Project design document form
(Version 10.1)

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

BASIC INFORMATION	
Title of the project activity	Daegu Bangcheon-Ri Landfill gas CDM Project (Ref.0851)
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	Version 13
Completion date of the PDD	30/03/2018
Project participants	Daegu Metropolitan City Daesung Eco-energy Co., Ltd. Korea District Heating Corporation Ecoeye Co., Ltd.
Host Party	Republic of Korea
Applied methodologies and standardized baselines	Methodology : ACM0001 Flaring or use of landfill gas (Ver. 15)
Sectoral scopes linked to the applied methodologies	Sectoral Scope 13: Waste Handling and Disposal
Estimated amount of annual average GHG emission reductions	177,923 tCO2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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Daegu Bangcheon-Ri Landfill gas CDM Project is located in 820, Dasa-Ro[1], Dasa-Eup, Dalsung-Gun, Daegu Metropolitan City, Korea. The total project area is 1,373,732 ㎡. The landfill site is 1,053,732 ㎡ including area of waste disposal, LFG utilization facility, road, afforestation and others. The area of the waste disposal is 853,400 ㎡[2], which was initially expanded from 585,334 ㎡, after legal approval of the local environmental authorities. Daegu Metropolitan City have a plan that the landfill will be operated until 2050.

The expected amount of MSW[3] till 2028 is as follows;

The expected amount of MWS at the landfill			
Year	Amount of MSW (ton/year)	Year	Amount of MSW (ton/year)
2014	448,841	2022	478,771
2015	452,637	2023	482,530
2016	456,323	2024	486,253
2017	460,083	2025	489,976
2018	463,806	2026	493,736
2019	467,565	2027	497,459
2020	471,288	2028	501,218
2021	475,011	Total	7,125,494 ton

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.

Following are the purpose of the project activity;

Daegu Bangcheon-Ri Landfill gas CDM Project:

- *changes the way of LFG treatment from simple incineration into improvement of capture efficiency and reuse as alternative energy;*
- *reduces adverse environmental impacts such as odour emission;*
- *prevents global warming by controlling methane emission to the atmosphere;*
- *reduces CO_2 emissions by altering usage of fossil fuel;*
- *creates financial benefit from CERs.*

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[1] Road name address was enacted on October 4, 2006 and is based on the road name address law that began to be enforced on April 5, 2007. The business, which assigns road names and building numbers, was started 1996 and completed in September 2010. Starting in 2014, only road name address will be used as legal addresses.

[2] The expansion of Daegu Bangcheon-Ri landfill was approved by Daegu environmental office in November 2006, which was prior the registration of the project as CDM.

[3] The source of the information is the feasibility study published by Daegu Metropolitan City in February 2006

The project activity contributes to sustainable development by following ways:

- To protect the environment, the project:
  - *traps major landfill gas, CH_4 and mitigation of climate change;*
  - *solves environmental problems in the vicinity of landfill site by reducing odor and danger of explosion;*
  - *reduces non-methane organic compound.*

- To replace fossil fuels, this project:
  - *transfers landfill gas into alternative energy;*
  - *activates economy/raise competitiveness for local development;*
  - *manages landfill gas and promotes initial settlement of the gas.*

- Socio-economic effect, this project:
  - *creates economic efficiency in the local area by selling medium quality gas;*
  - *brings positive reputation for Daegu Metropolitan City.*

A.2. Location of project activity

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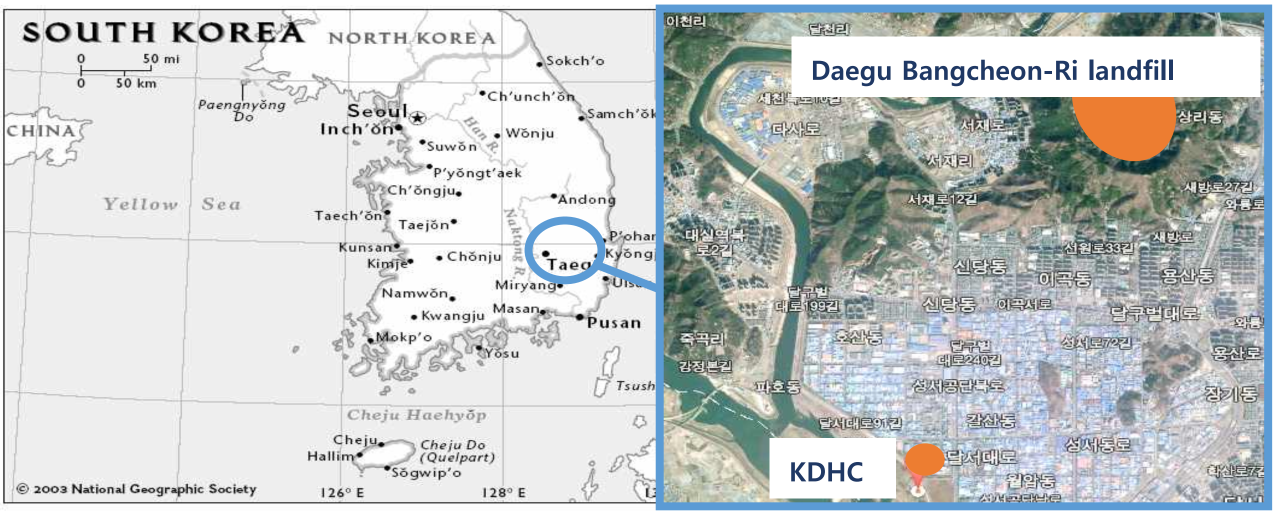
- Republic of Korea
- Daegu Metropolitan City
- Bangcheon-Ri, Dasa-Eup, Dalsung-Gun

Daegu Bangcheon-Ri Ladfill 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. The other project site is Korea District Heating Corporation(KDHC), which produces thermal energy by using LFG. KDHC is located at 351, Dalseo-daero, Dalseo-gu, Daegu Metropolitan city and the east longitude 128.4897, the north latitude 35.8312.



<Figure A-1> Location of Daegu Bangcheon-Ri Landfill site and KDHC

KDHC is about 8 km away from the Landfill, which is advantageous to utilize LFG geographically. For the project site location, refer to <Figure A-1> and <Figure A-2>.

