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	Daegu Bangcheon-Ri Landfill Gas CDM Project	
UNFCCC reference number of the project activity	0851	
Version number of the PDD applicable to this monitoring report	Version 13	
Version number of this monitoring report	1.0	
Completion date of this monitoring report	08/01/2019	
Monitoring period number	7th monitoring period	
Duration of this monitoring period	19/08/2017 ~ 18/08/2018	
Monitoring report number for this monitoring report	7th	
Project participants	Daegu Metropolitan City (Project developer) Daesung Eco-Energy Co., Ltd. (Project executer) Korea District Heating Corporation. (Project executer) Ecoeye Co., Ltd. (Project consultant)	
Host Party	Republic of Korea	
Sectoral scopes	Scope 13 : Waste handling and disposal	
Applied methodologies and standardized baselines	ACM0001 ver.15	
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 tCO2e	231,165 tCO2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	177,603 tCO2e (19/08/2017 ~ 18/08/2018)	

SECTION A. Description of project activity

A.1. General description of project activity

>>

Daegu Bangcheon-Ril landfill gases project(Ref.851) was registered as CDM project in 19 Aug 2007. Daegu Bangcheon-Ri Landfill gas CDM Project is a project which captures and refines LFG from the landfill and then the refined LFG is destroyed at LFG flaring system, electricity generation system and thermal system. There is no change for project design after the registration. This project is now on 2nd credit period after 1st credit period.

- **Basic information for the project activity**

Registered	1st Credit period	2nd Credit period	etc
19 Aug 2007	19 Aug 2007 ~ 18 Aug 2014	19 Aug 2014 ~ 18 Aug 2021	-

A.2. Location of project activity

>>

Figure 1. Landscape of Daegu Bancheon-Ri Landfill gas CDM project

- **Purpose of the project activity and the measures taken for GHG emission reductions or net GHG removals by sinks**

On aspects of the technology, Daegu Bangcheon-Ri Landfill gas CDM Project could improve the LFG capture efficiency and reuse of alternative energy which reducing CO_2 emissions by replacing fossil fuel. On aspects of environment, this project activity could prevents global warming by controlling methane emission to the atmosphere and also reduces adverse environmental impacts such as odour emission.

This project activity is comprised of LFG capturing system and LFG utilization system. The captured and refined LFG is literally destroyed at flaring stacks, gas engines and LFG boilers.

- **Brief description of the installed technology and equipment**

Daegu Bangcheon-Ri Landfill gas CDM Project is designed to minimize methane(CH_4) emission by capturing of LFG and utilizing it.

There are 2-main-part installed technology in this project activity. One is LFG capturing system and the other is LFG utilization system. Vertical pipelines are installed to capture LFG into the Wastes and lines are joined and connected to refinery system, which is a part of LFG utilization system. In

the utilization system, LFG are refined and supplied to LFG boilers of KDHC(another project participant).

More details about installed technology and equipment are described in Section B below.

- **Total GHG emission reductions or net GHG removals by sinks achieved in this monitoring period**

This is the 7th monitoring period covering 1 years (from 19/08/2017 to 18/08/2018) and total monitored emission reductions is 231,165 tCO_{2e}.

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** Daegu Metropolitan City Korea District Heating Corporation **Private entity** Daesung Eco-Energy Co., Ltd. Ecoeye Co., Ltd.	No

A.4. Reference to applied methodologies and standardized baselines

>>

The applied methodology is ACM0001 “Flaring or use of landfill gas” (version 15)

The applied Tools are

- “Tool to calculate project or leakage CO2 emissions form fossil fuel combustion” (version 02)
- “Emissions from solid waste disposal sites” (version 06.0.1)
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (version 01)
- “Tool to calculate the emission factor for an electricity system” (version 04)
- “Project emissions form flaring” (version 02)
- “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 02)
- “Combined tool to identify the baseline scenario and demonstrate additionality” (version 05)

For more information on applied methodology and applicable tools please refer to the following link. (http://cdm.unfccc.int/methodologies/DB/D44X8FH8SFCXREE6037AXJSBGGFVDO)

A.5. Crediting period type and duration

>>

- Type : Renewable type
- Renewable date : 17/09/2016
- Length of the 2nd crediting period : 19/08/2014 ~ 18/08/2021
- 7th monitoring period : 19/08/2017 ~ 18/08/2018

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>

The LFG at the Daegu Bangcheon-Ri Landfill site had been treated as the 'Simple on-site treatment' to prevent odour, air pollution and fire prior to the implementation of the project activity. Daegu Bangcheon-Ri Landfill gas CDM Project is a project including LFG captures, refinement and utilization. The project includes vertical collection gas pipes, refinery facility and LFG utilities for energy generation. The refined LFG for the project activity is finally destroyed at Gas engines for electricity generation, at flare stacks in Daegu Bangcheon-Ri landfill and LFG boilers in Korea District Heating Corporation for thermal energy production. The project activity will contribute to reducing methane which may be released to atmosphere.

According to the feasibility study, steady supply of LFG will be available about 20 years. The project has been designed taking into account its expectation. The main features of the LFG facilities are presented below.

As amount of FIQ-201 which monitoring for power generation was 0 Nm^3, gas engines didn't operate during this monitoring period. Especially in summer, LFG generates lower than winter due to the rainy season and heat demands are also lower. During that time, the flaring system of this project could handle the collected LFG at low operating cost comparing to power generation system.

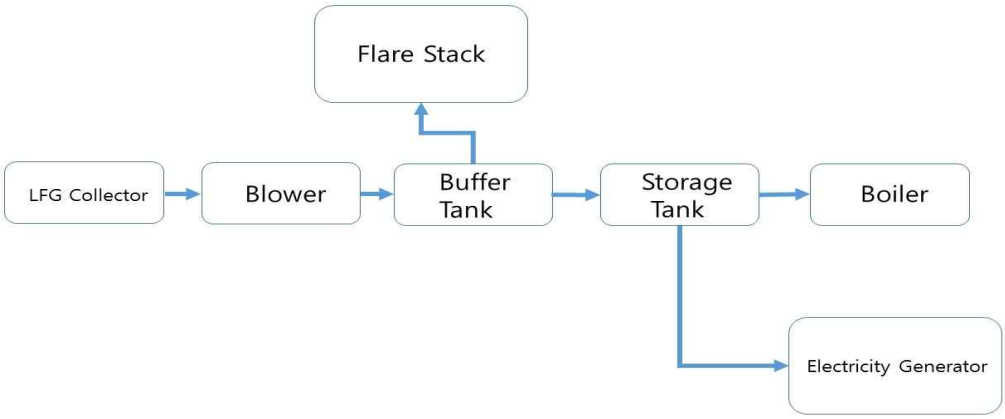
Temperature of collected LFG at TI-204, TI-301 and TI-A installed at flow meters are less than 60°C during this monitoring period. As per option A of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)", LFG are considered as dry basis.

Korea District Heating Corporation requests Daesung Eco-Energy Co., Ltd. to stop supplying LFG due to its heat capacity (Heat demand in summer is lower than in winter). In the period of supplying stop, Daesung Eco-Energy supply the LFG to Flare stack and LFG is burnt.

▶ Technical process

The captured LFG is blown through vertical pipeline. Blower gathers LFG and refinery facilities refine LFG. Refined LFG is stored in the Storage Tank and supplies Korea District Heating Corporation. Korea District Heating Corporation burns LFG to make Heating and supplies its customers.

▶ System diagram



▶ Installed technology

● LFG capturing system

In order to capture LFG, vertical capturing pipes are installed for the project. The type of LFG capturing system is expected to enhance maintenance and LFG capturing efficiency because vertical capturing system has higher capturing efficiency and is easier to maintain and repair system compared to the horizontal capturing system.

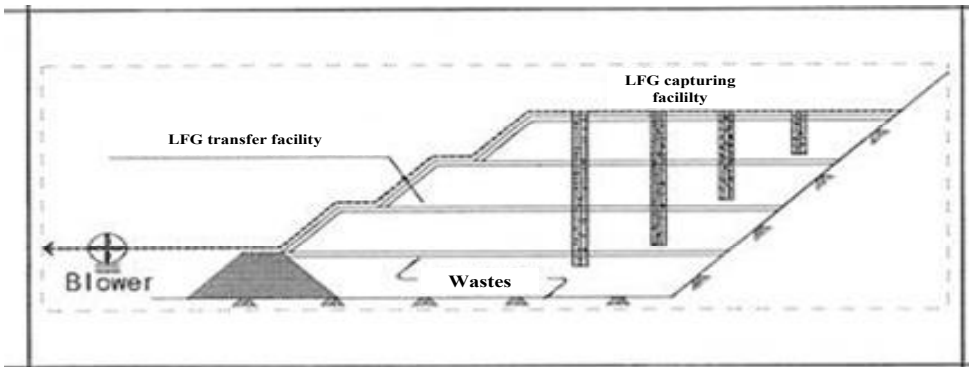


Figure 3 Vertical LFG capturing equipment installation concept

● LFG utilization system

LFG utilization system consists of four parts including LFG capture, refinery facilities, LFG fuel supply facilities, utilization facilities.

