Monitoring report form for CDM project activity
(Version 08.0)

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	12/10/2021		
Monitoring period number	10th monitoring period		
Duration of this monitoring period	19/08/2020 ~ 18/08/2021		
Monitoring report number for this monitoring period	10th		
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		
Applied methodologies and standardized baselines	ACM0001 ver.15		
Sectoral scopes	Scope 13 : Waste handling disposal		
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 until 31 December 2020	Amount achieved from 1 January 2021
	0 tCO2eq	100,079 tCO2eq	122,865 tCO2eq
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	178,808 tCO2eq		

SECTION A. Description of project activity

A.1. General description of project activity

>>

Daegu Bangcheon-Ri 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 the 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	-

- **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 odor 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).

A.2. Location of project activity

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Daegu Bangcheon-Ri Landfill site is located at 820, Dasa-Ro Dasa-Eup, Dalsung-Gun, Daegu Metropolitan City, Korea. Daegu Metropolitan City is located in the centre of Gyeongsangbuk-Do province located in the south-eastern part of Korea. The project site is located on the east longitude 128.5096, the north latitude 35.8814 and surrounded by mountains except the north site.

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. References 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 from 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 from flaring” (version 02)
- “Tool to determine the mass flow of a greenhouse gas in a gaseous steam” (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

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- Type : Renewable type
- Renewable date : 17/09/2016
- Length of the 2nd crediting period : 19/08/2014 ~ 18/08/2021
- 10th monitoring period : 19/08/2020 ~ 18/08/2021

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 odor, 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.

▶ 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

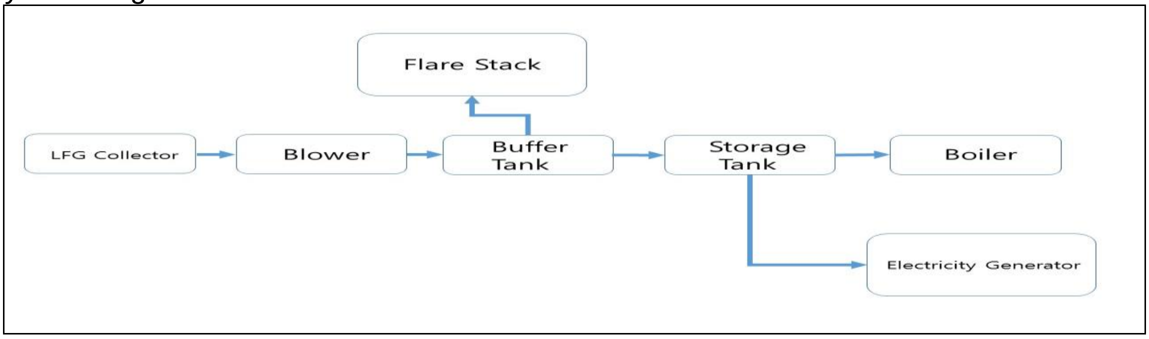

Figure 1 system diagram,

▶ Installed technology

1) 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.

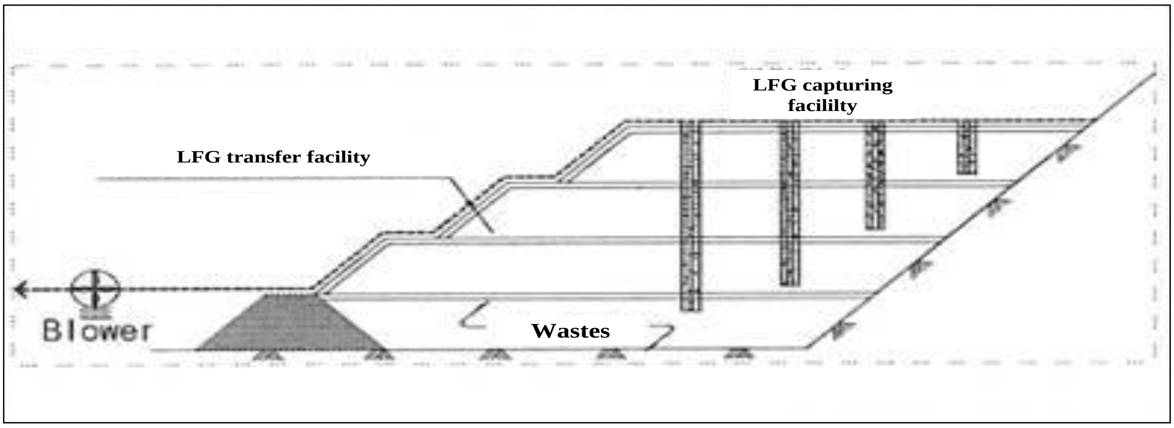

Figure 2 Vertical LFG capturing equipment installation concept

2) LFG utilization system

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

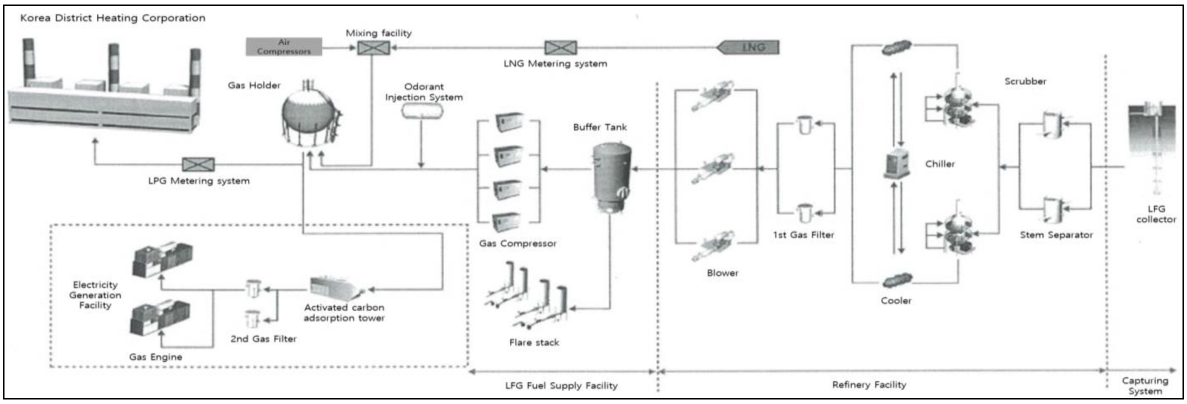

Figure 3 LFG utilization system flow chart

▶ Equipment

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 4 Turbo Blower

Equipment	Blower
No. of Equipment	FN-1-05A/B/C (3units)
Type	Turbo
Capacity	75 Nm³/min
Pressure	3,800 mmAq

2) Filter

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

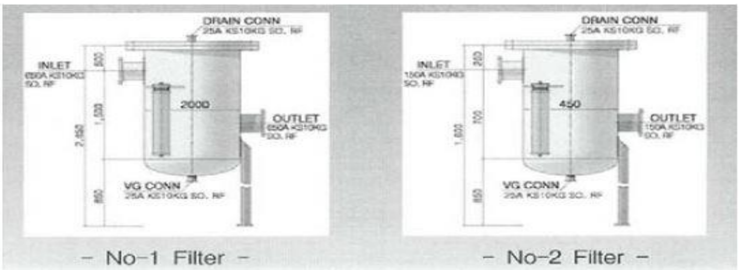

Figure 5 Filter

Equipment	No-1 Filter (before a blower)	No-2 Filter (before gas engine)
No. of Equipment	F-1-01A/B (2units)	F-2-01AB (2units)
Type	Demister	Demister
Capacity	150 Nm³/min	17 Nm³/min
Pressure	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 6 Scrubber

Equipment	SCRUBBER
No. of Equipment	SR-1-02A/B (2units)
Type	Packed Tower with Demister
Capacity	75 Nm³/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.