<Figure A-2> Bird's-eye-view of Daegu Bangcheon-ri Landfill site

A.3. Technologies/measures

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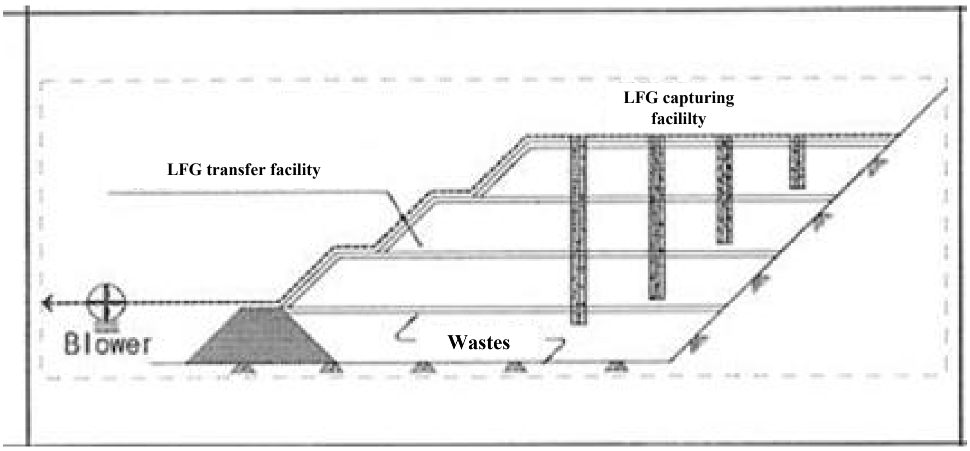
● LFG capturing system

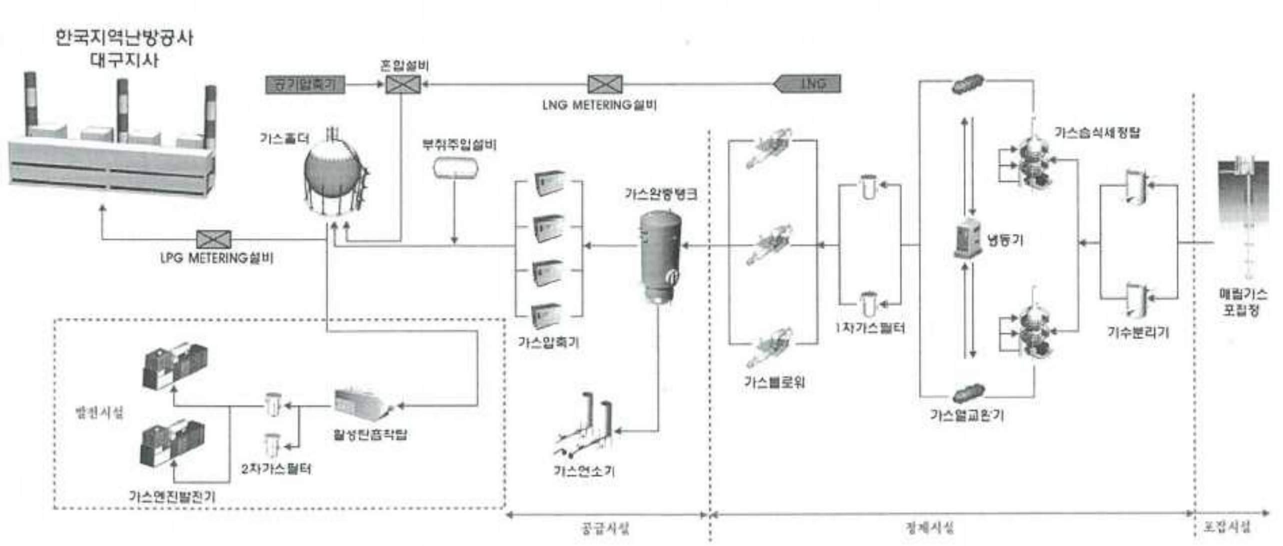
In order to capture LFG, vertical capturing pipes are installed for the project. The type of LFG capturing system is expected to enhance maintenance and LFG capturing efficiency because vertical capturing system has higher capturing efficiency and is easier to maintain and repair system compared to the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



<Figure A-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 A-4> LFG utilization system flow chart

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.

► Blower

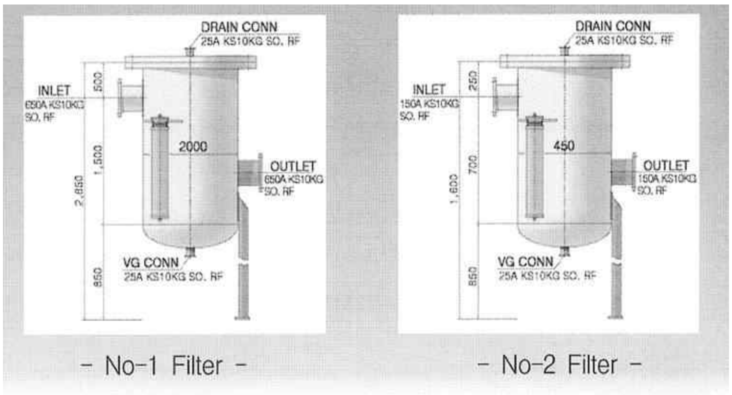
Blower is available to adjust LFG capturing pressure and delivery LFG into Buffer tank. Blower type is turbo type, which keeps consistent pressure and has a remarkable efficiency. Three Blowers are installed in a project site and one of them is a spare for an emergency situation.

<Figure A-5> Blower

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

► Filter

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



<Figure A-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

► Scrubber

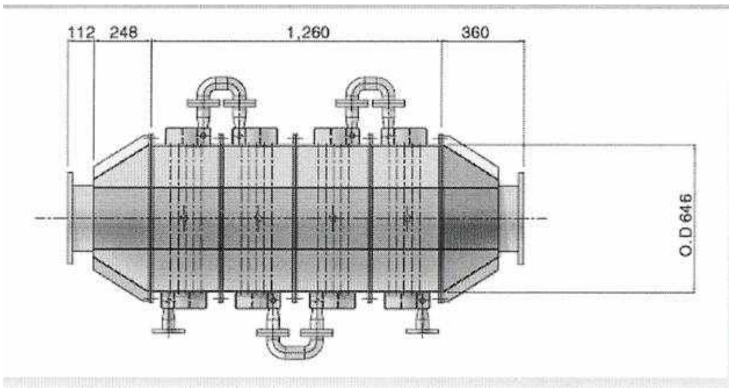
Scrubber removes acid gas (H_2S, NH_3 etc.) from LFG using solubility, so that the problem of erosion of the facility and pollutant emissions can be reduced.

<Figure A-7> Scrubber

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

► Cooler

Cooler removes moisture in LFG, so that caloric value of the gas rises and trouble cause for the facility can be removed.



<Figure A-8> Cooler

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

► Chiller

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

<Figure A-9> Chiller

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

► Gas Engine

Gas Engine generates electricity which used for the internal use.