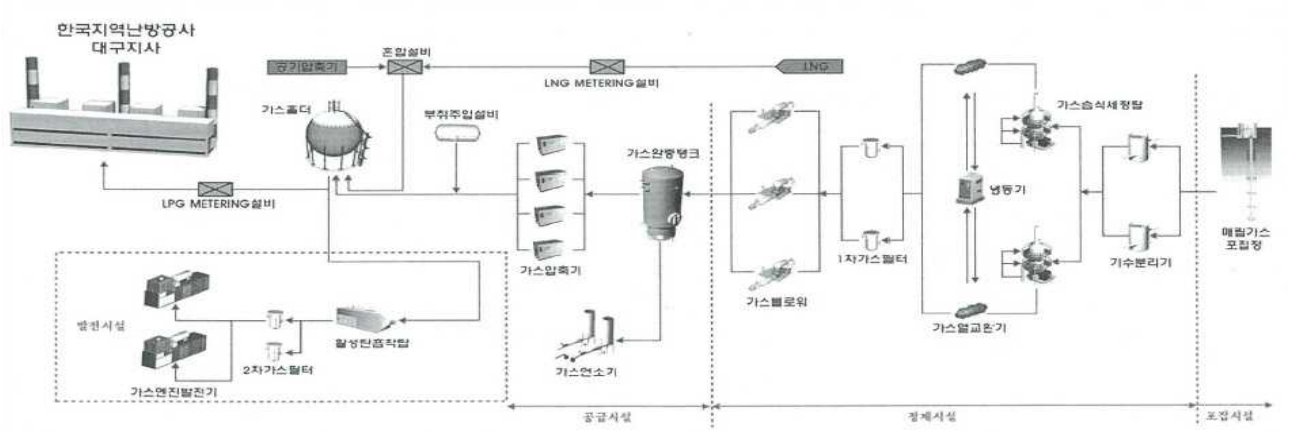


Figure 4 LFG utilization system flow chart

▶ Eq**uipment**

1) Blower

Blower is available to adjust LFG capturing pressure and delivery LFG into Buffer tank. Blower type is turbo type, which keeps consistent pressure and has a remarkable efficiency. Three blowers are installed in a project site and one of them is a spare for an emergency situation.

Figure 5. Turbo Blower

Equipment	Blower
No. of Equipment	FN-1-05A/B/C (3units)
Type	Turbo
Capacity	75 Nm^3/min
Pressure	3,800 mmAq

2) Filter

Filter separates and removes particles flowing into the pipe with LFG.

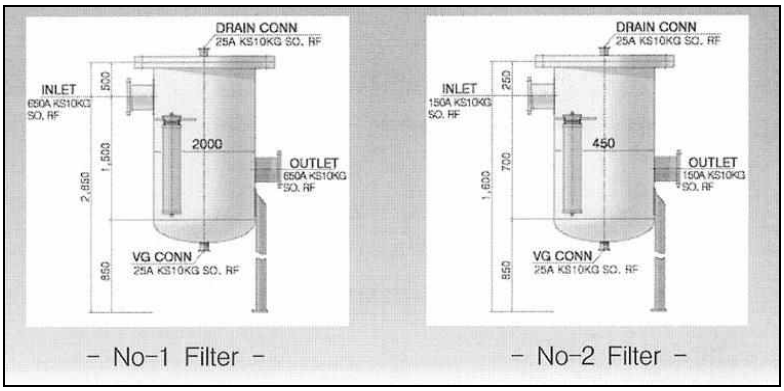


Figure 6. Filter

Equipment	No-1 Filter (before a blower)	No-2 Filter (before gas engine)
No. of Equipment	F-1-01A/B (2units)	F-2-01A/B (2units)
Type	Demister	Demister
Capacity	150 Nm^3/min	17 Nm^3/min
Filtration Element	5μm	0.3μm

3) Scrubber

Scrubber removes acid gas (H_2S, NH_3 etc.) of LFG using solubility, so that the problem of erosion of the facility and pollutant emission can be reduced.

Figure 7. Scrubber

Equipment	SCRUBBER
No. of Equipment	SR-1-02A/B (2units)
Type	Packed Tower with Demister
Capacity	75 Nm^3/min

4) Cooler

Cooler removes moisture from LFG, so that caloric value of the gas is rising and trouble cause of the facility can be removed.

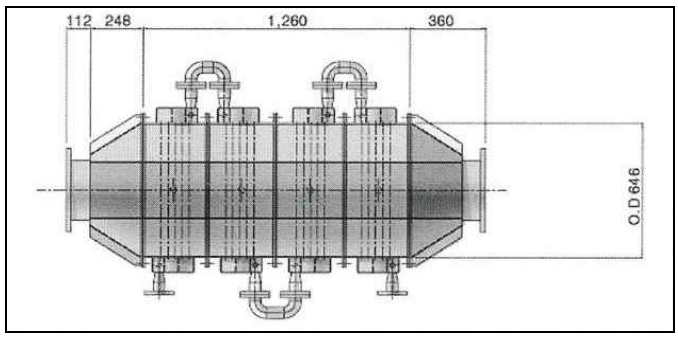


Figure 8. Cooler

Equipment	LFG Cooler
No. of Equipment	CO-1-03A/B (2units)
Type	Fin Tube
Flow Rate	75 Nm^3/min

5) Chiller

Chiller produces chilled water and supplies it to Cooler Tube Side.

Figure 9. Chiller

Equipment	CHILLER
No. of Equipment	CH-1-04 (1unit)
Type	Brine-Cooling(Compact)
Capacity	147 RT

6) Gas Engine

Gas Engine generates electricity and generated electricity is for internal use.

Figure 10. Gas Engine

Equipment	GAS ENGINE
No. of Equipment	EN-2-03 A/B (2 units)
Type	Container Type
Generating Power	1,500kW (750kW x 2 sets)

7) Flare Stack

Flare Stack combusts remaining LFG, and treats LFG so that odour effect can be minimized. There are four flare stacks including two existing flare stacks and two newly installed flare stacks. The type of flare stack applied to this project is Cylindrical Type. Two newly installed flare stacks are installed in 2018 for reducing odour from the landfill.

Figure 11 Flare Stack

Equipment	FLARE STACK	
No. of Equipment	IF-3-01A/B (2 units)	IF-3-01C/D (2 units)
Type	Cylindrical, Open	Cylindrical, Enclosed
Capacity	4,200 (2,100 Nm3/h x 2 units)	4,000 (2,000 Nm3/h x 2 units)

8) Gas storage tank

The refined LFG has a medium energy which is subject to fluctuation. The refined LFG is homogenized as a fuel while stored in a gas storage tank.

Figure 12. Gas storage tank

Equipment	BALL TANK
No. of Equipment	T-3-05 (1unit)
Type	Globular type

9) LFG boilers

Refined LFG from the landfill is supplied to LFG boilers of KDHC. LFG boilers produce hot water, which is distributed to the end users. The LFG used as a main fuel of base-load in the KDHC.

Equipment	LFG boilers
No. of Equipment	PLB #1,2(LFG) (2 units)
Capacity	34.4 Gcal/hr (LNG) 33.0 Gcal/hr (LFG)
Type	Hot water

B.2. Post-registration changes

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

>>
N/A

B.2.2. Corrections

>>
N/A

B.2.3. Corrections

>>
Refer to B.2.9 Changes to project design

B.2.4. Changes to the start date of the crediting period

>>
N/A

B.2.5. Inclusion of monitoring plan

>>
N/A

B.2.6. Changes to the start date of the crediting period

>>
N/A

B.2.7. Inclusion of monitoring plan

>>
N/A

B.2.8. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

>>
N/A

B.2.9. Changes to project design

>>
PPs have commissioned DOE to carry out the validation for post registration change of the CDM project titled “Daegu Bangcheon-Ri Landfill Gas CDM Project” (hereinafter referred to as the proposed project). The purpose of PRC is to install the additional flare stacks (2unints).

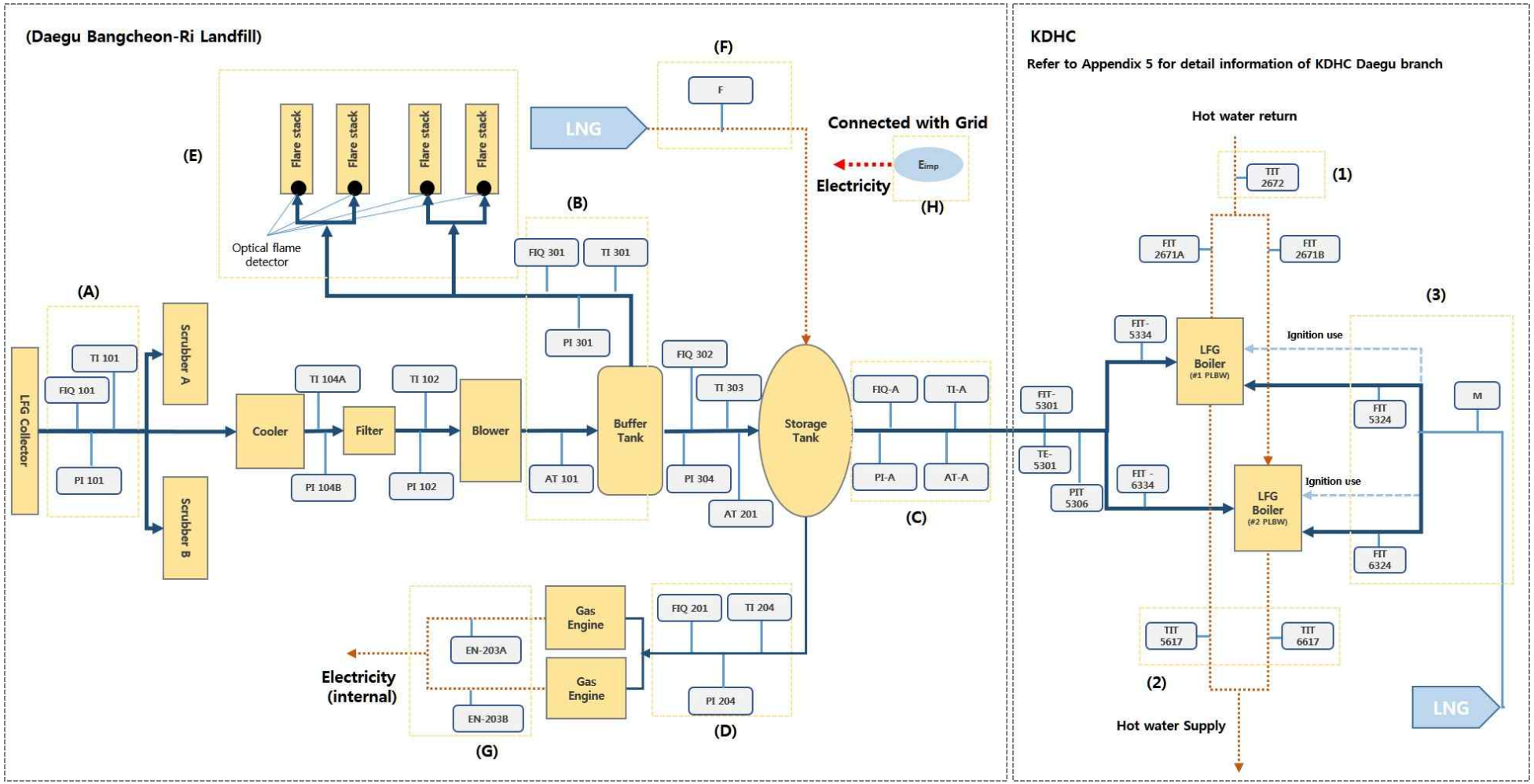
As for the project, two flare stacks with a capacity of 4,200 Nm3/h(open type 2,100Nm3*2 units) were initially installed on 13/10/2006. However, there was an additional flare stacks (enclosed type, 2,000 Nm3*2 units) installed on 31/05/2018.