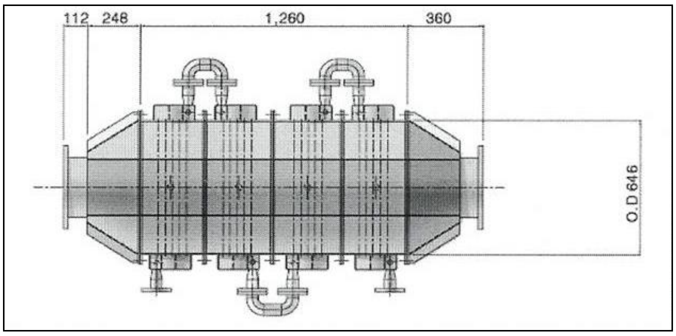

Figure 7 Cooler

Equipment	LFG Cooler
No. of Equipment	CO-1-03A/B (2units)
Type	Fin Tube
Flow Rate	75 Nm³/min

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

Figure 8 Chiller

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

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

Figure 9 Gas Engine

Equipment	GAS ENGINE
No. of Equipment	EN-2-03 A/B (2 units)
Type	Container Type
Capacity	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 10 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 Nm^3/h x 2 units)	4,000 (2,000 Nm^3/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 11 Gas storage tank

Equipment	BALL TANK
No. of Equipment	T-3-05 (1 unit)
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)
Type	Hot water
Capacity	34.4 Gcal/hr (LNG) 33.0 Gcal/hr (LFG)

Gas engines were not operated during this monitoring period, as attested by the fact that the reading from FIQ-201 monitoring LFG feed to the power generation system was 0 Nm^3. The facility decided to process the excess LFG at the flare stacks rather than to generate electricity at the gas engine due to high operation cost of the gas engine system.
LFG demand from KDHC for the summer season used to be lower than that for the remaining seasons due to low heat demand from the area caused by hot summertime weather. However, LFG supply to KDHC was not decreased even during summer time as KDHC needed more LFG to compensate the decreased energy supply from Seongseo Incinerator, one of energy suppliers to KDHC.

LFG temperature data collected from TI-204, TI-301 and TI-A was applied when it was lower than 60℃ degrees. Therefore LFG are considered as dry basis, as per option A of “Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver.02.0.0)”.

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

Item	Date and Details	
Downtime	- Heat Exchanger (#1,#2)	
	Date	Details
	24/08/2020~27/08/2020	Discontinued supply due to CHP operation
	29/08/2020~31/08/2020	Full of heat water in heat storage tank
	27/10/2020~27/10/2020	Full of heat water in heat storage tank
	21/02/2021~21/02/2021	Inspection of the facility
	08/03/2021~19/03/2021	Inspection of the facility
	24/03/2021~25/03/2021	Full of heat water in heat storage tank
	25/05/2021~26/05/2021	Inspection of the facility
	21/06/2021~22/06/2021	Inspection of the facility
	02/07/2021~02/07/2021	Inspection of the facility
	15/07/2021~16/07/2021	Full of heat water in heat storage tank
	20/07/2021~27/07/2021	Full of heat water in heat storage tank
	28/07/2021~10/08/2021	Discontinued supply due to CHP operation
	*All installation was checked by quarter *Detail contents are described in Maintain report	

B.2. Post-registration changes

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

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N/A

B.2.2. Corrections

>>
N/A

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

>>
N/A

B.2.4. Inclusion of monitoring plan

>>
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 methodological regulatory documents

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N/A

B.2.6. Changes to project design

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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 (2 units).

As for the project, two flare stacks with a capacity of 4,200 Nm^3/h(open type, 2,100 Nm^3*2 units) were initially installed on 13/10/2006. However, there was an additional flare stacks (enclosed type, 2,000 Nm^3/h *2 units) installed on 29/05/2018.

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 Nm^3/h * 2 units) and the actual implementation of 8,200 Nm^3 (2,100 Nm^3 * 2 units, 2,000 Nm^3/h * 2 units). The revised PDD was approved on 25/09/2018 by UNFCCC.

B.2.7. Changes specific to afforestation or reforestation project activity

>>
N/A

SECTION C. Description of monitoring system

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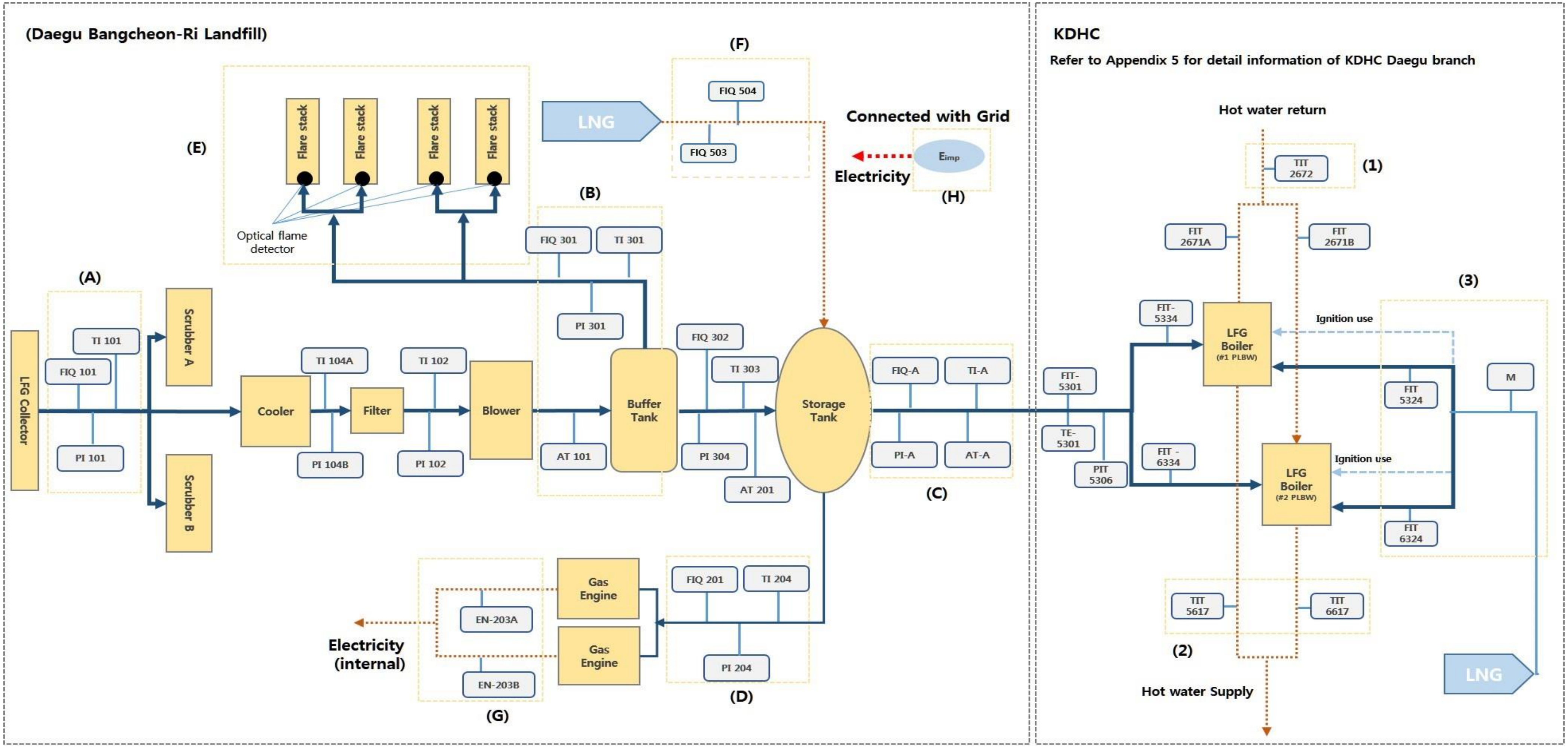
All kinds of measuring instruments, including gas analyzer and gas meter, are present. The data collected is registered continuously by the PLC (Programmable Logic Controller). The following equipment is used to monitor the operation of the project and to monitor the emission reduction.