<Figure A-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)

► 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 A-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)

► 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 A-12> Gas storage tank

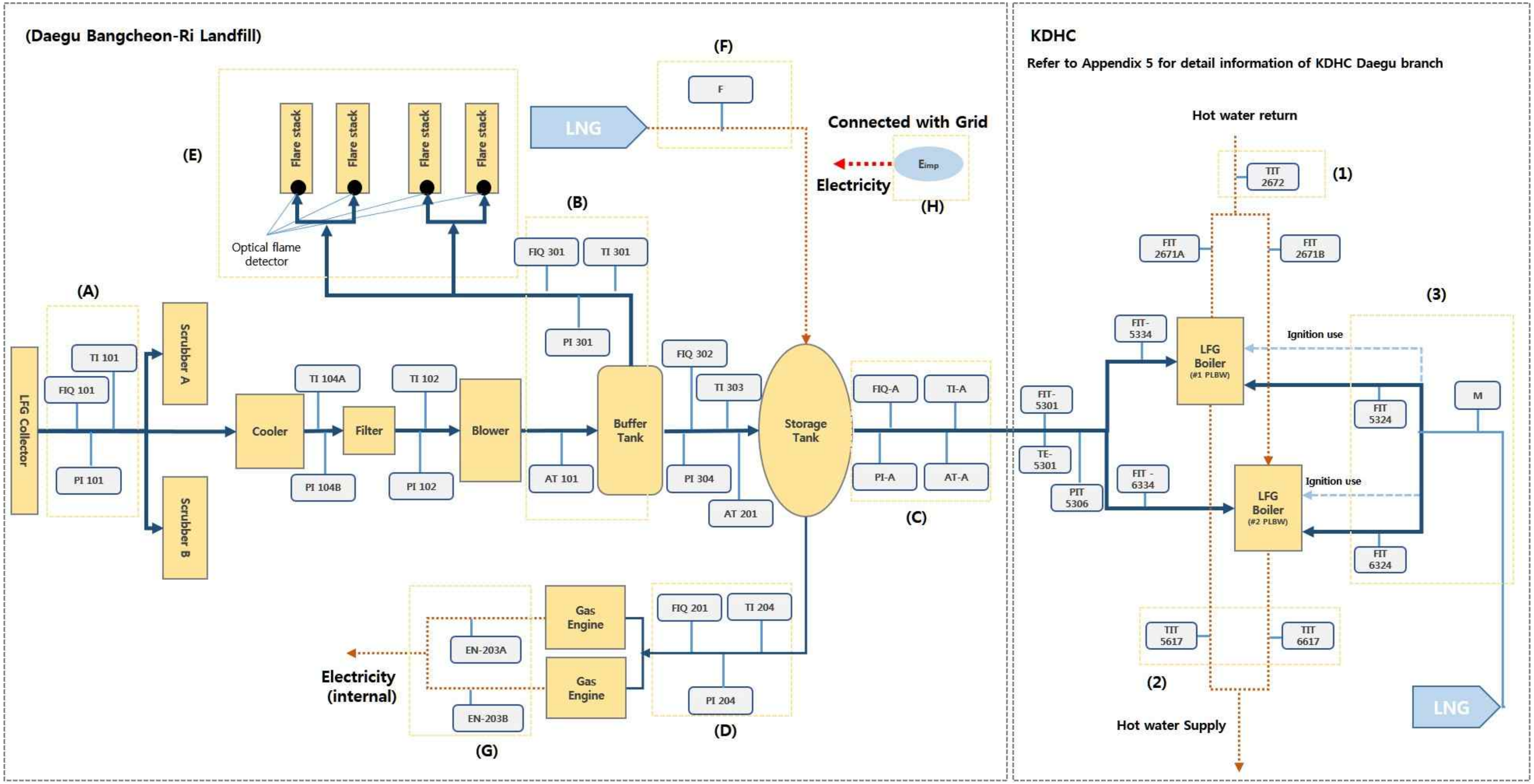
Equipment	BALL TANK
No. of Equipment	T-3-05 (1unit)
Type	Globular type

► 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

● Location of monitoring equipment
Monitoring equipment is composed of Flow meters, Manometer, thermometers, etc. Location of monitoring equipment is presented as follows.



<Figure A-13> Diagram of monitoring points

<table>
<tr><td rowspan="27">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.

A.4. 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 Party)	▪ Public entity: Daegu Metropolitan City (Project developer) ▪ Private Entity: Daesung Eco-energy Co., Ltd. (Project executor) ▪ Public Entity: Korea District Heating Corporation (Project executor) ▪ Private Entity: Ecoeye Co., Ltd. (Project consultant)	No

A.5. Public funding of project activity

>>

This CDM project has not been funded by official development assistance or other sources counted towards the financial obligations of Parties included in Annex I.

A.6. History of project activity

>>

The CDM project(Ref.0851) was registered in 19 Aug 2007 and is now on Renewal crediting period which approved in 17 Sep 2016.

<table>
<tr><th></th><th>(a)</th><th>(b)</th></tr>
<tr><td rowspan="2">1.Confirmation</td><td>The proposed CDM project activity is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA);</td><td>The proposed CDM project activity is not a project activity that has been deregistered.</td></tr>
<tr><td colspan="2">The CDM project(Ref. 0851)registered in 19 Aug 2007 is now on 2^{nd} crediting period. The CDM project is not linked to other CDM project.</td></tr>
<tr><td rowspan="2">2. Declaration</td><td>The proposed CDM project activity is not a project activity that has been deregistered.</td><td>A registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired (hereinafter referred to as former project) exists in the same geographical location as the proposed CDM project activity.</td></tr>
<tr><td colspan="2">The CDM project(Ref. 0851)registered in 19 Aug 2007 is now on 2^{nd} crediting period. The second crediting period is from 19 Aug 2014 to 18 Aug 2021. The CDM project is not linked to other CDM project.</td></tr>
</table>

A.7. Debundling

>>
Not applicable

SECTION B. Application of selected methodologies and standardized baselines

B.1. Reference to methodologies and standardized baselines

>>
ACM0001 Ver. 15 “Flaring or use of landfill gas”, has been applied to this project.

The other methodological tools applied along with the methodology are:

- “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”(Ver.02)
- “Emissions from solid waste disposal sites” (Ver.06.0.1)
- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (Ver.01)
- “Tool to calculate the emission factor for an electricity system” (Ver.04.0.0)
- “Project emissions from flaring” (Ver.02.0.0)
- “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Ver.02.0.0)
- “Combined tool to identify the baseline scenario and demonstrate additionality” (Ver.05.0.0)

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

B.2. Applicability of methodologies and standardized baselines

>>
There are some updates on ACM0001 methodology. The project was originally registered under methodology ACM0001(Ver. 5) “Consolidated baseline methodology for landfill gas project activities”. The latest approved version of the baseline and monitoring methodology applied in this CDM-PDD is ACM0001(Ver. 15) “Flaring or use of landfill gas”.