Therefore, the list of facilities, systems and equipment described in the PDD has changed due to the addition of two flare stacks (enclosed type, 2,000 Nm3*2 units) and the actual implementation of 8,200 Nm3(2,100 Nm3*2 units, 2,000 Nm3*2 units).

SECTION C. Description of monitoring system

>>

All kinds of measuring instruments, including gas analyser and gas meter, are present. The data collected is registered continuously by the PLC(Programmable Logic Controller). The following equipment is used to monitor the operation of the project and to monitor the emission reduction.



<table>
<tr><td rowspan="20">Landfill</td><td rowspan="3">(A)</td><td>FIQ 101</td><td>Flow meter</td><td rowspan="20">Flow meter
- Type : Vortex or Turbine, Rotary flow meter
- Accuracy : ±1.0%(Vortex), ±0.5%(Turbine, Rotary)

Manometer (pressure, transmitter)
- Type : Diaphragm, Volume corrector
- Accuracy : ±0.075%, ±0.25%

Thermometer
- Type : Thermocouple, RTD, Volume corrector
- Accuracy : ±0.2%, ±0.305|t|, ±0.25%

Optical flame detector (Type : UV-IR)
- FD -101,102 (Accuracy : ±5%)
- FD -103,104
Operating Temperature Rating : -18℃ ~ 102℃
Maximum Pressure Rating : 5 psi (34.5kPa)
Gas Analyzer
- Repeatability : ± 0.5 %
- Linearity : 1%
- Measurable Range
<table><tr><th>Gas</th><th>Minimum range</th><th>Maximum range</th></tr><tr><td>CH_4</td><td>0~1000 ppm</td><td>0 ~ 100 vol%</td></tr><tr><td>CO_2</td><td>0~500 ppm</td><td>0 ~ 100 vol%</td></tr><tr><td>O_2(Built-in paramagnet)</td><td>0~ 5 vol%</td><td>0 ~ 100 vol%</td></tr></table></td></tr>
<tr><td>TI 101</td><td>Thermometer</td></tr>
<tr><td>PI 101</td><td>Manometer</td></tr>
<tr><td rowspan="4">(B)</td><td>FIQ 301</td><td>Flow meter</td></tr>
<tr><td>AT 101</td><td>Gas analyzer</td></tr>
<tr><td>TI 301</td><td>Thermometer</td></tr>
<tr><td>PI 301</td><td>Manometer</td></tr>
<tr><td rowspan="4">(C)</td><td>FIQ-A</td><td>Flow meter</td></tr>
<tr><td>TI-A</td><td>Temperature</td></tr>
<tr><td>PI-A</td><td>Manometer</td></tr>
<tr><td>AT-A</td><td>Gas analyzer</td></tr>
<tr><td rowspan="3">(D)</td><td>FIQ 201</td><td>Flow meter</td></tr>
<tr><td>TI 204</td><td>Thermometer</td></tr>
<tr><td>PI 204</td><td>Manometer</td></tr>
<tr><td rowspan="4">(E)</td><td>FD-101</td><td>Optical flame detector</td></tr>
<tr><td>FD-102</td><td>Optical flame detector</td></tr>
<tr><td>FD-103</td><td>Optical flame detector</td></tr>
<tr><td>FD-104</td><td>Optical flame detector</td></tr>
<tr><td>(F)</td><td>F</td><td>LNG flow meter</td><td>- Type : Rotary
- Accuracy : ±0.5%</td></tr>
<tr><td rowspan="2">(G)</td><td>EN-203A</td><td rowspan="2">Generated electricity indicator</td><td rowspan="2">Generated electricity Indicator on gas engines</td></tr>
<tr><td>EN-203B</td></tr>
<tr><td>(H)</td><td>E_{imp}</td><td>Electricity meter (incoming)</td><td>- Three-phase four-wire system
- 110/190 V 5(2.5)A 60 Hz 0.5 Rank</td></tr>
<tr><td>(1)</td><td>TIT-2672</td><td>Thermometer</td><td>- Accuracy : ±0.25%</td></tr>
<tr><td rowspan="2">(2)</td><td>TIT-5617</td><td>Thermometer</td><td>- Accuracy : ±0.25%</td></tr>
<tr><td>TIT-6617</td><td>Thermometer</td><td>- Accuracy : ±0.25%</td></tr>
<tr><td rowspan="3">(3)</td><td>M</td><td>LNG flow meter</td><td>- Type : Rotary
- Accuracy :
±1% : Qmin ~ 0.2 Qmax
±0.5% : 0.2 Qmax ~ Qmax</td></tr>
<tr><td>FIT-5324</td><td>LNG flow meter</td><td rowspan="2">- Type : Vortex
- Accuracy : ±1%
※ Reading Volumes in normalized cubic meters</td></tr>
<tr><td>FIT-6324</td><td>LNG flow meter</td></tr>
</table>

The monitoring equipment directly involved with emission reduction are named from Group (A) to Group (H) and from Group (1) to Group (3). And there are three gas analysers in this project as below;

① Behind of the buffer tank (for reference, AT 201)

② In front of the buffer tank : The data measured by this gas analyser will be used to calculate flaring. (AT 101)

③ Behind the gas storage tank (right before supplying gas to user) : The data measured by this gas analyser will be used to calculate heat and electricity generation. (AT-A)

● Technology of LFG utilization transfer

Daegu Bangcheon-Ri landfill is only a landfill in Daegu Metropolitan which has an area of 883.48 Km^2 and 2.5 million people live in. The project is one of the best examples for green gas reduction in Republic of Korea. The project will contribute to enhance the knowledge and spread technology of waste utilization. These knowledge and experience will be an asset for the local area.

1) LFG flow

LFG should be refined for enhancing fuel worth. In process of LFG refinement, captured LFG goes to scrubber for removing acid gas and dust, and then goes to cooler for removing moisture. There are no extra process for adding moisture.

Captured LFG is monitored by FIQ-101 and combusted LFG is monitored by FIQ-201, FIQ-301 and FIQ-A. These flow meters measure LFG flow continuously and the measuring values are recorded hourly. Each volumetric flow rates are normalized its thermometer and manometer.

To calculate baseline emission, FIQ-201, FIQ-301 and FIQ-A is used. In the only case of abnormal situation or to check total volumetric flow rate, FIQ-101 will be used.

Thermometers(TI-204, TI 301 and TI-A) installed around FIQ-201, FIQ-301 and FIQ-A are used for normalization. And these also tell whether the collected LFG are a dry basis. Temperature of collected LFG at TI-204, TI-301 and TI-A are less than 60°C during this monitoring period. As per option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)”, LFG are considered as dry basis.

That’s the reason that LFG gases are considered as dry basis as option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)”, Relevant evidence are added on ‘Comparing Captured and Used LFG’ in the ER sheet.

2) CH_4 fraction of LFG

The fraction of CH_4 in LFG is measured continuously by using gas analyzers, which are AT-101 and AT-A. The analyser which is monitoring CH_4 fraction fed to flare is AT-101 and the analyser which is monitoring CH_4 fraction fed to LFG boilers and gas generators is AT-A. These analyzers measure CH_4 fraction continuously and the measured values are recorded hourly.

3) Flare Operating check

As developing housing development at nearby Bangcheon-Ri landfill, odor from the landfill spreads to resident area and the complaints highly increase in every summer season. In order to reduce the problem, there is a need to introduce two enclosed flare stacks which have high efficiency. So the project activity run four flare stacks including two enclosed and two open type flare stacks.

As for detailed monitoring plan for flare stack system, the same monitoring activity will be carried out. FIQ-301, temperature transmitters(TI-301) and manometer(PI-301) are monitoring all of flare stacks.

Each flame detector and valve condition at each flare stack is monitored and recording in PLC data. In exceptional case, when flare stacks have breakdowns or regular inspections, these documentary evidences for the exceptional case will be provided to DOE during the verification.