<table>
<tr><td rowspan="29">Landfill</td><td rowspan="3">(A)</td><td>FIQ-101</td><td>Flow meter</td><td rowspan="17">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 rowspan="2">(F)</td><td>FIQ-503</td><td rowspan="2">LNG flow meter</td><td rowspan="2">- Type : Rotary
- Accuracy : ±0.5%</td></tr>
<tr><td>FIQ-504</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 Qmin ~ 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 analyzers in this project as below;

① Behind of the buffer tank(for reference, AT201)

② In front of the buffer tank: The data measured by this gas analyzer 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 analyzer 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. Collected temperature LFG of TI-204, TI-301 and TI-A was applied when it was lower than 60℃ degrees. 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 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 analyzer which is monitoring CH_4 fraction fed to flare is AT-101 and the analyzer 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, odour from 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. Hence, 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 was carried out. FIQ-301, temperature transmitters (TI-301) and manometer (PI-301) were monitored 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.

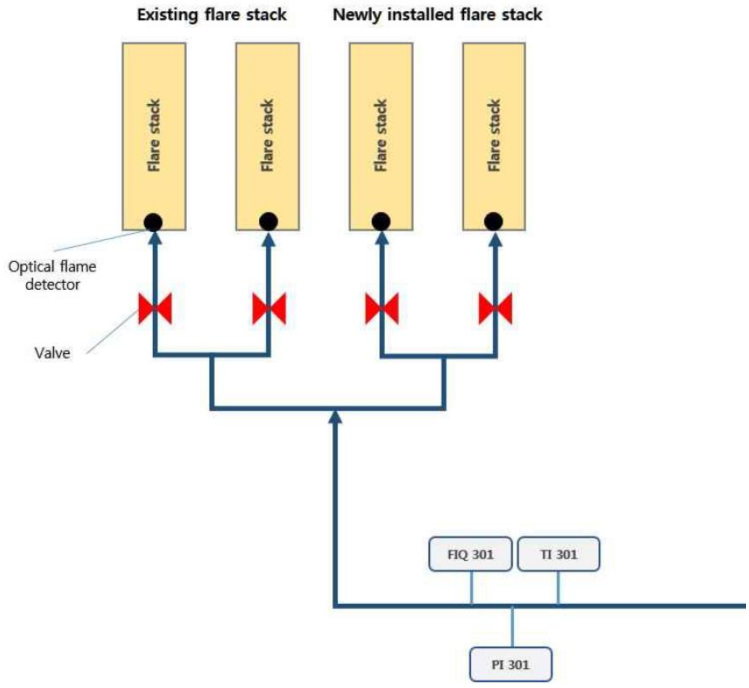


Figure 12 Detailed diagram of flare stacks monitoring

4) LNG usage

The amount of LNG used consists of mainly to 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 the 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. Consumption of ignition use was found to influence the 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, FIT6324) 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.

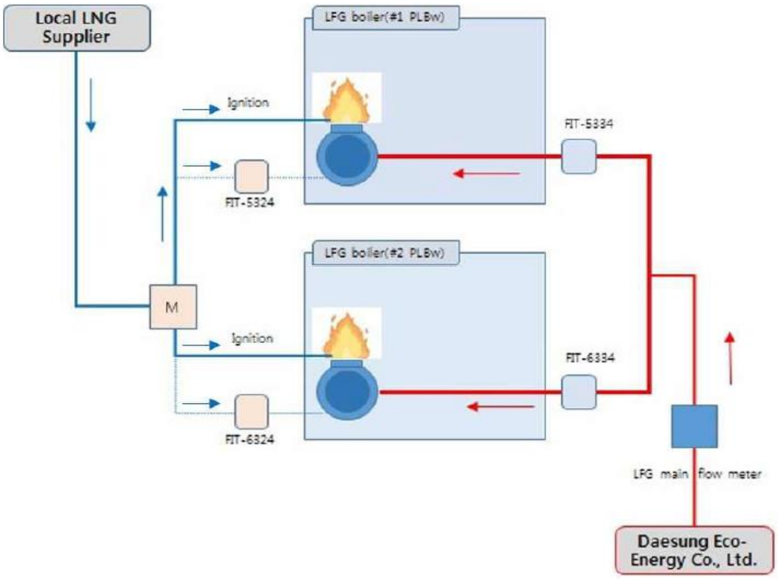


Figure 13 Monitoring diagram of LFG boilers

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/QC of $FC_{LNG,j,y}$.

5) Electricity generation Operating check

LFG which is measured at FIQ-201 is fed to LFG generators. To chek whether electricity generation is operating or not, electricity indicator (EN-203A, EN-203B) was used. According to registered PDD, parameter OP_j needs to be applied but not really needed (Temperature, Flame and Products generated. i.e, result of using of LFG). Generated electiricity was used to chek operating as a result of using LFG in this project.

6) Electricity imported

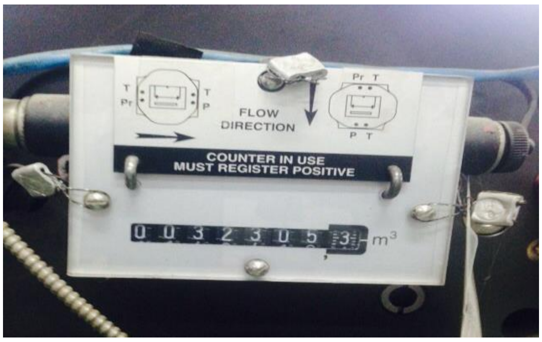
The imported electricity is used for LFG capturing and treating. The amount of electricity is continuously measured by watt-hour meter (E_{imp}) and double-checked with electricity bill monthly provided by KEPCO.