The project activity meets following applicability conditions of the latest version methodology;

Methodological requirements		Justification
This methodology is applicable to the project activities which		
A	Install a new LFG capture system in a new or existing SWDS where no LFG capture system was installed prior to the implementation of the project activity; or	LFG was treated by simple flaring system prior to the implementation of the project activity. The simple flaring system prevented odor and safety for resident. Therefore A is not applicable.

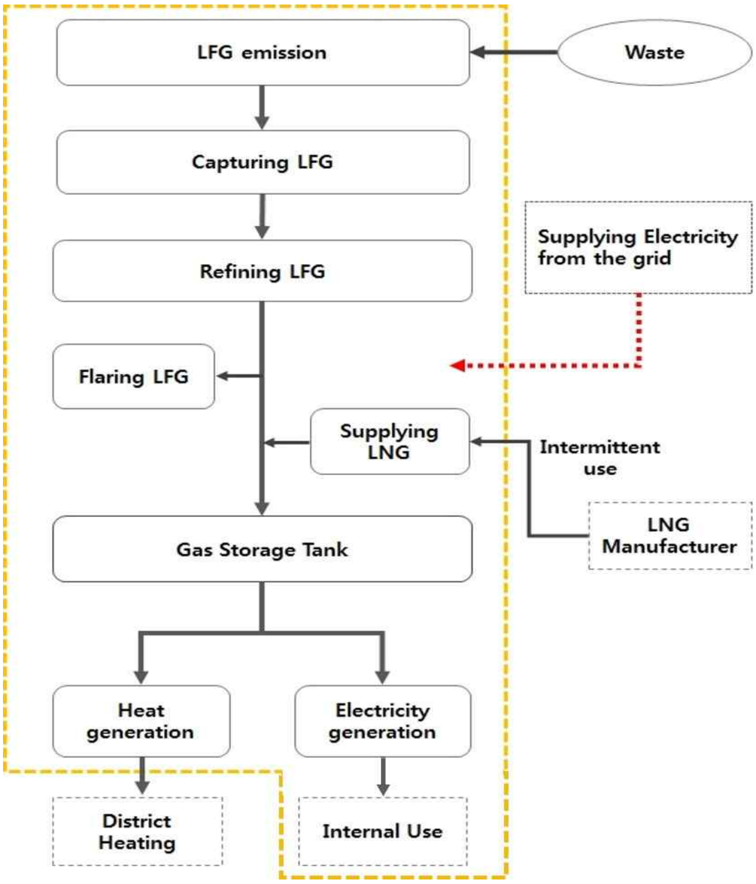
B	Make an investment into an existing LFG capture system to increase the recovery rate or change the use of the captured LFG, provided that: i) The captured LFG was vented or flared and not used prior to the implementation of the project activity; and ii) In the case of an existing active LFG capture system for which the amount of LFG cannot be collected separately from the project system after the implementation of the project activity and its efficiency is not impacted on by the project system: historical data on the amount of LFG capture and flared is available.	This project introduces the efficient LFG capture system instead of existing LFG capture system. An existing capture part(i.e. LFG collection well) is reused for enhancing LFG capture efficiency. i) A significant amount of LFG from the landfill was released to atmosphere and not used even though the LFG is captured partially and combusted the simple flaring system. ii) Existing simple flaring system was one of the passive capture system. Therefore B is applicable.
C	Flare the LFG and/ or use the captured LFG in any (combination) of the following ways: i) Generation electricity; ii) Generating heat in a boiler, air heater or kiln (brick fire only) or glass melting furnace; and/or (iii) Supplying the LFG to consumers through a natural gas distribution network; (iv) Supplying compressed/liquefied LFG to consumers using trucks;	The captured LFG will be flared and be used for; i) Electricity generation; ii) Producing heat by using LFG at boilers and supplying thermal energy to end users. Hence this version of methodology is applicable. However, these emission reduction aren't claimed for 2nd crediting period.
D	Do not reduce the amount of organic waste that would be recycled in an absence of the project activity.	The project activity does not imply any change in the waste received at the landfill. Therefore D is satisfied.
The methodology is only applicable if the application of the procedure to identify the baseline scenario confirms that the most plausible baseline scenario is:		
A	Atmospheric release of the LFG or capture of LFG and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons; and	The most plausible baseline scenario is the atmospheric release of the significant LFG even though simple flaring system was installed for safety and odour problem as complied with environment regulation. Hence, it is applicable.
B	In the case that the LFG is used in the project activity for generating electricity and/or generating heat in a boiler, air heater, glass melting furnace or kiln; i) For electricity generation: that electricity would be generated in the grid or in captive fossil fuel fired power plant and/ or ii) For heat generation: that heat would be generated using fossil fuels in equipment located within the project boundary.	i) Electricity is supplied from the grid for internal use. ii) Oil boiler works and produces the heat using Residual fuel(i.e. B-C oil). So the methodology is applicable. However, these emission reduction aren't claimed for 2nd crediting period. There is no change on baseline scenario between 1st and 2nd crediting period.

This methodology is not applicable in the following:		
A	In combination with other approved methodologies. For instance, ACM0001 cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the CDM project activity is to implement energy efficiency measures at a kiln or glass melting furnace;	No other approved methodology is applied.
B	If the management of the SWDS in the project activity is deliberately changed during the crediting in order to increase methane generation compared to the situation prior to the implementation of the project activity.	The project implementers have no intention to change the management of the SWDS in the project activity to increase the methane generation over the project life cycle.

B.3. Project boundary, sources and greenhouse gases (GHGs)

>>

The project boundary includes capturing, flaring LFG and utilizing captured LFG to generate electricity for in-house consumption and to produce thermal energy. Methane(CH_4) in LFG is destroyed by flaring at the incinerator, generating electricity at the gas engine and producing heat at the boilers.