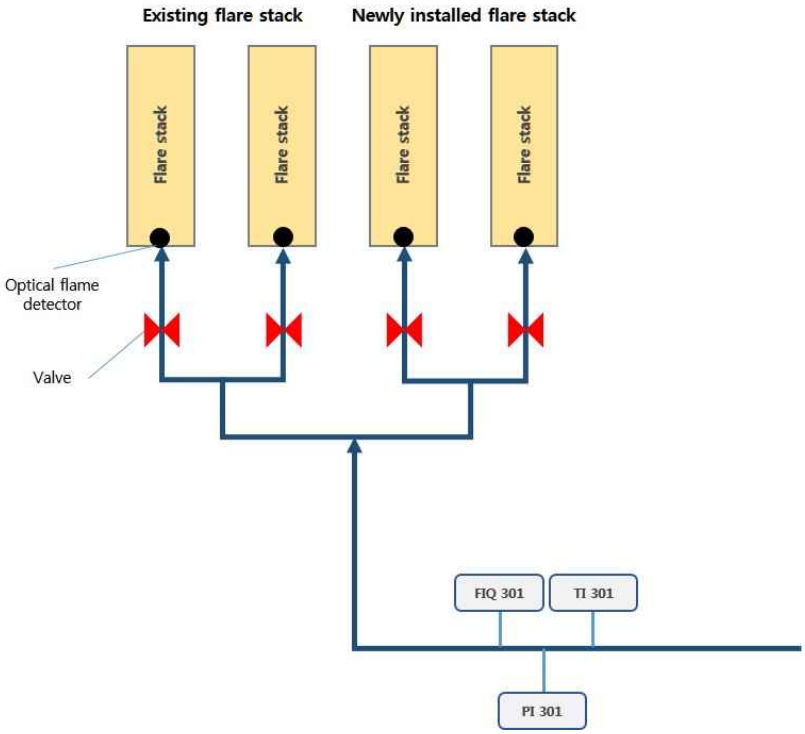


Figure 13. Detailed diagram of flare stacks monitoring

4) LNG usage

The amount of LNG used is consist of mainly two parts. First, LNG may be supplied to landfill site and mix with LFG which is supplied to the LFG boilers as fuel to satisfy the operation condition for the LFG boilers. The amount of supplied LNG is continuously measured by flow meter F(FIT-503, FIT-504) and double-checked with Gas bill monthly provided by LNG supplier. Second, LNG are used to ignite LFG boilers, which is located in KDHC, and used as a fuel of LFG boiler at the emergency situation. The amount of supplied LNG is continuously measured by flow meter (M, FIT-5324, FIT-6324) and double-checked with Gas bill monthly provided by LNG supplier.

This appendix describes monitoring plan of LFG boilers in detail. This part is newly added as project emissions for 2nd crediting period. KDHC is charge of monitoring associated with LFG boilers and detail monitoring plan for KDHC is as follows;

Both LFG and LNG are available as the boiler's fuel for producing the heat generation. LNG is also used as ignition in order to start up LFG boilers. Its consumption for ignition use will be reflected as project emission.

There are three LNG meters on LFG boilers. One is a main LNG meter of LNG supplier(i.e. M) and others are LNG sub meters(i.e. FIT-5324, FIT-6324) of KDHC for measuring LNG fuel. LNG consumption for Ignition is an amount which sum of both sub flow meters is deducted from a value of LNG main flow meter.

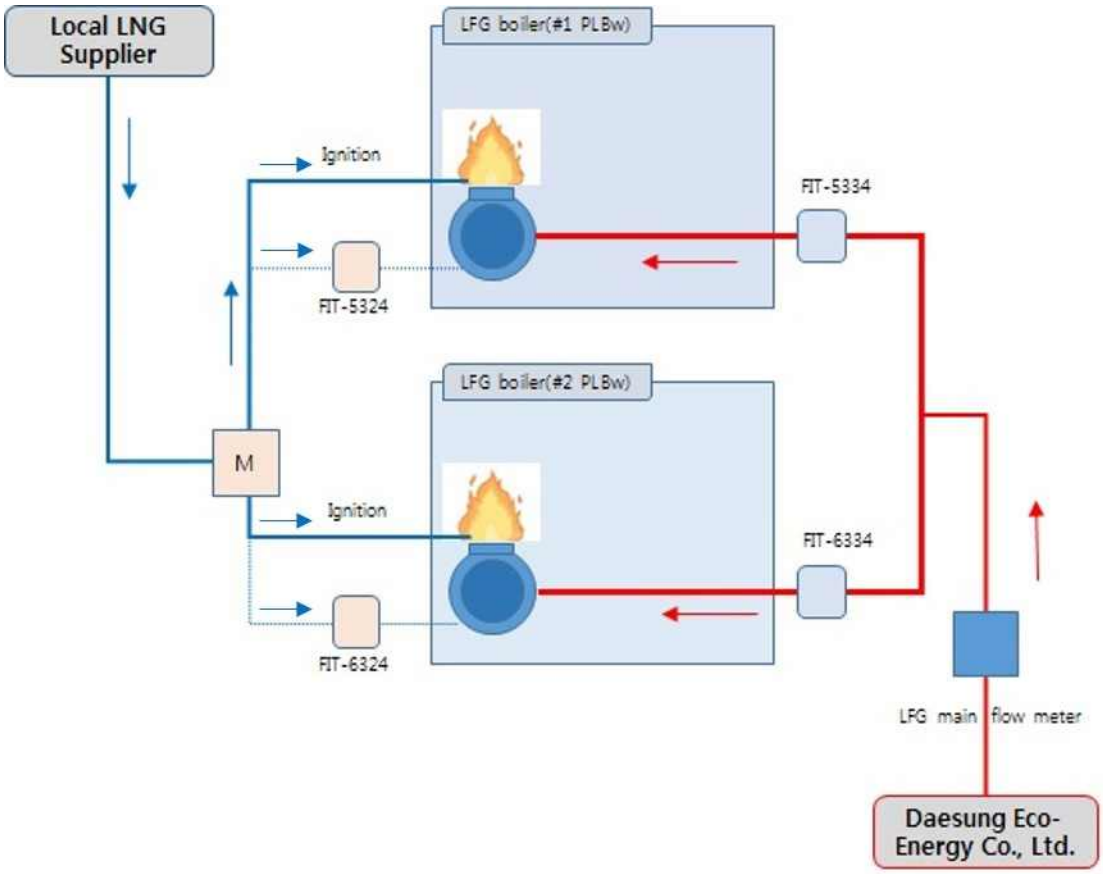


Figure 14. Monitoring diagram of LFG boilers

Quality control(QC) and Quality assurance(QA) procedure

Monitoring equipment and calibration

Measuring equipment for LFG boiler is managed by KDHC and fuel suppliers. Calibration and frequency of calibration are determined as local regulation. Exceptionally the LNG main flow meter(which is a M) is complied with QA/AC of $\mathbf{FC_{LNG,j,y}}$.

5) Electricity generation Operating check

LFG which is measured at FIQ-201 is fed to LFG generators. To check whether electricity generation is operating or not, electricity indicator (EN-203A, EN-203B) was used. According to registered PDD, parameter OP_j could select one of the operating signal. (Temperature, Flame and Products generated. i.e. result of using of LFG) Generated electricity was used to check operating as a result of using LFG in this project.

6) Electricity imported

The imported electricity is used for LFG capturing and treating. The amount of electricity is continuously measured by watt-hour meter (E_{imp}) and double-checked with Electric bill monthly provided by KEPCO.

7) Boiler Operating check

Thermometers including TIT-2672, TIT-5617 and TIT-6617 check whether LFG boilers is operating or not. The LFG boilers is a type of hot water boiler and operating condition of the LFG boilers could be recognized by checking a difference between inlet and outlet water temperature. LFG boilers designed more than 55℃ temperature rise.

- **Main monitoring equipment**

1) Flow meter

► Rotary Flow Meter (LNG flow meter)

- Type : Rotary
- Accuracy: ± 0.5%
- Flow range : 0.6 ~ 1600 m^3/h

► Turbine Flow Meter(FIQ-A)

- Type : Turbine
- Accuracy : ± 0.5%
- Flow range : 13 ~ 40,000m^3/h

► Vortex Flow Meter(FIQ-201)

- Type : Vortex
- Accuracy : ± 1.0%
- flow range : 15 ~ 19 Nm3/min

► Vortex Flow Meter(FIQ-301)

- Type : Vortex
- Accuracy : ± 1.0%
- Flow range : 42 ~ 150 Nm3/min

2) Gas Analyzer(AT-A, AT-101)

- Type : Infrared analyzer
- Repeatability : ± 0.5%
- Linearity : ± 1.0%
- Measurable Range;

Gas	Minimum range	Maximum range
CO_2	0 ~ 500 ppm	0 ~ 100vol%
CH_4	0 ~ 1000 ppm	0 ~ 100 vol%
O_2(built-in paramagnet)	0 ~ 5 vol%	0 ~ 100 vol%

- **Data Collection Procedures**

All monitoring parameters are controlled by an electrical control system which is based on a PLC (Programmable Logic Controller). All the measuring signals are processed by the PLC. The main functions of PLC are described as below.

1) Monitoring Function
All of the status and trouble about the other equipment and PLC are monitored. If there are breakdowns or abnormal status, it is indicated, if necessary, the counterplan of it is also informed.

2) Recording Function
Data about gas flow, temperature and pressure measured by each monitoring equipment is collected and recorded.

3) Accumulation of DATA Function
Recorded data is accumulated and saved in computer.

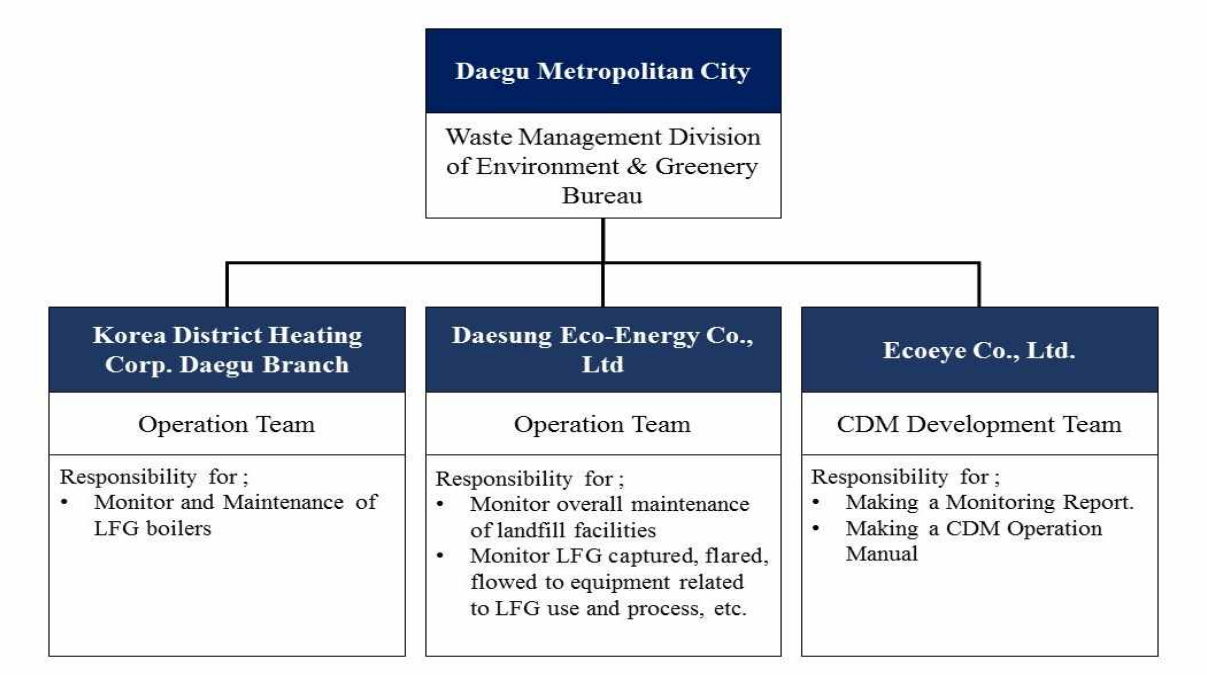
4) Down Loading Function
Saved data is able to download by excel file for monitoring.

