(fraction)
$\varepsilon_{PR,1}$	Destruction efficiency of the system used in the project activity that will remain fixed for the whole crediting period(fraction)

AF	ε_{BL}	$\varepsilon_{PR,1}$
6.92%	5.2%	75%

2. Emission reduction

$ER_y = MD_y - MD_{reg,y} + (EC_{BL,y} - EC_{PJ,y}) \times EF_{CO2} - PE_y - Leakage$

Where:

MD_y	Methane captured and destroyed by the project activity in the year "y"(tCO_2e)
$MD_{reg,y}$	Methane emissions that would be captured and destroyed to comply with national or local safety requirement or legal regulations in the year "y" (tCO_2e)
$EC_{BL,y}$	Total amount of electricity exported to the grid by the project activity in the year y (MWh)
$EC_{PJ,y}$	Electricity supplied from the grid for the project activity in the year y (MWh)
EF_{CO2}	CO_2 Emission Factor in year y; tCO_2e/MWh. EF_{CO2} value corresponds to EFgrid,CM,y
PE_y	Project emissions in year y (tCO_2e/yr)
Leakage	If the methane recovery technology is equipment transferred from another activity or if the existing equipment is transferred to another activity, leakage effects are to be considered. The project leakage is zero.

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

>>

As the project activity is not supplied any electricity from (an) off-grid fossil fuel fired captive power plant(s) or not used any fossil fuel during the activity, project emissions not to be calculated.

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

Where:

$PE_{EC,y}$	Project emissions from the electricity generated by (an) off-grid fossil fuel fired captive power plant(s). The project emissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
$PE_{FC,j,y}$	Project emissions from fossil fuel combustion in process *j* for the project activity during the year *y* The project emissions from fossil fuel combustion ($PE_{FC,j,y}$) will be calculated following the latest version of "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

$PE_y = 0$

E.3. Calculation of leakage emissions

>>

As the methane recovery technology is not equipment transferred from another activity, leakage is not to be considered.

$LE_y = 0$

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	36,819	0	0	0	0	36,819

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 ($t CO_2e$)
36,819	33,777

E.6. Remarks on increase in achieved emission reductions

>>

The actual amount of emission reduction in the monitoring period are 36,819 tCO2e, which are about 9% more than estimated 2017y in the PDD.

This is because that the GWP_{CH4} has been updated from 21 in the registered PDD into 25 as per EB's guidance. Also, collected methane from waste land was greater than expected at the time of registration of PDD. From 2015 to 2017 is the most efficient period in terms of methane collection of landfill site.