<Figure B-1> Boundary of the Project

Source		GHG	Included?	Justification/Explanation
Baseline	Emissions from decomposition of waste at the SWDS site	CO_2	No	CO_2 emissions from the decomposition of organic waste are not accounted, even though CO_2 is also released under the project activity.
		CH_4	Yes	Methane is the major source of the emissions in the baseline.
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
	Emissions from electricity generation	CO_2	No	There is a major emission source. Its emission reductions caused by displacing energy from other sources are not claimed.
		CH_4	No	There is a minor emission source. Its emission reductions caused by displacing energy from other sources are not claimed.
		N_2O	No	There is a minor emission source. Its emission reductions caused by displacing energy from other sources are not claimed.
	Emissions from heat generation	CO_2	No	There is a major emission source. Its emission reductions caused by displacing energy from other source are not claimed.
		CH_4	No	There is a minor emission source. Its emission reductions caused by displacing energy from other sources are not claimed.
		N_2O	No	There is a minor emission source. Its emission reductions caused by displacing energy from other sources are not claimed.
	Emission from the use of natural gas	CO_2	No	Not applicable as there is no use of natural gas
		CH_4	No	Not applicable as there is no use of natural gas
		N_2O	No	Not applicable as there is no use of natural gas
Project activity	Emission from fossil fuel consumption for purpose other than electricity generation or transportation due to the project activity	CO_2	Yes	It is an important emission source.
		CH_4	No	Excluded for simplification. This is an emission source assumed to be very small
		N_2O	No	Excluded for simplification. This is an emission source assumed to be very small
	Emissions from electricity consumption due to the project activity	CO_2	Yes	In case there is a shortage of electricity in the project for operation, electricity from the grid will be used and CO_2 emission from the grid will be accounted as the project emissions.
		CH_4	No	Excluded for simplification. This is an emissions source assumed to be very small.
		N_2O	No	Excluded for simplification. This is an emission source assumed to be very small.
	Emission from flaring	CO_2	No	Emissions are considered negligible
		CH_4	Yes	It is a major emission source due to an incomplete combustion at the open type flaring system.
		N_2O	No	Emissions are considered negligible
	Emission from distribution of LFG using trucks	CO_2	No	Not applicable as there is no distribution of LNG by truck
		CH_4	No	Not applicable as there is no distribution of LNG by truck

Source		GHG	Included?	Justification/Explanation
		N_2O	No	Not applicable as there is no distribution of LNG by truck

B.4. Establishment and description of baseline scenario

>>

The baseline scenario of the first crediting period is that LFG was treated by a simple flaring system prior to the project activity. Although some of the LFG were treated by the flaring system, the significant amount of LFG is released into the atmosphere.

According to "CDM project standard" (Ver. 07.0), the project for renewal of the crediting period requires validation whether the original project baseline is still valid or has been updated taking into account the new data.

The validity of the original baseline is assessed as the tool "Assessment of the validity of the original/current baseline and update the baseline at the renewal of a crediting period" (Ver. 03.0.1).

First up, an assessment of the impact of new relevant national and/or sectoral policies and circumstances on the baseline is carried out at the time of requesting a renewal of crediting period. When the current baseline is needed to update, the current baseline is updated and new parameters are added.

The validity of the current baseline of the registered CDM project activity is assessed using the following Steps:

Step 1: Assess the validity of the current baseline for the next crediting period

Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies

In order to determine whether or not this baseline scenario still complies with all relevant mandatory national and/or sectoral policies, which has come into effect since validation, an examination must be conducted in order to determine whether or not any current regulations require the landfill to capture and destroy more amount of LFG or any additional mitigation activities.

The baseline scenario is that a significant amount of LFG generated at the Daegu Bancheon-Ri landfill was released to atmosphere even though the LFG is captured partially and combusted by the simple flaring system.

According to the article 7 on "Enforcement decree of the wastes control Act[4]", a landfill has facilities for gas incineration(such as simple burning system)or power generation and fuel-making are required in order to prevent surrounding environment problem(e.g. air pollution, odour, etc.). However, the regulation does not specify the amount of the LFG flared and captured, efficiency and specification of relevant equipment.

Current baseline complies with the all the relevant mandatory national policy because there is no regulatory changes regarding the relevant LFG treatment after CDM registration. Therefore, current baseline complies with all relevant mandatory national policies.

[4] The relevant regulation can refer to

http://www.law.go.kr/lsSc.do?menuId=0&p1=&subMenu=1&nwYn=1&query=%ED%8F%90%EA%B8%B0%EB%AC%BC%EA%B4%80%EB%A6%AC%EB%B2%95&x=0&y=0#liBgcolor5

As for a post registration changes which is an addition of component or extension of technology(i.e. adding two flare stacks), there is no effect on assessment for compliance of the current baseline with relevant mandatory national and/or sectoral policies due to the PRC.

Step 1.2 Assess the impact of circumstances

There are some changes on ACM0001 methodology. According to the original PDD, project activity is captured LFG, generates electricity and produces heat by using LFG, but emission reduction for electricity and heat generation was not claimed due to an application limitation of ACM 0001 methodology(Ver. 5).

Although the latest ACM0001 methodology(Ver. 15) applied on the renewal PDD could cover emission reduction of heat and electricity generation, baseline scenario of heat and electricity generation for 2nd crediting period will not be considered consistently like 1st crediting period.

As "Assessment of the validity of the original/current baseline and update the baseline at the renewal of a crediting period(Version 03.0.1)", it required an assessment of the impact of existing circumstances for renewal of the crediting period on the current baseline emissions without reassessing the baseline scenario.

As for a post registration changes which is an addition of component or extension of technology(i.e. adding two flare stacks), there is no effect on assessment for the existing impact of circumstances due to the PRC.

Consequently, the original baseline scenario for 1st crediting period is not reassessed, the original baseline scenario is still valid for 2nd crediting period.

Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which is requested.

All equipment for the project activity were installed newly and will be kept for the renewal crediting period. Remaining technical lifetime of all equipment still cover for second crediting period.

As for a post registration changes which is an addition of component or extension of technology(i.e. adding two flare stacks), the newly installed LFG flare stacks in 2018 cover for the 2nd crediting period(2014 ~ 2021).

Step 1.4: Assessment for the validity of the data and parameters

There are differences of methodological approaches, which are applicable. It should be considered as ex-ante determined parameter, other default values and assumptions between ACM0001 Version 5 and 15.

For this reason, other data and ex-ante determined parameters, other default values are applied for estimation of baseline emissions during the 2nd crediting period. Thus, some of data and parameters are displaced and newly added.

The baseline emission, ex-ante determined parameter and monitored parameters for the 2nd crediting period are presented and justified in the following Step 2.

Step 2: Updates the current baseline and the data and parameters

Step 2.1: Update the current baseline

There are no updates on current baseline because the original baseline scenario is still valid for 2nd crediting period.

As for a post registration changes which is an addition of component or extension of technology(i.e. adding two flare stacks), there is no effect on current baseline.

Step 2.2: Update the data and parameters

There are some changes in default value of some parameters and some new parameters are added due to the emission reduction calculation procedures and used algorithms. IPCC has updated the value of global warming potential of Methane (GWP_{CH4}) and the new value should be used for the 2nd crediting period. CO_2 emissions intensity of the electricity imported (currently known as grid emission factor) will be calculated based on the historical data available. New values based on the recent version of applicable tools and methodology will be added and the same values will be used for this crediting period.