Every five minutes, PLC reads data from the server and the data could be checked on MMI program. At the end of each day (at 12:00pm), the data is automatically stored into the PC at operation team. Archiving process of the stored data is as follows;

1) A person in charge of operation who belongs to operation team prints out the data of captured LFG (amount, temperature and pressure, etc.) as document.
2) The team leader of operation team inspects the document.
3) The document gets approval from the executive director.

The archived data are to be kept during the crediting period and two years after.

- **Monitoring Structure**



Responsible department for the monitoring are as follows :

- Responsible person/department for the project :
  Waste Management Division of Environment & Greenery Bureau of Daegu Metropolitan /city

- Practical and responsible monitoring (about electricity, LFG and LNG) :
  Daesung Eco-Energy Co., Ltd.(Operation Team)

- Practical and responsible monitoring (about LFG boilers) :
  Korea District Heating Corp. Daegu office (Operation Team)

- Making CDM documents (about Monitoring report, CDM operation Manual) :
  Ecoeye. Co., Ltd.

SECTION D. Data and parameters

D.1. Data and parameters 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”(Version 06.0.1)
Value(s) applied	0.1
Choice of data or measurement methods and procedures	N/A

Purpose of data/parameter	Calculation of baseline emission
Additional comments	N/A

Data/Parameter	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global warming potential (GWP) of methane
Source of data	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	25
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emission
Additional comments	N/A

Data/Parameter	$EF_{grid,CM,y}$
Unit	tCO_2e/MWh
Description	Combined margin CO_2 emission factor in year y
Source of data	Calculated
Value(s) applied	0.5421
Choice of data or measurement methods and procedures	This value was calculated according to “Tool to calculate the emission factor for an electricity system” (version 04.0). The applied value was derived from “2010, 2011, 2012 Statistics of Electric Power in Korea (2011, 2012, 2013)” (KEPCO) and “2012 Status of Generation facility (published in 2013)” (Korea Power Exchange).
Purpose of data/parameter	Calculation of project emission
Additional comments	N/A

Data/Parameter	ρ_{CH4}
Unit	tCH_4/Nm^3CH_4
Description	Density of CH_4
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver.02.0.0)
Value(s) applied	0.0007157
Choice of data or measurement methods and procedures	1. Calculated value at 0℃, 1atm, according to “Tool to determine the mass flow of greenhouse gas in a gaseous stream (Ver.02.0.0)
Purpose of data/parameter	2. Calculation of baseline emission
Additional comments	This value is calculated considering 0℃ and 1atm according to “Tool to determine the mass flow of greenhouse gas in a gaseous steam (Ver.02.0.0). The volume metric flowrate which is measured at FIQ-201, FIQ-301 and FIQ-A is already based on 0℃ and 1atm. So, PP doesn’t need to calculate ρ_{CH4} on every hour. The calculation formula is submitted to DOE for verification purpose.

D.2. Data and parameters monitored

Data/Parameter	Management of SWDS
Unit	-
Description	Management of SWDS
Measured/calculated/ default	-

<table>
<tr><td>Source of data</td><td>Use different sources of data:
(a) Original design of the landfill;
(b) Technical specifications for the management of the SWDS;
(c) Local and national regulation</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>(a) Original design of the landfill
There is no change of area of waste disposal(853,400 ㎡) as per the lasted ‘Installation approval of Waste disposal facility’.

(b) Technical specifications for the management of the SWDS
SFR facility was constructed in July 2016. So much combustibles wastes are handled in SRF incineration facility. As a result, dumping waste amounts in the landfill reduced.

(c) Local and national regulation
Daegu Metropolitan City was taking outright ban on dumping illegal waste in April 2016. Those who not get legal license for dumping wastes was prohibited. 2016 amount of MSW so dramatically goes down and its trend continued in 2017.

<table>
<tr><th>Year</th><th>Expected amount of MSW (ton/year)</th><th>Actual amount of MSW (ton/year)</th><th>Difference</th></tr>
<tr><td>2014</td><td>448,841</td><td>466,987</td><td>4.04%</td></tr>
<tr><td>2015</td><td>452,637</td><td>494,887</td><td>9.33%</td></tr>
<tr><td>2016</td><td>456,323</td><td>357,522</td><td>-21.65%</td></tr>
<tr><td>2017</td><td>460,083</td><td>282,632</td><td>-38.56%</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>N/A</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Recording annually</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>N/A</td></tr>
<tr><td>Purpose of data/parameter</td><td>N/A</td></tr>
<tr><td>Additional comments</td><td>N/A</td></tr>
</table>

Data/parameter:	$Op_{j,h}$
Unit	-
Description	Operation of the equipment that consumes the LFG
Measured/calculated/default	Measured
Source of data	PLC data - Temperature : TIT-2672, TIT-6617, TIT-5617 - Flame Detector : FD-101, FD-102
Value(s) of monitored parameter	N/A

Monitoring equipment

(1) $F_{CH4,HG}$ (LFG Boiler)

Tag	TIT-2672
Type	Temperature transmitter
Accuracy class	± 0.25%
Serial number	TIT-2672
Past Calibration Date	28/08/2012
Calibration frequency	3 years
Date of last calibration	09/09/2015
Validity	09/09/2015~08/09/2018

Tag	TIT-5617
Type	Temperature transmitter
Accuracy class	± 0.25%
Serial number	TIT-5617
Past Calibration Date	28/08/2012
Calibration frequency	3 years
Date of last calibration	02/09/2015
Validity	02/09/2015~01/09/2018

Tag	TIT-6617
Type	Temperature transmitter
Accuracy class	± 0.25%
Serial number	TIT-6617
Past Calibration Date	11/09/2012
Calibration frequency	3 years
Date of last calibration	02/09/2015
Validity	02/09/2015~01/09/2018

(2) $F_{CH4,flared}$ (Flare stack)

Tag	FD-101
Type	UV-IR
Accuracy class	± 5%
Serial number	53131
Calibration frequency	3 years
Date of last calibration	14/12/2015
Validity	14/12/2015~13/12/2018

Tag	FD-102
Type	UV-IR
Accuracy class	± 5%
Serial number	53067
Calibration frequency	3 years
Date of last calibration	14/12/2015
Validity	14/12/2015~13/12/2018

Tag	FD-103
Type	UV-IR
Accuracy class	± 5%
Serial number	-
Calibration frequency	40,000 hours
Date of last calibration	03/07/2018
Validity	03/07/2018~02/07/2022

Tag	FD-104
Type	UV-IR
Accuracy class	± 5%
Serial number	-
Calibration frequency	40,000 hours
Date of last calibration	03/07/2018
Validity	03/07/2018~02/07/2022

Measuring/reading/recording frequency:	TIT-2672, TIT-5617, TIT-6617 : Recording hourly FD-101, FD-102, FD-103, FD-104 : Measuring minutely
Calculation method (if applicable):	N/A
QA/QC procedures:	Temperature transmitter and UV-IR(Flame Detector) are subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of baseline emissions
Additional comments:	Regarding O_p of Boiler, changes of over 55℃ between inlet and outlet were recognize operation of LFG boilers according to the LFG boiler's design.

Data/parameter:	$EG_{EC,y}$
Unit	MWh
Description	Amount of electricity consumed by the activity in year y
Measured/calculated/default	Measured
Source of data	PLC data(E_{imp}) and KEPCO data (Electricity bill)
Value(s) of monitored parameter	19/08/2017 ~ 31/12/2017 : 3,036 MWh 01/01/2018 ~ 18/08/2018 : 4,659 MWh This values are in $EC_{PJ,grid}$ sheet of the Daegu 6th ER sheet.
Monitoring equipment	

Tag	E_{imp} (A)
Type	Three-phase four-wire
Accuracy class	± 0.5%
Serial number	25102000031
Calibration frequency	7 years
Date of last calibration	09/08/2013
Validity	09/08/2013~08/08/2020

Tag	E_{imp} (B)
Type	Three-phase four-wire
Accuracy class	± 0.5%
Serial number	02162018282
Calibration frequency	7 years
Date of last calibration	08/07/2016
Validity	08/07/2016~07/07/2023

Measuring/reading/recording frequency:	Measuring and recording hourly on PLC data Reading monthly in Electricity bill data
Calculation method (if applicable):	N/A
QA/QC procedures:	Electricity meter is calibrated every 7 years. This value was double-checked with the invoice from KEPCO(Supplier) and the bigger value was used to calculate project emission($EC_{PJ,grid}$).
Purpose of data:	Calculation of project emission
Additional comments:	The calculation formula of project emission is below. $PE_{EC} = EC_{PJ,grid} * EF_{EL,grid} * (1 + TDL_{grid})$ In this formula, there is no $EG_{EC,y}$ parameter. However, when the PDD is considered, the $EG_{EC,y}$ parameter will be $EC_{PJ,grid}$.