7) Boiler Operating check

Thermometers including TIT-2672, TIT-5617 and TIT-6617 check wheter 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 ~ 40,000 m^3/h

▶ Vortex Flow Meter(FIQ-201)

- Type : Vortex
- Accuracy: ±1.0%
- Flow range : 15 ~ 19 Nm^3/min

▶ Vortex Flow Meter (FIQ-301)

- Type : Vortex
- Accuracy: ±1.0%
- Flow range : 42 ~ 150 Nm^3/min

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

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

Gas	Minimum Range	Maximum range
CH_4	0~1000 ppm	0 ~ 100 vol%
CO_2	0~500 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.

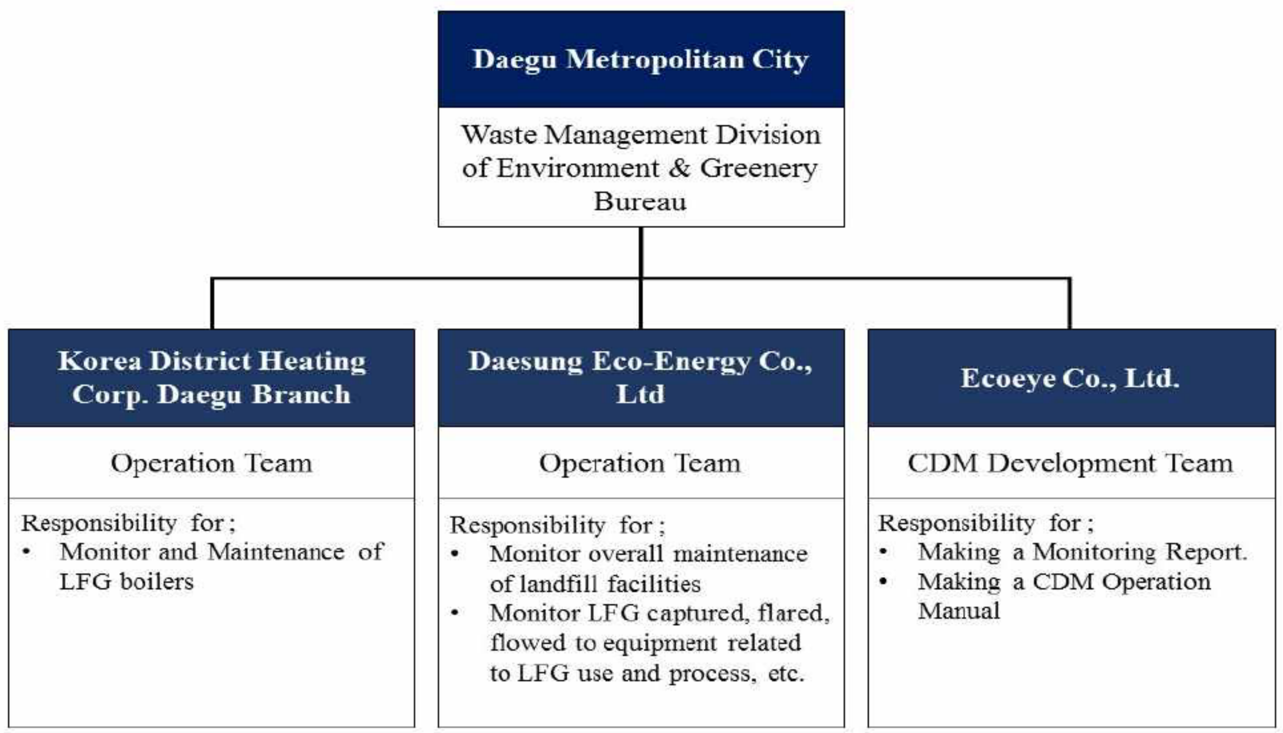
4) Down Loading Function
Saved data is able to download by excel file for monitoring.

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

(Copy this table for each data or parameter.)

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_2eq/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	GWP_{CH4}
Unit	tCO_2eq/tCH_4
Description	Global warming potential (GWP) of methane
Source of data	The IPCC second assessment report(AR2)
Value(s) applied	21
Choice of data or measurement methods and procedures	Refer the regulatory requirements under temporary measures for post-2020 cases version 01.1
Purpose of data/parameter	Calculation of baseline emission
Additional comments	21 is applied by calculation of baseline emissions after 1 January 2021 in accordance with temporary measures. Furthermore, it will be updated according to decision by the CMP 16.

Data/Parameter	$EF_{grid,CM,y}$
Unit	tCO_2eq/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” (version04.0). 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	Calculated value at 0℃ and 1atm according to “Tool to determine the mass flow of greenhouse gas in a gaseous stream (Ver.02.0.0)”
Purpose of data/parameter	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 flow rate 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

(Copy this table for each data or parameter.)

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

<table>
<tr><td>Value(s) of monitored parameter</td><td>(a) Original design of the landfill
There is no change of area of waste disposal (853,400m^2) 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 2020.

<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>
<tr><td>2018</td><td>463,806</td><td>301,056</td><td>-35.09%</td></tr>
<tr><td>2019</td><td>467,565</td><td>322,241</td><td>-31.08%</td></tr>
<tr><td>2020</td><td>471,288</td><td>347,796</td><td>-26.20%</td></tr>
<tr><td>2021</td><td>475,011</td><td>205,721</td><td>-56.69%</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, FD-103, FD-104
Value(s) of monitored parameter	N/A

<table>
<tr>
<td>Monitoring equipment</td>
<td>
(1) $F_{CH4,HG}$ (LFG Boiler)
<table>
<tr><td>Tag</td><td>TIT-2672</td></tr>
<tr><td>Type</td><td>Temperature transmitter</td></tr>
<tr><td>Accuracy class</td><td>± 0.25%</td></tr>
<tr><td>Serial number</td><td>TIT-2672</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>26/07/2021</td></tr>
<tr><td>Validity</td><td>26/07/2021 ~ 25/07/2024</td></tr>
</table>
<table>
<tr><td>Tag</td><td>TIT-5617</td></tr>
<tr><td>Type</td><td>Temperature transmitter</td></tr>
<tr><td>Accuracy class</td><td>± 0.25%</td></tr>
<tr><td>Serial number</td><td>TIT-5617</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>26/07/2021</td></tr>
<tr><td>Validity</td><td>26/07/2021 ~ 25/07/2024</td></tr>
</table>
<table>
<tr><td>Tag</td><td>TIT-6617</td></tr>
<tr><td>Type</td><td>Temperature transmitter</td></tr>
<tr><td>Accuracy class</td><td>± 0.25%</td></tr>
<tr><td>Serial number</td><td>TIT-6617</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>26/07/2021</td></tr>
<tr><td>Validity</td><td>26/07/2021 ~ 25/07/2024</td></tr>
</table>
(2) $F_{CH4,flared}$ (Flare stack)
<table>
<tr><td>Tag</td><td>FD-101</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>53131</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>16/07/2020</td></tr>
<tr><td>Validity</td><td>16/07/2020~15/07/2023</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-102</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>10531</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>21/07/2020</td></tr>
<tr><td>Validity</td><td>21/07/2020~20/07/2023</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-103</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>1710241556</td></tr>
<tr><td>Calibration frequency</td><td>40,000 hours</td></tr>
<tr><td>Date of last calibration</td><td>01/05/2018</td></tr>
<tr><td>Validity</td><td>01/05/2018~30/04/2022</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-104</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>1710241568</td></tr>
<tr><td>Calibration frequency</td><td>40,000 hours</td></tr>
<tr><td>Date of last calibration</td><td>01/05/2018</td></tr>
<tr><td>Validity</td><td>01/05/2018~30/04/2022</td></tr>
</table>
</td>
</tr>
<tr>
<td>Measuring/reading/recording frequency</td>
<td>TIT-2672, TIT-5617, TIT-6617 : Recording hourly
FD-101, FD-102, FD-103, FD-104 : Measuring minutely</td>
</tr>
<tr>
<td>Calculation method
(if applicable)</td>
<td>N/A</td>
</tr>
</table>