For the purpose of the ex-ante emission reductions calculation, in the original registered PDD, a modified version of the US EPA First Order of Decay Model was used to calculate the methane destruction by the project. However, in the revised PDD for the 2nd crediting period, as per ACM0001(ver. 15), the methane generation from the landfill in the absence of the project activity ($BE_{CH4, SWDS,y}$) is calculated as instructed in the "Emissions from solid waste disposal sites (Ver. 06.0.1)". Baseline emission from the flaring of LFG is calculated in accordance with the methodological tool "Project emissions from flaring".

As the latest ACM0001 Ver.15 and related methodological tool is applied for the 2nd credit period, all applicable parameter(including the PRC which adding two flare stacks) are presented in Section B.6.1., B.6.2. and B.7.1.

B.5. Demonstration of additionality

>>
The baseline is determined as follows together with the "tools for the demonstration and assessment of additionality(version 3)".

During the 2nd crediting period, there is a post registration changes which is an addition of component or extension of technology(i.e. adding two flare stacks). There is no significant change on the baseline scenario and the additionality for the 2nd crediting period. On Step 2, the additionality for the change will be demonstrated by using the original economical data.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a. Define alternatives to the project activity:
The following alternative scenarios are assessed to determine which of the scenarios is plausible to occur in the absence of the project (baseline scenario).

<u>Scenario 1 : Maintain the status quo.</u> The previous status has been continued when this project was not existed. Prior to this project, LFG was flared by simple burning system.

<u>Scenario 2 : This project not undertaken as a CDM project activity.</u> LFG is captured compulsory and flared through vertical captured pipe and horizontal captured pipe. Additionally, thermal energy is produced from LFG and produced thermal energy is provided to users.

<u>Scenario 3 : The project activity that deliver outputs and on services with comparable quality.</u> This project treats LFG and reduces greenhouse gas emission. From the point of treating LFG, LFG incinerator can be considered as alternative which provides similar service, treating LFG. The activity which captures LFG and incinerates it using an incinerator also reduces CH_4 emission. However, it does not give positive influence to the environment more than reducing CH_4 emission. Also, the project participant can not make profit under this alternative.

Considering one of the policies of Daegu Metropolitan City, 'making green city', and other advantages, the project participant chose this project which reduces greenhouse gas emission and

also influences the reduction of fossil fuel use by utilizing LFG as energy rather than other alternatives.

Sub-step 1b : Enforcement of applicable laws and regulations :
Each of the above three scenarios complies with Korean laws and regulatory requirements.

Step 2. Investment Analysis

GHG emission activity occurs in Daegu Bangcheon-Ri landfill site and Korea District Heating Corp. by capturing LFG, utilizing LFG and producing thermal energy using LFG. However, emission reductions caused by displacing energy from other sources are not claimed in this project.

Therefore, the boundary of investment analysis for this project is Daegu Bangcheon-Ri landfill site and income from sale of the refined LFG to Korea District Heating Corporation is included. In the post registration change, there is no revenue for this change, construction cost for installation of the two type flare stacks and O&M cost were only reflected on original economic analysis data.

Sub-step 2a. Determine appropriate analysis method

The CDM project contains income(from sale of the refined LFG) other than CERs. Therefore, Option I (Apply simple cost analysis) can not be selected, so it is necessary to choose from either Option II (Apply Investment comparison analysis) or Option III (Apply benchmark analysis). According to the methodology for determination of additionality, if the alternative to the CDM project activity does not include investments of comparable scale to the project, then Option III must be used. Option III will be applied for this project.

Sub-step 2b.-Option III. Apply benchmarking Analysis

IRR(Internal Rate of Return) is selected for the economic analysis indicator. IRR is the discount rate which makes that present value of income and present value of outcome are same. IRR can be compared to government bond rates increased by risk premium, required rate of return (RRR) on equity etc. to evaluate financial attractiveness of the project.

In this project, calculated IRR of the project is compared to 3 year term government bond rates increased by risk premium. Considering that the project executor (DaeDaesung Eco-Energy Co., Ltd.) and the project developer (Daegu Metropolitan city) concluded an revised agreement for details of the project in 2005, applied government bond rate for investment analysis of the project was the average 3 year term government bond rate in 2004~2005 and the value is 4.2%.

Additionally, risk premium was substantiated by an accountant, independent financial expert. Considering the level of rate of return by SOC(Social Overhead Capital) project in Korea, the level of rate of return by environment related projects and the level of rate of return of the similar project to Daegu Bangcheon-Ri landfill gas utilization project, substantiated risk premium is 2.8%~3.8%.

Therefore, in this project, benchmark can be 7.0% which is the sum of average 3 year term government bond rate in 2004~2005 and the minimum value of risk premium, 2.8%, as conservative manner and IRR is compared to 7.0% benchmark.

Sub-step 2c. Calculation and comparison of financial indicator
-Calculation : The process for calculating IRR(Internal Rate of Return) is followed.

<Table B-1> Process for economic analysis

Used values for economic analysis		
Content	Value	Remarks
Analysis period (years)	23	Construction period and expected project activity period
Construction period	2005.5~2006.10 2009.7~2009.9	
Unit cost of LFG purchase(won/m3)	Depends on each year	Source : Unit cost of LFG purchase applied to financial analysis for the project

Details of economic analysis implementation												
Year / Content	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Construction cost (million Won)	-	15,145	2,602	-	-	2,226	-	-	-	-	-	-
New installation for LFG flaring stock (million Won)	-	-	-	-	-	-	-	-	-	-	-	-
Other investment cost (except construction cost) (million Won)	231	200	-	-	-	55	-	-	-	-	-	-
Operation & Maintenance cost (million Won)	-	-	480	1,270	1,272	1,620	1,360	1,927	1,539	2,507	1,834	1,868
Other expenses (million Won)	60	997	660	417	401	501	370	356	344	330	317	305
Corporation tax (million Won)	-	-	-	739	740	8	754	599	704	430	611	597
Amount of sold LFG (10^3m3)	-	-	12,982	50,691	50,886	52,010	52,855	53,070	53,239	53,093	53,093	53,093
Income of LFG purchase (million Won)	-	-	1,128	4,376	4,363	4,429	4,471	4,459	4,443	4,401	4,372	4,343

Year / Content	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Construction cost (million Won)	-	-	-	-	-	-	-	-	-	-	-
New installation for LFG flaring stock (million Won)	-	-	566	-	-	-	-	-	-	-	-
Other investment cost (except construction cost) (million Won)	-	-	-	-	-	-	-	-	-	-	-
Operation & Maintenance cost (million Won)	2,624	1,273	1,454	1,641	1,276	1,725	1,97	1,548	1,540	1,274	1,758
Other expenses(million Won)	294	285	274	264	254	245	240	231	222	214	155
Corporation tax(million Won)	387	750	539	639	737	605	662	642	642	707	303
Amount of sold LFG (10^3m3)	53,239	53,093	53,093	53,093	53,239	53,093	53,093	53,093	53,239	53,093	39,711
Income of LFG purchase (million Won)	4,325	4,285	4,255	4,227	4,210	4,170	4,142	4,115	4,098	4,060	3,016

Outcome		
Content	Value	Remarks
Cash outflow (Current value)	43,058,226,959	Accumulated from 2004 to 2026
Cash inflow (Current value)	38,947,294,252	Accumulated from 2004 to 2026
IRR (%)	4.579%	

*Economic analysis detail calculation contents will be submitted to DOE as an excel file
*Construction period above means the construction period of LFG utilization facility

-comparison of indicator : Result of comparing benchmark 7.0% is followed.