Data/parameter:	$Flame_m$
Unit	-
Description	Flame detection of flare stack in the minute *m*
Measured/calculated/default	Measured
Source of data	PLC data (FD-101, FD-102)

Value(s) of monitored parameter	-
Monitoring equipment	

Tag	FD-101
Type	UV-IR
Accuracy class	± 5 %
Serial number	53131
Calibration frequency	3 years
Date of last calibration	14/12/2015
Validity	14/12/2015~13/12/2018

Tag	FD-102
Type	UV-IR
Accuracy class	± 5 %
Serial number	53067
Calibration frequency	3 years
Date of last calibration	14/12/2015
Validity	14/12/2015~13/12/2018

Tag	FD-103
Type	UV-IR
Accuracy class	± 5%
Serial number	-
Calibration frequency	40,000 hours
Date of last calibration	03/07/2018
Validity	03/07/2018~02/07/2022

Tag	FD-104
Type	UV-IR
Accuracy class	± 5%
Serial number	-
Calibration frequency	40,000 hours
Date of last calibration	03/07/2018
Validity	03/07/2018~02/07/2022

Measuring/reading/recording frequency:	Recording minutely
Calculation method (if applicable):	N/A
QA/QC procedures:	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations or local regulation.
Purpose of data:	Calculation of baseline emissions
Additional comments:	This parameter is used to confirm flare stack operating.

Data/parameter:	$V_{t,db}$
Unit	Nm^3 dry gas/h
Description	Volumetric flow of the gaseous stream in a time interval *t* on a dry basis
Measured/calculated/default	Measured
Source of data	PLC data (FIQ-201, FIQ-301, FIQ-A)

<table>
<tr><td>Value(s) of monitored parameter</td><td>FIQ-201
19/08/2017~31/12/2017 : 0 Nm3
01/01/2018~18/08/2018 : 0 Nm3

FIQ-301
19/08/2017~31/12/2017 : 3,318,393 Nm3
01/01/2018~18/08/2018 : 9,058,771 Nm3

FIQ-A
19/08/2017~31/12/2017 : 16,422,973 Nm3
01/01/2018~18/08/2018 : 23,728,382 Nm3</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Tag</td><td>FIQ-201</td></tr>
<tr><td>Type</td><td>Vortex</td></tr>
<tr><td>Accuracy</td><td>1.0%</td></tr>
<tr><td>Serial number</td><td>C10-S1000HN</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>09/08/2012</td></tr>
<tr><td>Validity</td><td>09/08/2012~08/08/2020</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FIQ-301</td></tr>
<tr><td>Type</td><td>Vortex</td></tr>
<tr><td>Accuracy</td><td>1.0%</td></tr>
<tr><td>Serial number</td><td>DE26015G</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>11/08/2014</td></tr>
<tr><td>Validity</td><td>11/08/2014~10/08/2022</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FIQ-A</td></tr>
<tr><td>Type</td><td>Turbine</td></tr>
<tr><td>Accuracy</td><td>0.5%</td></tr>
<tr><td>Serial number</td><td>10517644</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>29/02/2012</td></tr>
<tr><td>Validity</td><td>29/02/2012~28/02/2020</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Measuring hourly</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>This monitoring equipment is calibrated every 8 years.</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments:</td><td>Flaring, power generator and LFG Boilers in the project activity are operating for the collected LFG destruction, LFG Boilers is a primary methane destruction facility. Others are operating when heat demands are low in summer season. Especially in summer, flaring system can handle the LFG at low operating cost comparing to power generation system. For this reason, gas engines didn’t operate and FIQ-201 for measuring power generation measured at 0 Nm3 during the monitoring period.

Thermometers(TI-204, TI 301 and TI-A) installed around FIQ-201, FIQ-301, FIQ-A are used for normalization. And these also tell whether the collected LFG are a dry basis. Temperature of collected LFG at TI-204, TI-301 and TI-A are less than 60°C during this monitoring period. As per option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)”, the collected LFG are considered as dry basis.</td></tr>
</table>

Data/parameter:	$v_{CH4,t,db}$
Unit	Nm^3_{CH4}/Nm^3 dry gas(or %)
Description	Volumetric fraction of CH_4 in a time interval *t* on a dry basis
Measured/calculated/default	Measured
Source of data	PLC data (AT-101, AT-A)
Value(s) of monitored parameter	**AT-101** 19/08/2017~31/12/2017 : 51.63 % 01/01/2018~18/08/2018 : 49.59 % **AT-A (related with FIQ-A)** 19/08/2017~31/12/2017 : 43.96 % 01/01/2018~18/08/2018 : 45.84 % **AT-A (related with FIQ-201)** 19/08/2017~31/12/2017 : 0 % 01/01/2018~18/08/2018 : 0 %
Monitoring equipment	Tag: AT-101 Type: Infrared analyzer Serial number: A1E5039T Past calibration date: 16/05/2011 Calibration frequency: 5 years Date of last calibration: 03/05/2016 Validity: 03/05/2016~02/05/2021 Tag: AT-A Type: Infrared analyzer Serial number: N5L0895 Calibration frequency: 5 years Date of last calibration: 28/10/2015 Validity: 28/10/2015~27/10/2020
Measuring/reading/recording frequency:	Measuring hourly
Calculation method (if applicable):	N/A
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data:	Calculation of baseline emissions
Additional comments:	AT-A(the fraction of methane) is related with FIQ-A and FIQ-201. The values of monitored parameter above is calculated using weighted-average with volumetric flow rate. AT-A for FIQ-201 is regard as “0 %” because flow of FIQ-201 measured “0” Nm3 during 6th monitoring period. Thermometers(TI-204, TI 301 and TI-A) installed around FIQ-201, FIQ-301, FIQ-A are used for normalization. And these also tell whether the collected LFG are a dry basis. Temperature of collected LFG at TI-204, TI-301 and TI-A are less than 60°C during this monitoring period. As per option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)”, LFG are considered as dry basis.

Data/parameter:	P_t
Unit	Pa
Description	Pressure of the gaseous stream in time interval *t*
Measured/calculated/default	Measured
Source of data	PLC (PI-204, PI-301, PI-A)

Value(s) of monitored parameter	-
Monitoring equipment	

Tag	PI-204
Type	Diaphragm
Accuracy	± 0.075%
Serial number	91F625744
Past calibration date	24/06/2016
Calibration frequency	1 month
Date of last calibration	21/07/2017
Validity	
Delayed period	

Tag	PI-301
Type	Diaphragm
Accuracy	± 0.075%
Serial number	91F347307
Past calibration date	24/06/2016
Calibration frequency	1 month
Date of last calibration	21/07/2017
Validity	
Delayed period	

Tag	PI-A (B)
Type	Diaphragm
Accuracy	± 0.25%
Serial number	08506921
Past calibration date	24/06/2016
Calibration frequency	1 month
Date of last calibration	21/07/2017
Validity	
Delayed period	

Measuring/reading/recording frequency:	Hourly
Calculation method (if applicable):	-
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	Manometer is applied to volumetric flowrate automatically to convert 0℃, 1atm.

Data/parameter:	T_t
Unit	℃ or K
Description	The temperature of the gaseous stream (LFG) in time interval *t*.
Measured/calculated/default	Measured
Source of data	PLC data (The thermocouple : TI-201, TI-301, TI-A)
Value(s) of monitored	-

<table>
<tr><td>parameter</td><td></td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Tag</td><td>TI-204</td></tr>
<tr><td>Type</td><td>RTD</td></tr>
<tr><td>Accuracy</td><td>± 0.305|t|</td></tr>
<tr><td>Serial number</td><td>10020523</td></tr>
<tr><td>Past calibration date</td><td>11/08/2014</td></tr>
<tr><td>Calibration frequency</td><td>2 years</td></tr>
<tr><td>Date of last calibration</td><td>22/07/2016</td></tr>
<tr><td>Validity</td><td>22/07/2016~21/07/2018</td></tr>
</table>
<table>
<tr><td>Tag</td><td>TI-301</td></tr>
<tr><td>Type</td><td>RTD</td></tr>
<tr><td>Accuracy</td><td>± 0.305|t|</td></tr>
<tr><td>Serial number</td><td>06010670</td></tr>
<tr><td>Past calibration date</td><td>08/08/2014</td></tr>
<tr><td>Calibration frequency</td><td>2 years</td></tr>
<tr><td>Date of last calibration</td><td>22/07/2016</td></tr>
<tr><td>Validity</td><td>22/07/2016~21/07/2018</td></tr>
</table>
<table>
<tr><td>Tag</td><td>TI-A</td></tr>
<tr><td>Type</td><td>RTD</td></tr>
<tr><td>Accuracy</td><td>±0.25%</td></tr>
<tr><td>Serial number</td><td>08506921</td></tr>
<tr><td>Calibration frequency</td><td>2 years</td></tr>
<tr><td>Date of last calibration</td><td>26/07/2016</td></tr>
<tr><td>Validity</td><td>26/07/2016~25/07/2018</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Measuring hourly</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>Flow meters are 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>Thermometers(TI-204, TI 301 and TI-A) installed around FIQ-201, FIQ-301, FIQ-A are used for normalization. And these also tell whether the collected LFG are a dry basis. Temperature of collected LFG at TI-204, TI-301 and TI-A are less than 60°C during this monitoring period. As per option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)”, LFG are considered as dry basis.