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/parameter	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	19/08/2020 ~ 31/12/2020 : 3,595 MWh 01/01/2021 ~ 18/08/2021 : 4,909 MWh This values are in $EC_{PJ, grid}$ sheet of the Daegu 10th ER sheet.
Monitoring equipment	Tag: E_{imp} 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/parameter	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, FD-103, FD-104)
Value(s) of monitored parameter	-

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Tag</td><td>FD-101</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>53131</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>16/07/2020</td></tr>
<tr><td>Validity</td><td>16/07/2020~15/07/2023</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-102</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>10531</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td></tr>
<tr><td>Date of last calibration</td><td>21/07/2020</td></tr>
<tr><td>Validity</td><td>21/07/2020~20/07/2023</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-103</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>1710241556</td></tr>
<tr><td>Calibration frequency</td><td>40,000 hours</td></tr>
<tr><td>Date of last calibration</td><td>01/05/2018</td></tr>
<tr><td>Validity</td><td>01/05/2018~30/04/2022</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FD-104</td></tr>
<tr><td>Type</td><td>UV-IR</td></tr>
<tr><td>Accuracy class</td><td>± 5%</td></tr>
<tr><td>Serial number</td><td>1710241568</td></tr>
<tr><td>Calibration frequency</td><td>40,000 hours</td></tr>
<tr><td>Date of last calibration</td><td>01/05/2018</td></tr>
<tr><td>Validity</td><td>01/05/2018~30/04/2022</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Recording minutely</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>Equipment shall be maintained and calibrated in accordance with manufacturer’s recommendations or local regulation.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>This parameter is used to confirm flare stack operating.</td></tr>
</table>

Data/Parameter	$V_{t,db}$
Unit	Nm^3dry 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)
Value(s) of monitored parameter	**FIQ-201** 19/08/2020~31/12/2020 : 0 Nm^3 01/01/2021~18/08/2021 : 0 Nm^3 **FIQ-301** 19/08/2020~31/12/2020 : 2,718,246 Nm^3 01/01/2021~18/08/2021 : 6,750,131 Nm^3 **FIQ-A** 19/08/2020~31/12/2020 : 17,820,734 Nm^3 01/01/2021~18/08/2021 : 26,904,102 Nm^3

Monitoring equipment	Tag: FIQ-201 Type: Vortex Accuracy class: 1.0% Serial number: C10-S1000HN Calibration frequency: 8 years Date of last calibration: 06/08/2014 Validity: 06/08/2014~05/08/2022 Tag: FIQ-301 Type: Vortex Accuracy class: 1.0% Serial number: DE26015G Calibration frequency: 8 years Date of last calibration: 06/08/2014 Validity: 06/08/2014~05/08/2022 Tag: FIQ-A Type: Turbine Accuracy class: 0.5% Serial number: 10517644 Calibration frequency: 8 years Date of last calibration: 02/03/2015 Validity: 02/03/2015~01/03/2023
Measuring/reading/recording frequency	Measuring hourly
Calculation method (if applicable)	N/A
QA/QC procedures	This monitoring equipment is calibrated every 8 years.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	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 Nm^3 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℃ 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.

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)

<table>
<tr><td>Value(s) of monitored parameter</td><td>AT-101
19/08/2020~31/12/2020 : 45.42%
01/01/2021~18/08/2021 : 44.51%

AT-A (related with FIQ-A)
19/08/2019~31/12/2019 : 44.89 %
01/01/2020~18/08/2020 : 42.37 %

AT-A (related with FIQ-201)
19/08/2020~31/12/2020 : 0 %
01/01/2021~18/08/2021 : 0 %</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Tag</td><td>AT-101</td></tr>
<tr><td>Type</td><td>Infrared analyzer</td></tr>
<tr><td>Serial number</td><td>N9A0697</td></tr>
<tr><td>Calibration frequency</td><td>5 years</td></tr>
<tr><td>Date of last calibration</td><td>25/03/2019</td></tr>
<tr><td>Validity</td><td>25/03/2019~24/03/2024</td></tr>
</table>
<table>
<tr><td>Tag</td><td>AT-A</td></tr>
<tr><td>Type</td><td>Infrared analyzer</td></tr>
<tr><td>Serial number</td><td>N0E1361</td></tr>
<tr><td>Calibration frequency</td><td>5 years</td></tr>
<tr><td>Date of last calibration</td><td>20/05/2020</td></tr>
<tr><td>Validity</td><td>20/05/2020~19/05/2025</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 should be subject to a regular maintenance and testing regime to ensure accuracy.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>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” Nm^3 during 10^{th} 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. Collected temperature LFG of TI-204, TI-301 and TI-A was applied when it was lower than 60 degrees. 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.</td></tr>
</table>