<Table B-2> Result of economic analysis

	IRR of the Project excluding CER income	Benchmark
Result (%)	4.579	7.0

Based on result of analysis, IRR of the Project is 4.579% which is lower than benchmark value 7.0%. Therefore, this project cannot be considered financially attractive.

Sub-step 2d. Sensitivity Analysis

Sensitivity analysis is performed as followed parameter variables
- +5% ; Growth of benefit (Increasing unit cost of thermal energy purchase)
- -5% ; Decrease total cost of construction
- -5% ; Decrease O&M cost

Above parameters choose high variable values and chosen parameters analyse the result which is IRR with increased or decreased value.

<Table B-3> Result of sensitivity analysis

Scenario	IRR (%)
Standard	4.579
+5% ; Growth of benefit (Increasing unit cost of LFG purchase)	5.631
-5% ; Decrease total cost of construction	5.116
-5% ; Decrease O&M cost	4.898

As a result of analysing, the result is lower than benchmark (7.0%). Therefore, this project is not available for commercial purpose. The purpose of this project is only for CDM which prevent global warming.

Step 3. Barrier analysis

Step 3 is skipped.

Step 4. Common practice analysis

Sub-step 4a. Analyse other activities similar to the proposed activity

Total number of landfill site is 238 all over the country in Korea. Because of high investment cost, only 7 sites utilize LFG for generating electricity or producing thermal energy (Source : Ministry of Environment of Korea 2004). 6 of those 7 sites generate electricity utilizing LFG and 1 site, Ulsan Seongam landfill site, utilizes LFG for producing thermal energy for internal use or selling Medium Energy Content Gas from refined LFG like Daegu Bangcheon-Ri landfill site which utilizes LFG for producing thermal energy. Also, considering that only 7 sites out of 238 landfill sites (about 3%) utilize LFG for generating and that 7 sites which utilize LFG developed the project through CDM project, it can be known that LFG utilization project including this project is not common in Korea.

<Table B-4> Landfill gas utilizing status in 2004

Landfill name	Province	Capacity (m3)	Total size of landfill (m2)
Sudokwon	Gyeyang-gu, Incheon	240,000,000	19,582,000
Busan, Sanggok	Busan	24,493,000	758,342
Unjeong-dong	Buk-gu, Gwang ju	4,369,000	261,898
Ulsan, Seongam	Nam-gu, Ulsan	4,255,000	142,663

Gunsan	Jeonbuk	2,562,000	278,000
Daejeon Keumgo-dong	Daejeon	8,762,000	602,429
Hwoicheon	Jeju	2,404,000	203,320
Daegu Bangcheon-Ri	Dalsung-gun, Daegu	9,224,941	585,334

(Source : National landfill statistic in 2004, Ministry of Environment)

Sub-step 4b : Discuss any similar options that are occurring

Most of Korean landfill is currently just flaring LFG. Only a few landfills utilize LFG because of high cost. Even though Daegu city prefer utilizing LFG to using other fossil fuel, it is not compulsory. Therefore, without generating CERs, utilizing LFG and producing thermal energy hardly occur in Daegu Bangcheon-Ri landfill site. Just flaring LFG does not violate Korean law.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

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ACM0001(Ver. 15) and applicable tools are used to calculate the emission reductions. The captured LFG will be used to generate energy (heat and electricity) in replacement of fossil fuel.

Baseline emissions
Baseline emissions are determined according to equation (1) and comprised the following sources:

(a) Methane emissions from the SWDS in the absence of the project activity;
(b) Electricity generation using fossil fuels or supplied by the grid in the absence of the project activity;
(c) Heat generation using fossil fuels in the absence of the project activity; and
(d) Natural gas used from the natural gas network in the absence of the project activity.

$$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y} \quad (1)$$

Where:

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

The project activity also produces heat and power generation by using LFG. LFG captured is sent to KDHC(Korea District Heating Corporation) for heat generation. However baseline scenario for the project activity do not include its heat and power generation so that $BE_{EC,y}$ *and* $BE_{HG,y}$ = 0. The Project does not sent LFG to the natural gas distribution network. Hence and $BE_{NG,y}$= 0. In such condition equation (1) could be simplified in the following form.

$$BE_y = BE_{CH4,y} \quad (2)$$

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

Baseline emissions of methane from the SWDS are determined as follows, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as due to regulations). In addition, the effect of methane oxidation that is present in the baseline and absent in the project is taken into account:

$$BE_{CH4,y} = \left((1-OX_{top\_layer}) \times F_{CH4,PJ,y} - F_{CH4,BL,y}\right) \times GWP_{CH4} \quad (3)$$

Where:

$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/yr)
OX_{top_layer}	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/tCH_4)

Step (A.1): Ex post determination of $F_{CH4,PJ,y}$

During the crediting period, $F_{CH4,PJ,y}$ is determined as the sum of the quantities of methane flared and used in power plant(s), boiler(s), air heater(s), kiln(s) and natural gas distribution network, as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} + F_{CH4,NG,y} \quad (4)$$

Where:

$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is destroyed by flaring in year *y* (t CH_4/yr)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/yr)
$F_{CH4,HG,y}$	=	Amount of methane in the LFG which is used for heat generation in year *y* (t CH_4/yr)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG which is sent to the natural gas distribution network in year *y* (t CH_4/yr)

As the proposed Project Activity has not involved in natural gas generation, $F_{CH4,NG,y}$= 0. The equation (4) could be simplified as equation (5) bellow;

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + F_{CH4,HG,y} \quad (5)$$

The operation of the power plant, boiler and the flare should be monitored and no emission reduction should be claimed for methane destruction during non-working hours. This is taken into account by monitoring the hours that the equipment utilizing the LFG is operating in the year y ($OP_{j,h,y}$).

Amount of methane destroyed by power plant and boiler ($F_{CH4,EL,y}$, $F_{CH4,HG,y}$)

$F_{CH4,EL,y}$ and $F_{CH4,HG,y}$ are determined using the "*Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Ver. 02.0.0)".*

<Table B-5> : Measurement options

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

Option A from Table B-5 (measurement options) of the above tool is applied, that is, the volume flow is on a dry basis, and volumetric fraction is on a wet/dry basis. Absolute humidity is not calculated, as the gaseous stream is considered dry, which will be demonstrated by a gas temperature of less than 60°C (333.15 K) at the flow measurement point[5].