Thermometer is applied to volumetric flowrate automatically to convert 0℃, 1atm.</td></tr>
</table>

Data/parameter:	$FC_{LNG,j,y}$
Unit	Nm^3/yr
Description	Quantity of LNG combusted in process j during the year y
Measured/calculated/default	Measured
Source of data	PLC data(F) and Dae sung energy corporation(LNG supplier)data(LNG bill)
Value(s) of monitored parameter	08/01/2017~31/12/2017 : 0 01/01/2018~18/08/2018 : 0

Monitoring equipment	

Tag	F (FIQ-503)
Type	Rotary
Accuracy class	± 0.5%
Serial number	20536708
Calibration frequency	8 years
Date of last calibration	16/08/2016
Validity	16/08/2016~15/08/2024

Tag	F (FIQ-504)
Type	Rotary
Accuracy class	± 0.5%
Serial number	20536703
Calibration frequency	8 years
Date of last calibration	16/08/2016
Validity	16/08/2016~15/08/2024

Tag	M
Type	Turbine
Accuracy class	± 1%
Serial number	520128
Calibration frequency	8 years
Date of last calibration	28/09/2010
Validity	28/09/2010~27/09/2018

Tag	FIT-5324
Type	Vortex
Accuracy class	± 1%
Serial number	C15-S0540HN
Calibration frequency	8 years
Date of last calibration	28/04/2015
Validity	28/04/2015~27/04/2023

Tag	FIT-6324
Type	Vortex
Accuracy class	± 1%
Serial number	C15-S0442HN
Calibration frequency	8 years
Date of last calibration	14/05/2015
Validity	14/05/2015~13/05/2023

Measuring/reading/recording frequency:	Measuring hourly
Calculation method (if applicable):	N/A
QA/QC procedures:	LNG meters are calibrated or displaced every 8 years by LNG supplier as “Measures Act”. This value was double-checked with the invoice from Daesung energy corporation(LNG Supplier) and the bigger value are used to calculate project emission($FC_{LNG,j,y}$).
Purpose of data:	Calculation of project emissions
Additional comments:	FIT-5324 and FIT-6324 are included to monitor point from 2nd crediting period. These two meters were installed to check volumetric flow rate of LNG for LNG ignition consumption of LFG boilers.

Data/parameter:	$NCV_{LNG,y}$
Unit	GJ/Nm^3
Description	Weighted average net calorific value of LNG in year y
Measured/calculated/default	Measured/calculated

Source of data	Invoices of LNG supplier
Value(s) of monitored parameter	08/19/2017~31/12/2017 : 0.04257 01/01/2018~18/08/2018 : 0.04257
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Reading monthly
Calculation method (if applicable):	N/A
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	Information for net calorific value of LNG is posted by the LNG supplier. https://cyber.daesungenergy.com/charge/solvAvgMJ#

Data/parameter:	$EF_{CO2,LNG,y}$
Unit	tCO_2/GJ
Description	Weighted average CO_2 emission factor of LNG in year y
Measured/calculated/default	Default
Source of data	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter 1 of Vol.2(Energy) of 2006 IPCC Guidelines on National GHG Inventories.
Value(s) of monitored parameter	0.0583
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Reading any future revision of the IPCC Guidelines should be taken into account
Calculation method (if applicable):	N/A
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	There is no information of CO_2 emission factor in invoice from fuel supplier. PP decided to choose option (d), which is 2006 IPCC default values,

Data/parameter:	$TDL_{j,y}$
Unit	%
Description	Average technical transmission and distribution losses for providing electricity to source j in year y.
Measured/calculated/default	Measured
Source of data	KEPCO
Value(s) of monitored parameter	18/08/2017~31/12/2017 : 3.59 01/01/2018~18/08/2018 : 3.59
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Monthly reading
Calculation method (if applicable):	N/A
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	These values are from 'Statistics of Electric Power in Korea', published on June 2017 by Korea electric power corporation. As for $TDL_{j,y}$ in 2017, 3.59% in 2016 is reused because the latest 'Statistics of Electric Power in Korea' is not yet published.

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

>>
Temperature of collected LFG at TI-204, TI-301 and TI-A are less than 60°C during this monitoring periods. As per option A of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)", LFG are considered as dry basis.

· Calculations for all formulae used and calculation of baseline emissions

$BE_{,y} = BE_{CH4,y}$

The total sum of Methane destroyed.

BE_y	tCO_2eq	Baseline emissions in year y
$BE_{CH4,y}$	tCO_2eq	Baseline emissions of methane from the SWDS in year y

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

$BE_{CH4,y}$	tCO_2eq	Baseline emissions of methane from the SWDS in year y
OX_{top_layer}	Constant	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline
$F_{CH4,PJ,y}$	tCH_4	Amount of methane in the LFG which is flared and/or used in the project activity in year y
$F_{CH4,BL,y}$	tCH_4	Amount of methane in the LFG that would be flared in the baseline in year y
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of CH_4

1) $F_{CH4,BL,y} = F_{CH,PJ,y} \times 20\%$

$F_{CH4,BLy}$	tCH_4	Amount of methane in the LFG that would be flared in the baseline in year y
$F_{CH4,PJ,y}$	tCH_4	Amount of methane in the LFG which is flared and/or used in the project activity in year y
20%	Constant	Fraction of LFG that is required to be flared due to a requirement in year y

2) $F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y}$

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

2-1) $F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - PE_{flare,y} / GWP_{CH4}$

$F_{CH4,flared,y}$	tCH_4	Amount of methane in the LFG which is destroyed by flaring in year y
$F_{CH4,sent\_flare,y}$	tCH_4	Amount of methane in the LFG which is sent to the flare in year y
$PE_{flare,y}$	tCO_2	Project emissions from flaring of the residual gas stream in year y
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of CH4

2-1-1) $F_{CH4,sent\_flare,t} = V_{flare,t,db} * v_{CH4,t,db} * \rho_{CH4,t}$

$F_{CH4,sent\_flare,t}$	tCH_4	Mass flow of CH4 in the LFG which is sent to flare in time interval t

$V_{flare,t,db}$	m^3 dry LFG	Volumetric flow of the LFG which is destroyed by flaring in time interval t on a dry basis
$v_{CH4,t,db}$	m^3CH_4/m^3 dry LFG	Volumetric fraction of CH4 in the LFG in time interval t on a dry basis
$\rho_{CH4,t}$	tCH_4/m^3CH_4	Density of Ch4 in time interval t

※ $\rho_{CH4,t}$ is fixed as 0.0007157 because $V_{t,db}$ is already converted by 0℃ and 1atm

※ All parameter about $F_{CH4,sent\_flare,t}$ is considered as normal condition (0℃ and 1atm)

※ $V_{flare,t,db}$ is considered as by dry basis because TI-301, temperature of FIQ-301 show less than 60°C during this monitoring period.

2-1-2) $$PE_{flare,m,y} = GWP_{CH4} * \sum_{m=1}^{525600} F_{CH4,RG,m} * (1 - \eta_{flare,m}) * 10^{-3}$$

$PE_{flare,y}$	tCO_2e	Project emissions form flaring of the residual gas stream in year y
$F_{CH4,RG,m}$	kg	Mass flow of methane in the LFG in the minute m
$\eta_{flare,m}$	%	Flare efficiency in minute m
GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment period

2-2) $F_{CH4,EL,t} = V_{t,db} * v_{CH4,t,db} * \rho_{CH4,t}$

$F_{CH4,t}$	tCH_4	Amount of CH_4 combusted in Electricity generator
$V_{t,db}$	m^3 dry LFG	Volumetric flow of the LFG (used for electricity generation) in time interval t on a dry basis
$v_{CH4,t,db}$	m^3CH_4/m^3 dry LFG	Volumetric fraction of CH4 in the LFG in time interval t on a dry basis
$\rho_{CH4,t}$	tCH_4/m^3CH_4	Density of CH4 in time interval t

※ This formula is used to calculate $F_{CH4,EL,y}$

※ $\rho_{CH4,t}$ is fixed as 0.0007157 because $V_{t,db}$ is already converted by 0℃ and 1atm.

※ All parameter about $F_{CH4,t}$ is considered as normal condition. (0℃ and 1atm)

※ $V_{t,db}$ is considered as by dry basis because TI-204, temperature of FIQ-201 show less than 60°C during this monitoring period.

2-3) $F_{CH4,HG,t} = V_{t,db} * v_{CH4,t,db} * \rho_{CH4,t}$

$F_{CH4,flared,t}$	tCH_4	Amount of landfill gas combusted in boiler
$V_{t,db}$	m^3 dry LFG	Volumetric flow of the LFG (used for heat generation) in time interval t on a dry basis
$v_{CH4,t,db}$	m^3CH_4/m^3 dry LFG	Volumetric fraction of CH4 in the LFG in time interval t on a dry basis
$\rho_{CH4,t}$	tCH_4/m^3CH_4	Density of CH4 in time interval t

※ This formula is used to calculate $F_{CH4,HG,y}$

※ $\rho_{CH4,t}$ is fixed as 0.0007157 because $V_{t,db}$ is already converted by 0℃ and 1atm

※ All parameter about $F_{CH4,t}$ is considered as normal condition (0℃ and 1atm)

※ $V_{t,db}$ is considered as by dry basis because TI-A, temperature of FIQ-A show less than 60°C during this monitoring period.

The detail information related with BE is described below.

►$BE = BE_{CH4}$

Period	BE	=	BE_{CH4}
Unit	tCO_2eq		tCO_2eq
2017-08-19 ~ 2017-12-31	88,668	=	88,668
2018-01-01 ~ 2018-08-18	146,819	=	146,819
Total	235,487		235,487

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

Period	BE_{CH4}	OX_{top_layer}	$F_{CH4,PJ}$	$F_{CH4,BL}$	GWP_{CH4}
Unit	tCO_2eq	Constant	tCH_4	tCH_4	tCO_2/tCH_4
2017-08-19 ~ 2017-12-31	88,668	0.1	5,067	1,013	25
2018-01-01 ~ 2018-08-18	146,819	0.1	8,390	1,678	25
Total	235,487				

1) $F_{CH4,B} = F_{CH,PJ} \times 20\%$

Period	$F_{CH4,BL}$	$F_{CH4,PJ}$
Unit	tCH_4	tCH_4
2017-08-19 ~ 2017-12-31	1,013	5,067
2018-01-01 ~ 2018-08-18	1,678	8,390
Total	2,691	13,456

2) $F_{CH4,PJ} = F_{CH4,flared} + F_{CH4,EL} + F_{CH4,HG}$

Period	$F_{CH4,PJ}$	$F_{CH4,flared}$	$F_{CH4,EL}$	$F_{CH4,HG}$
Unit	tCH_4	tCH_4	tCH_4	tCH_4
2017-08-19 ~ 2017-12-31	5,067	353	0	4,532
2018-01-01 ~ 2018-08-18	8,390	1,611	0	6,778
Total	13,456			