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 class	± 0.075%	
	Serial number	91F625744	
	Calibration frequency	Yearly	
	Date of last calibration	18/09/2020	
	Validity	18/08/2020~17/09/2020 18/09/2020~17/10/2020 20/10/2020~19/11/2020 20/11/2020~19/12/2020 20/12/2020~19/01/2021 22/01/2021~21/02/2021 19/02/2021~18/03/2021	19/03/2021~18/04/2021 30/04/2021~21/05/2021 21/05/2021~19/06/2021 24/06/2021~23/07/2021 27/07/2021~26/08/2021 24/08/2021~23/09/2021
	Tag	PI-301	
	Type	Diaphragm	
	Accuracy class	± 0.075%	
	Serial number	91F347307	
	Calibration frequency	Yearly	
	Date of last calibration	18/09/2020	
	Validity	18/08/2020~17/09/2020 18/09/2020~17/10/2020 20/10/2020~19/11/2020 20/11/2020~19/12/2020 20/12/2020~19/01/2021 22/01/2021~21/02/2021 19/02/2021~18/03/2021	19/03/2021~18/04/2021 30/04/2021~21/05/2021 21/05/2021~19/06/2021 24/06/2021~23/07/2021 27/07/2021~26/08/2021 24/08/2021~23/09/2021
	Tag	PI-A	
	Type	Diaphragm	
	Accuracy class	± 0.25%	
	Serial number	80506921	
	Calibration frequency	Yearly	
	Date of last calibration	18/09/2020	
	Validity	18/08/2020~17/09/2020 18/09/2020~17/10/2020 20/10/2020~19/11/2020 20/11/2020~19/12/2020 20/12/2020~19/01/2021 22/01/2021~21/02/2021 19/02/2021~18/03/2021	19/03/2021~18/04/2021 30/04/2021~21/05/2021 21/05/2021~19/06/2021 24/06/2021~23/07/2021 27/07/2021~26/08/2021 24/08/2021~23/09/2021
Measuring/reading/recording frequency	Hourly		
Calculation method (if applicable)	N/A		
QA/QC procedures	N/A		
Purpose of data/parameter	Calculation of project emissions		
Additional comments	In this monitoring period, the calibration of the entire pressure as well as the pressure transducers is approved by the Korea Laboratory Accreditation Scheme, which is an independent accredited laboratory in accordance with local regulation. According to the KOLAS certification of the calibration, the results are valid for up to 12 months. Manometer is applied to volumetric flow rate 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-204, TI-301, TI-A)
Value(s) of monitored parameter	-
Monitoring equipment	Tag: TI-204 Type: RTD Accuracy class: ± 0.305|t| Serial number: 10020523 Calibration frequency: 2 years Date of last calibration: 15/06/2020 Validity: 15/06/2020~14/06/2022 Tag: TI-301 Type: RTD Accuracy class: ± 0.305|t| Serial number: 1002059 Calibration frequency: 2 years Date of last calibration: 15/06/2020 Validity: 15/06/2020~14/06/2022 Tag: TI-A Type: RTD Accuracy class: ± 0.25% Serial number: 08506921 Calibration frequency: 2 years Date of last calibration: 15/06/2020 Validity: 15/06/2020~14/06/2022
Measuring/reading/recording frequency	Measuring hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Flow meters are subject to a regular maintenance and testing regime to ensure accuracy
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	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. Collected temperature LFG of TI-204, TI-301 and TI-A was applied when it was lower than 60℃ degrees. 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 flow rate automatically to convert 0℃, 1atm.

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 Daesung energy corporation (LNG supplier) data (LNG bill)
Value(s) of monitored parameter	19/08/2020 ~ 31/12/2020 : 1,632 Nm^3 01/01/2021 ~ 18/08/2021 : 298,177 Nm^3

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Tag</td><td>F (FIQ-503)</td></tr>
<tr><td>Type</td><td>Rotary</td></tr>
<tr><td>Accuracy class</td><td>± 0.5%</td></tr>
<tr><td>Serial number</td><td>20536708</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>24/09/2016</td></tr>
<tr><td>Validity</td><td>24/09/2016~23/09/2024</td></tr>
</table>
<table>
<tr><td>Tag</td><td>F (FIQ-504)</td></tr>
<tr><td>Type</td><td>Rotary</td></tr>
<tr><td>Accuracy class</td><td>± 0.5%</td></tr>
<tr><td>Serial number</td><td>20536703</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>23/09/2016</td></tr>
<tr><td>Validity</td><td>23/09/2016~22/09/2024</td></tr>
</table>
<table>
<tr><td>Tag</td><td>M</td></tr>
<tr><td>Type</td><td>Turbine / Gas Volume Corrector</td></tr>
<tr><td>Accuracy class</td><td>± 1%</td></tr>
<tr><td>Serial number</td><td>3403636614</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>30/07/2018</td></tr>
<tr><td>Validity</td><td>30/07/2018~29/07/2026</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FIT-5324</td></tr>
<tr><td>Type</td><td>Vortex</td></tr>
<tr><td>Accuracy class</td><td>± 1%</td></tr>
<tr><td>Serial number</td><td>C15-S0540HN</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>28/04/2015</td></tr>
<tr><td>Validity</td><td>28/04/2015~27/04/2023</td></tr>
</table>
<table>
<tr><td>Tag</td><td>FIT-6324</td></tr>
<tr><td>Type</td><td>Vortex</td></tr>
<tr><td>Accuracy class</td><td>± 1%</td></tr>
<tr><td>Serial number</td><td>C15-S0442HN</td></tr>
<tr><td>Calibration frequency</td><td>8 years</td></tr>
<tr><td>Date of last calibration</td><td>14/05/2015</td></tr>
<tr><td>Validity</td><td>14/05/2015~13/05/2023</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>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 ($FC_{LNG, j, y}$).</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of project emissions</td></tr>
<tr><td>Additional comments</td><td>FIT-5324 and FIT-6324 are included to monitor point from the 2nd crediting period. These two meters were installed to check volumetric flow rate of LNG for LNG ignition consumption of LFG boilers.</td></tr>
</table>

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	19/08/2020 ~ 31/12/2020 : 0.04265 01/01/2021 ~ 18/08/2021 : 0.04264
Monitoring equipment	N/A
Measuring/reading/recording frequency	Reading monthly
Calculation method (if applicable)	N/A
QA/QC procedures	N/A
Purpose of data/parameter	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 lower 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/parameter	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	19/08/2020~31/12/2020 : 3.54 % 01/01/2021~18/08/2021 : 3.54 %
Monitoring equipment	N/A
Measuring/reading/recording frequency	Monthly reading
Calculation method (if applicable)	N/A
QA/QC procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	These values are from ‘Statistics of Electric Power in Korea’, published on May 2021 by Korea electric power corporation.

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℃ 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 formula 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 CH_4

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

$F_{CH4,sent\_flare,t}$	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 CH_4 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℃ during this monitoring period.

2-1-2)

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

$PE_{flare,y}$	tCO_2eq	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_2eq/tCH_4	Global Warming Potential of methane valid for the commitment period

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

$F_{CH4,t}$	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℃ during this monitoring period.

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

$F_{CH4,flared,t}$	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℃ 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
2020-08-19 ~ 2020-12-31	102,102	=	102,102
2021-01-01 ~ 2021-08-18	126,363	=	126,363
Total	228,465		228,465

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

Period	BE_{CH4}	OX_{top_layer}	$F_{CH4,PJ}$	$F_{CH4,BL}$	GWP_{CH4}
Unit	tCO_2eq	Constant	tCH_4	tCH_4	tCO_2eq /tCH_4
2020-08-19 ~ 2020-12-31	102,102	0.1	5,834	1,167	25
2021-01-01 ~ 2021-08-18	126,363	0.1	8,596	1,719	21
Total	228,465				

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

Period	$F_{CH4,BL}$	$F_{CH4,PJ}$
Unit	tCH_4	tCH_4
2020-08-19 ~ 2020-12-31	1,167	5,834
2021-01-01 ~ 2021-08-18	1,719	8,596
Total	2,886	14,431

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
2020-08-19 ~ 2020-12-31	5,834	216	0	5,619
2021-01-01 ~ 2021-08-18	8,596	549	0	8,047
Total	14,431	764		13,666

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
2020-08-19 ~ 2020-12-31	216	431	5,388	25
2021-01-01 ~ 2021-08-18	549	1,099	11,538	21
Total	765			

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

※ The detail calculation is in Daegu 10th 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 10th 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 10th 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 10th 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
$TDL_{grid,y}$	%	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
2020-08-19 ~ 2020-12-31	2,023	2,018	5
2021-01-01 ~ 2021-08-18	3,498	2,756	742
Total	5,521		

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	%

2020-08-19 ~ 2020-12-31	2,018	3,595	0.5421	1	3.54%
2021-01-01 ~ 2021-08-18	2,756	4,909	0.5421	1	3.54%
Total	4,774	8,504			

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

Period	PE_{FC}	FC_{LNG}	$COEF_{LNG}$
Unit	tCO_2eq	Nm^3	tCO_2/Nm^3
2020-08-19 ~ 2020-12-31	5	1,632	0.002487
2021-01-01 ~ 2021-08-18	742	298,177	0.002486
Total	747	299,809	

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
2020-08-19 ~ 2020-12-31	0.002487	0.04265	0.0583
2021-01-01 ~ 2021-08-18	0.002486	0.04264	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 until 31/12/ 2020	From 01/01/ 2021	Total amount
Total	228,465	5,521	0	0	100,079	122,865	222,944

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 for this monitoring period in the PDD (t CO_2e)
222,944	178,808 tCO2eq (Estimated Emission Reduction, which is illustrated in PDD page 50)

E.5.1. Explanation of calculation of “amount estimated ex ante for this monitoring period in the PDD”

>>
The actual emission reductions of the project activity will be calculated and claimed as the ex-post monitoring parameters during the 2nd crediting period. Ex-ante estimation of emission reductions is calculated according to ACM0001 (Version 15). Every methodological tools and formula mentioned in above sections of the PDD are applied for the ex-ante estimation of emission reduction.

1. Baseline emission (ex-ante estimation)

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

<Table B-10> Calculation of BE_y

Year	$BE_{CH4,y}$	$BE_{EC,y}$	$BE_{HG,y}$	BE_y (tCO_2eq)
2014.8.19 – 2015.8.18	182,330	0	0	182,330
2015.8.19 – 2016.8.18	182,067	0	0	182,067
2016.8.19 – 2017.8.18	182,000	0	0	182,000
2017.8.19 – 2018.8.18	182,110	0	0	182,110
2018.8.19 – 2019.8.18	182,395	0	0	182,395
2019.8.19 – 2020.8.18	182,790	0	0	182,790
2020.8.19 – 2021.8.18	183,315	0	0	183,315

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

<Table B-11> Calculation of $BE_{CH4,y}$

Year	$(1-OX_{top\_layer})$	$F_{CH4,PJ,y}$	$F_{CH4,BL,y}$	GWP_{CH4}	$BE_{CH4,y}$ (tCO_2eq)
2014.8.19 – 2015.8.18	0.9	10,418	2,083	25	182,330
2015.8.19 – 2016.8.18	0.9	10,403	2,080	25	182,067
2016.8.19 – 2017.8.18	0.9	10,400	2,080	25	182,000
2017.8.19 – 2018.8.18	0.9	10,406	2,081	25	182,110
2018.8.19 – 2019.8.18	0.9	10,422	2,084	25	182,395
2019.8.19 – 2020.8.18	0.9	10,444	2,088	25	182,790
2020.8.19 – 2021.8.18	0.9	10,474	2,094	25	183,315

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

Total amount of methane generated from disposal of waste at the SWDS could be calculated by using available data as per equation (11)

$$BE_{CH4,SWDS,y} = \varphi_y \cdot (1-f_y) \cdot GWP_{CH4} \cdot (1-OX) \cdot 16/12 \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_j W_{j,x} \cdot DOC_j \cdot e^{-kj(y-x)} \cdot (1-e^{-kj})$$

Parameters for determining $BE_{CH4,SWDS,y}$ are showed as follows;

<Table B-12> Parameters from "Emissions from solid waste disposal sites (ver.06.0.1)"

Parameter		Value
Model correction factor	φ_y	0.75
Global Warming Potential of Methane	GWP_{CH4}	25
Oxidation factor	OX	0.1
Fraction of methane in the SWDS gas	F	0.5
Fraction of degradable organic carbon (DOC) that can decompose	$DOC_{f,y}$	0.5
Methane correction factor	MCF_y	1
Fraction of methane captured at the SWDS and flared, combusted or used in another manner	f_y	0

Detail information for calculating $BE_{CH4,SWDS,y}$ is included in the separate calculation sheet.

Amount of methane in LFG which is flared and/or used in the project activity $F_{CH4,PJ,y}$ is calculated by using the equation (10)

<Table B-13> Calculation of $F_{CH4,PJ,y}$

Year	*$BE_{CH4,SWDS,y}$*	*η_{PJ}*	*GWP_{CH4}*	*$F_{CH4,PJ,y}$ (tCO_2eq)*
2014.8.19 – 2015.8.18	*410,423*	*63.46%*	*25*	*10,418*
2015.8.19 – 2016.8.18	*409,841*	*63.46%*	*25*	*10,403*
2016.8.19 – 2017.8.18	*409,710*	*63.46%*	*25*	*10,400*
2017.8.19 – 2018.8.18	*409,974*	*63.46%*	*25*	*10,406*
2018.8.19 – 2019.8.18	*410,576*	*63.46%*	*25*	*10,422*
2019.8.19 – 2020.8.18	*411,475*	*63.46%*	*25*	*10,444*
2020.8.19 – 2021.8.18	*412,629*	*63.46%*	*25*	*10,474*

b). $F_{CH4,BL,y} = 20\% \times F_{CH4,PJ,y}$

<Table B-14> Calculation of $F_{CH4,BL,y}$

Year	*$F_{CH4,PJ,y}$*	*20%*	*$F_{CH4,BL.y}$ (tCO_2eq)*
2014.8.19 – 2015.8.18	*10,418*	*20%*	*2,083*
2015.8.19 – 2016.8.18	*10,403*	*20%*	*2,080*
2016.8.19 – 2017.8.18	*10,400*	*20%*	*2,080*
2017.8.19 – 2018.8.18	*10,406*	*20%*	*2,081*
2018.8.19 – 2019.8.18	*10,422*	*20%*	*2,084*
2019.8.19 – 2020.8.18	*10,444*	*20%*	*2,088*
2020.8.19 – 2021.8.18	*10,474*	*20%*	*2,094*

2) $BE_{EC,y} = \Sigma EC_{BL,k,y} \times EF_{EL,grid,y} \times (1 + TDL_{grid,y})$

This project activity is only involved with methane avoidance in the landfill. There is no baseline emission associated with electricity gerneration in year y ($BE_{EC,y}$).

3) $BE_{HC,y} = NCV_{CH4} \times \Sigma(R_{efficiency,\ h,\ y} \times F_{CH4,HG,dest,j,y} \times EF_{CO2,BL,HG,j})$

This project activity is only involved with methane avoidance. There is no baseline emission associated with heat generation in year y ($BE_{HC,y}$).

2. Project emission

Main source of project emission in the project activity are the consumption of electricity and LNG. The electricity is used for the operation of LFG collection and refine facilities. LNG is supplementary to LFG which have uneven quality of methane seasonally. It assures quality of LFG as a fuel for energy generation. Amounts of electricity and LNG for the project activity will be recorded and used for ex-post calculation.