2-1) $F_{CH4,flared} = F_{CH4,sent\_flare} - PE_{flare} / GWP_{CH4}$

Period	$F_{CH4,flared}$	$F_{CH4,sent\_flare}$	PE_{flare}	GWP_{CH4}
Unit	tCH_4	tCH_4	tCO_2	tCO_2/tCH_4
2017-08-19 ~ 2017-12-31	535	1,070	13,375	25
2018-01-01 ~ 2018-08-18	1,611	3,223	40,284	25
Total	2,146			

2-1-1) $F_{CH4,sent\_flare} = V_{flare,db} \times v_{CH4,db} \times \rho_{CH4}$

※ The detail calculation is in Daegu 6th ER sheet ($F_{CH4,sent,flare,h}$ Sheet)

2-1-2) $PE_{flare} = GWP_{CH4} \times v_{CH4,db} \times \rho_{CH4}$

※ The detail calculation is in Daegu 6th ER sheet ($F_{CH4,sent,flare,h}$ Sheet)

2-2) $F_{CH4,EL} = V_{db} \times v_{CH4,db} \times \rho_{CH4}$

※ The detail calculation is in Daegu 6th ER sheet ($F_{CH4,EL,h}$ Sheet)

2-3) $F_{CH4,HG} = V_{db} \times v_{CH4,db} \times \rho_{CH4}$

※ The detail calculation is in Daegu 6th ER sheet ($F_{CH4,HG,h}$ Sheet)

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

>>

· Calculations for all formulae used and calculation of project emissions

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

$PE_{,y}$	tCO_2eq	Project emissions in year y
$PE_{EC,y}$	tCO_2eq	Emissions from consumption of electricity due to the project activity in year y
$PE_{FC,y}$	tCO_2eq	Emissions form consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y

※ There are 2 Electricity generator, #1 and #2. $BE_{EC,y}$ are calculated separately.

1) $PE_{EC,y} = EC_{PJ,grid,y} \times EF_{EL,grid,y} \times (1 + TDL_{grid,y})$

$PE_{EC,y}$	tCO_2eq	Project emissions form electricity consumption in year y
$EC_{PJ,grid,y}$	MWh	Quantity of electricity consumed by the project electricity consumption source *j* in year y
$EF_{EL,grid,y}$	tCO_2/MWh	Emission factor for electricity generation for source grid in year y
$TDL_{grid,y}$	Constant	Average technical transmission and distribution losses for providing to source *j* in year y

2) $PE_{FC,y} = FC_{LNG,y} \times COEF_{LNG,y}$

$PE_{FC,y}$	tCO_2eq	Emissions form consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y
$FC_{LNG,y}$	Nm^3	Quantity of LNG combusted in process *j* during the year y
$COEF_{LNG,y}$	tCO_2/Nm^3	CO_2 emission coefficient of LNG in year y

2-1) $COEF_{LNG,y} = NCV_{LNG,y} \times EF_{CO2,LNG,y}$

$COEF_{LNG,y}$	tCO_2/Nm^3	CO_2 emission coefficient of LNG in year y
$NCV_{LNG,y}$	GJ/Nm^3	Net calorific value of the LNG in year y
$EF_{CO2,LNG,y}$	tCO_2/GJ	CO_2 emission factor of LNG in year y

The detail information related with PE is described as below.

► $PE = PE_{EC} + PE_{FC}$

Period	PE	PE_{EC}	PE_{FC}
Unit	tCO_2eq	tCO_2eq	tCO_2eq
2017-08-19 ~ 2017-12-31	1,705	1,705	0
2018-01-01 ~ 2018-08-18	2,617	2,617	0
Total	4,322		

1) $PE_{EC} = EC_{PJ,grid} \times EF_{EL,grid} \times (1 + TDL_{,grid})$

Period	PE_{EC}	$EC_{PJ,grid}$	$EF_{EL,grid}$	1	$TDL_{,grid}$
Unit	tCO_2eq	MWh	tCO_2/MWh	Constant	%
2017-08-19 ~ 2017-12-31	1,705	3,036	0.5421	1	3.59%
2018-01-01 ~ 2018-08-18	2,617	4,659	0.5421	1	3.59%
Total	4,322	7,695			

2) $PE_{FC} = FC_{LNG} \times COEF_{LNG}$

Period	PE_{FC}	FC_{LNG}	$COEF_{LNG}$
Unit	tCO_2eq	Nm^3	tCO_2/Nm^3

2017-08-19 ~ 2017-12-31	0	0	0.002482
2018-01-01 ~ 2018-08-18	0	0	0.002482
Total	0	0	

2-1) $COEF_{LNG} = NCV_{LNG} \times EF_{CO2,LNG}$

Period	$COEF_{LNG}$	NCV_{LNG}	$EF_{CO2,LNG}$
Unit	tCO_2/Nm^3	GJ/Nm^3	tCO_2/GJ
2017-08-19 ~ 2017-12-31	0.002482	0.04257	0.0583
2018-01-01 ~ 2018-08-18	0.002482	0.04257	0.0583

E.3. Calculation of leakage emissions

>>
N/A

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	253,487	4,322	0	0	231,165	231,165

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)
231,165 t CO_2e	177,603 tCO2e (Estimated Emission Reduction, which is described in PDD page 50)

E.6. Remarks on increase in achieved emission reductions

>>

This monitoring report claims the emission reductions of 231,165 tCO_{2e} which is larger than estimated emission reductions of 177,493 tCO_2e from the registered PDD. It rose up 130%. The expected reasons are as follow.

Efficiency of the LFG capture system

The main thing comes down to the efficiency of the LFG capture system. At those renewal time, the efficiency 63.46 % was reflected in FOD modelling and its efficiency came out feasibility study published in Feb. 2005. But its value is conservative and end up to affecting these difference between the estimated and actual emission reductions.

< Comparing between estimated and actual captured CH_4>

Year	Baseline CH_4 (tCO_{2e})		Estimated CH_4 capture(tCO_{2e})	Actual CH_4 capture (tCO_{2e}, MD project)	Difference rate
	Baseline CH_4	Efficiency			

	(tCO_{2e})				
2014	410,423	63.46 %	260,454	370,580	42.3 %
2015	409,841	63.46 %	260,085	341,658	31.4 %*
2016	409,710	63.46 %	260,002	373,731	43.7 %**
2017	409,974	63.46 %	164,655	222,687	35.2 %

※ Baseline CH4 in 2017 reflected from 1st. Jan to 18th. Aug

Given similar landfill in South Korea, these efficiencies of LFG capture system which adopting active collection system also show well over 90% and LFG gas collection efficiency of Bangcheon-ri landfill is estimated about 89.1% based on IPCC FOD model as a latest "Final report for LFG generation improving way for Daegu Bangcheon-ri landfill".

Daegu Bancheon-ri landfill is a one of the largest landfill in Korea and have been operating a high technical LFG capture and refinery facilities. This project has also adopted active LFG collection system including three blowers for capturing LFG.

The efficiency applied in the project, 63.46 %, is much lower than those of similar landfills in Korea and its value is very conservative comparing to Yongin landfill adopting simple flaring of LFG, showing 38.3% of the efficiency.

<Efficiency of LFG capture system >

Domestic landfill list	Efficiency of LFG Capture	Type	Monitoring period.
Oukcheon	94.7 (90.8 ~ 98.6)%	Active collection system	2008~2010
Dangjin	94.7 (90.9 ~ 98.5)%	Active collection system	2009
Wonju	91.7%	Active collection system	2008~2010
Ansung	90.8%	Active collection system	2008~2010
Yongin	38.3 (35.6~ 41.4%)	Simple flaring of LFG	2006

*** Additional installation of collection well (in 2011)**

Daesung Eco-Energy is a company for managing and operating Daegu Bangcheon-ri landfill. The company had significantly invested enhancing the efficiency of LFG capture system. For these efforts or investments, this landfill is well known for the good management and operation of the landfill sector in Korea.

In 2006, this project had started from 105 collection wells. And then 76 collection wells are installed in 2011. These investment can booster LFG captured amounts in 2011. According to the internal report, these 76 collection well would contribute to increase about 36.5 Nm3/min. It can prevent LFG to rapid decrease of LFG captured amounts.

**** Annual precipitation variation (in 2015)**

Daegu region is a wet region of Boreal and Temperate climate and have climate factors as below table;

<Climate Factors of Daegu region>

Climate Factors	Value	Source
Mean Annual Temperature (MAT)	13.2 ℃	Registered PDD
Mean Annual Precipitation (MAP)	1,224.8 mm	Registered PDD
Potential Evapotranspiration (PET)	1,069 mm	Registered PDD

But, Daegu region had been struggling to severe drought in 2015. According to the Korea Meteorological Administration, its annual precipitation recorded 908.5 mm and then rebounded as

1,227.1 mm in 2016. The drought in 2015 would make decay rates of wastes low from wet to dry as per the methodological tool "Emissions from solid waste disposal sites". These end up to decrease of LFG captured amount at those time.

***** Additional installation of collection well (in 2015)**

In Dec 2015, 21 collection wells were also installed and efficiency of the LFG capture system would rise up in 2016. Now, Daegu Bangcheon-ri landfill had have total 202 collection wells. *Given initial 105 collection wells and additional 76 collection well, 21 collection wells were consistent investment and these trigger a large amount of LFG capture.*

As a result, Daesung Eco-Energy and Korea District Heating Corporation, project participants, hope steady supply of LFG as a fuel for LFG Boilers.

****** The PRC is approved on 06 May 2016.**

There is another post registration change in 2018, which is of the second crediting period. Two flare stack for the enclosed type were newly installed onsite due to a lots of complains for odor from landfill.

Item	Capacity	LFG supply pressure
Flare stack system (Enclosed type)	2,000 N^3m/hr x 2 ea	1,000 mmAq

The project activity runs four flare stacks including two existing open type and two newly enclosed type in every summer season. The new flare stacks will be complement the existing flare stacks which is out of date.

- - - - -

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.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report