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

<Table B-15> Calculation of PE_y

Year	*$PE_{EC,y}$*	*$PE_{FC,y}$*	*PE_y (tCO_2eq)*
2014.8.19 – 2015.8.18	*4,069*	*438*	*4,507*
2015.8.19 – 2016.8.18	*4,069*	*438*	*4,507*
2016.8.19 – 2017.8.18	*4,069*	*438*	*4,507*
2017.8.19 – 2018.8.18	*4,069*	*438*	*4,507*
2018.8.19 – 2019.8.18	*4,069*	*438*	*4,507*
2019.8.19 – 2020.8.18	*4,069*	*438*	*4,507*
2020.8.19 – 2021.8.18	*4,069*	*438*	*4,507*

a) $PE_{EC, y}$

<Table B-16> Calculation of $PE_{EC,y}$

Year	$EC_{PJ,grid,y}$	$EF_{CO2,CM,y}$	$(1+TDL_{grid,y})$	$PE_{EC,y}$
2014.8.19 – 2015.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2015.8.19 – 2016.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2016.8.19 – 2017.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2017.8.19 – 2018.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2018.8.19 – 2019.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2019.8.19 – 2020.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*
2020.8.19 – 2021.8.18	*7,224*	*0.5421*	*1.0392*	*4,069*

b) $PE_{FC, y}$

<Table B-17> Calculation of $PE_{FC,y}$

Year	$FC_{LNG,y}$	$NCV_{LNG,y}$	$EF_{CO2,LNG,y}$	$PE_{FC,y}$
2014.8.19 – 2015.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2015.8.19 – 2016.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2016.8.19 – 2017.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2017.8.19 – 2018.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2018.8.19 – 2019.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2019.8.19 – 2020.8.18	*200,505*	*0.03898*	*0.05610*	*438*
2020.8.19 – 2021.8.18	*200,505*	*0.03898*	*0.05610*	*438*

3. Leakage

No leakage effects need to be accounted under ACM0001(version 15).

4. Emission Reduction

Applying the ACM0001 Ver.15 and applicable methodical tools, ex-ante calculation of necessary parameters has been made above and emission reduction for the 2nd crediting period is presented in the following table.

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions(t CO_2e)
2014.8.19 – 2015.8.18	*182,330*	*4,507*	*0*	*177,823*
2015.8.19 – 2016.8.18	*182,067*	*4,507*	*0*	*177,560*
2016.8.19 – 2017.8.18	*182,000*	*4,507*	*0*	*177,493*
2017.8.19 – 2018.8.18	*182,110*	*4,507*	*0*	*177,603*
2018.8.19 – 2019.8.18	*182,395*	*4,507*	*0*	*177,888*
2019.8.19 – 2020.8.18	*182,790*	*4,507*	*0*	*178,283*
2020.8.19 – 2021.8.18	*183,315*	*4,507*	*0*	*178,808*
Total	*1,277,077*	*31,549*	*0*	*1,245,458*
Total number of crediting years	*7 years*			
Annual average over the crediting period	*182,430*	*4,507*	*0*	*177,923*

E.6. Remarks on increase in achieved emission reductions

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This monitoring report claims the emission reductions of 222,944 tCO_2eq which is larger than estimated emission reductions of 178,808 tCO_2eq from the registered PDD. It rose up 24.68 %. 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_{2eq})		Estimated CH_4 capture (tCO_{2eq})	Actual CH_4 capture (tCO_{2eq}, MD project)	Difference rate
	Baseline CH_4 (tCO_{2eq})	Effieciency			
2014.8.19 – 2015.8.18	*410,423*	*63.46%*	260,454	370,580	42.3%
2015.8.19 – 2016.8.18	*409,841*	*63.46%*	260,085	341,658	31.4%
2016.8.19 – 2017.8.18	*409,710*	*63.46%*	260,002	373,731	43.7%
2017.8.19 – 2018.8.18	*409,974*	*63.46%*	260,170	356,725	37.1%
2018.8.19 – 2019.8.18	*410,576*	*63.46%*	260,552	396,425	52.1%
2019.8.19 – 2020.8.18	*411,475*	*63.46%*	261,122	388,725	48.9%
2020.8.19 – 2021.8.18	*412,629*	*63.46%*	261,854	326,366	24.6%

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 Bangcheon-Ri landfill is one of the largest landfill in Korea and have been operating 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. Therefore, the efficiency value is conservative and end up to affecting these difference between the estimated and actual emission reductions.

<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

The Added flare stack operating after 2018 May

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 $Nm^3/hr \times 2$ 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 additional installed flare stacks complement the existing flare stacks, contributing to the increase in LFG capture.

Additional installation of sub-collection well (in 2020)

In order to secure the collection volume at the landfill site, more sub-collection wells are installed than at the time of project design. In September 2020, five additional LFG collection wells were installed to improve the total amount. Therefore, there are currently a total of 70 sub-collection wells, including 65 existing wells. As such, the steady maintenance of the landfill facility in Daegu Bangcheon-ri landfill not only contributes to the stable securing of LFG capture, but also has a positive effect on the landfill gas collection.

Rises in the total use of LFG compared to ex-ante calculation of $F_{CH4,PJ,y}$

Compared to ex-ante calculation of $F_{CH4,PJ,y}$, the amount of methane in the LFG used in the project activity during this monitoring period increased by 37.78% (3,957 tCH_4). This results in a significant difference between ex-ante and actual data.

The main factor that affects the increase in $F_{CH4,PJ,y}$ is the amount of LFG supplied to KDHC, which is monitored by FIQ-A. LFG supply from Daegu Bangcheon-ri landfill to KDHC was increased significantly during this monitoring period as shown by the increased reading from FIQ-A. This also indicates significant increase in the amount of methane in LFG supplied to KDHC.

In this monitoring period, the reasons for the surge are as follows:
The contract with Seongseo Incinerator, one of the suppliers of heat sources for KDHC, expired on December 31, 2018. After the expiry of the contract, new contract was signed on October 18, 2019. The new contract includes different terms on the heat supply, compared to the previous contract. Unlike the previous contract, the renewed contract states that “If surplus heat occurs, heat is supplied”. Consequently, the heat supply from the Seongseo Incinerator became a surplus heat sources to KDHC, rather than a main heat source.

In conclusion, the amount of heat supply from the Seongseo Incinerator was decreased as a result of renewed contract. In order to compensate the decreased heat supply from Seongseo Incinerator, KDHC received more supply from the Daegu Bangcheon-ri landfill. Therefore, the amount of LFG for the generation of heat energy in the Heat exchanger (FIQ-A) has been significantly increased during this monitoring period.

<Comparison of the value of $F_{CH4,PJ,y}$ between Ex-ante calculation and Actual data during the 10th monitoring period>

Data	Ex-ante calculation of $F_{CH4,PJ,y}$	Actual data of $F_{CH4,PJ,y}$
The amount of $F_{CH4,PJ,y}$ (tCH_4)	10,474	14,431
The amount of increase (tCH_4)		3,957
The rate of increase (%)		37.78%

E.7. Remarks on scale of small-scale project activity

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N/A

Document information

Version	*Date*	*Description*
08.0	6 April 2021	Revision to: • Reflect the "Clarification: Regulatory requirements under temporary measures for post-2020 cases" (CDM-EB109-A01-CLAR).
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
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).

Version	*Date*	*Description*
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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