As per Option A, the mass flow of greenhouse gas *i* (methane) is determined as follows:

$$F_{CH4,t} = V_{t,db} \times v_{CH4,t,db} \times \rho_{CH4,t} \quad (6)$$

Where:

$F_{CH4,t}$	=	Mass flow of CH_4 in the LFG in the gaseous stream (here used for electricity & heat generation) in time interval t (t CH_4/h)
$V_{t,db}$	=	Volumetric flow of the LFG (used for electricity and heat generation) in time interval t on a dry basis (m³ dry LFG/h)
$v_{CH4,t,db}$	=	Volumetric fraction of CH_4 in the LFG in time interval t on a dry basis (m³ CH_4/m³ dry LFG)
$\rho_{CH4,t}$	=	Density of CH_4 in time interval t (tCH_4/m^3 CH_4)

Equation (6) will be separately used to calculate mass flow of CH_4 in the LFG stream for electricity generation and heat generation and they are then summed up. The mass flow calculated for hour h is 0 if the equipment is not working in hour h ($Op_{j,h}$ = not working), the hourly values are then summed to a yearly unit basis ($Op_{j,h,y}$)

According to the tool, density of greenhouse gas *i* (here methane) in the gaseous stream in time interval t can be calculated using following formula.

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad (7)$$

Where:

$\rho_{i,t}$	=	Density of greenhouse gas *i* in the gaseous stream in time interval t (kg gas *i* / m^3 gas *i*)
P_t	=	Absolute pressure of the gaseous stream in time interval *t* (Pa)
MM_i	=	Molecular mass of greenhouse gas *i* (kg/kmol)
R_u	=	Universal ideal gases constant (Pa.m^3/kmol.K)
T_t	=	Temperature of the gaseous stream in time interval *t* (K)

Because of gas volumes in normalized cubic meter, gas volumes and density of methane in normal condition are applied directly for this project.

[5] Option A of "Tool to determine the mass flow of a greenhouse gas in a gaseous stream*(Ver. 02.0.0)*" :

Flow measurement on dry basis is not doable for a wet gaseous stream. If the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) is less than or equal to 0.05kgH_2O/m^3 dry gas or the temperature of the gaseous stream(T_t) is less than 60°C which is demonstrated that the gaseous stream is dry.

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

$F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare and any methane emissions from the flare, as follows:

$$F_{CH4,flared,y} = F_{CH4,sent\_flare,y} - PE_{flare,y} / GWP_{CH4} \quad (8)$$

Where:

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

(1) $F_{CH4,sent,flare,y}$

$F_{CH4,sent\_flare,y}$ is determined directly using the "*Tool to determine the mass flow of a greenhouse gas in a gaseous stream(Ver. 02.0.0)*".

As per Option A, the mass flow of greenhouse gas *i* (methane) is determined as follows:

$$F_{CH4,sent\_flare,t} = V_{flare,t,db} \times v_{CH4,t,db} \times \rho_{CH4,t} \quad (9)$$

Where:

$F_{CH4,sent\_flare,t}$	=	Mass flow of CH_4 in the LFG which is sent to flare in time interval t (t CH_4/h)
$V_{flare,t,db}$	=	Volumetric flow of the LFG which is destroyed by flaring in time interval t on a dry basis (m^3 dry LFG/h)
$v_{CH4,t,db}$	=	Volumetric fraction of CH_4 in the LFG in time interval t on a dry basis (m^3 CH_4/m^3 dry LFG)
$\rho_{CH4,t}$	=	Density of CH_4 in time interval t (tCH_4/m^3 CH_4)

Because of gas volumes in normalized cubic meter, gas volumes and density of methane in normal condition are applied for this project.

(2) $PE_{flare,y}$

This project operates two enclosed flaring stacks installed in 2018 and two existing open flaring stacks. These flare stacks have handled with the captured LFG when heat demands are low in summer season. Project emissions from flaring of the residual gas stream in year y($PE_{flare,y}$) is calculated as follow;

$PE_{flare,y}$ is determined using the methodical tool "Project emissions from flaring (Version.02.0.0)" and is the sum of the emissions for each flare determined separately.

According to the above tool, $PE_{flare,y}$ are calculated based on the flare efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare ($F_{CH4,RG,m}$). The flare efficiency is determined for each minute m of year y based either on monitored data or default values.

Two type flare stacks(open and enclosed type) for the project satisfy applicability of Methodological tool “Project emissions from flaring”.

- *Methane is the component with the highest concentration in the flammable residual gas (landfill gas); and*
- *The source of the residual gas is a biogenic (landfill gas).*

The project emissions calculation procedure is given in the following steps:

- *Step 1: Determination of methane mass flow of the residual gas;*
- *Step 2: Determination of the flare efficiency;*
- *Step 3: Calculation of project emissions from flaring.*

Step 1: Determination of the methane mass flow of the residual gas;

$F_{CH4,m}$ which is mass flow of methane in the residual gaseous stream in the minute *m* is determined as “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.

This project satisfy the following requirements on tool “Project emission from flaring(Version. 02.0.0)”.

- *The gaseous stream tool shall be applied to the residual gas;*
- *The flow of the gaseous stream shall be measured continuously;*
- *CH_4 is the greenhouse gas i for which the mass flow should be determined;*
- *The simplification offered for calculating the molecular mass of the gaseous stream is valid;*
- *The time interval t for which mass flow should be calculated is every minute m.*

$F_{CH4,m}$ which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane in kilograms fed to the flare in minute *m* ($F_{CH4,RG,m}$), i.e. ($F_{CH4,m} = F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis.

Step 2: Determination of the flare efficiency;

The flare efficiency depends on the efficiency of combustion in the flare and the time that the flare is operating. There are four flare stacks onsite including two flare stacks of enclosed type and two flare stack of open type. Although the different type of flare stacks will run onsite, as a conservative approach, a default value($\eta_{flare,m}$: 50%), which is an open type flare efficiency, is applied to all of the flare stacks of the project. The time is determined by monitoring the flame detectors.

The flare efficiency in the minute m ($\eta_{flare,m}$) is 50% when each flame is detected in the minute m ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%.

There are one LFG flow meter and four flame detectors on the flaring system. Each flare stack will be controlled by each valve. Monitoring results from valves condition(Open or Close condition) and operation of the flame detectors will be reflected in determination of the time that the flare is operating.

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.

Step 3: Calculation of project emissions from flaring

The project emission from flaring are calculated as the sum of emissions for each minute m in year y, based on the methane mass flow in the residual gas ($F_{CH4,RG,m}$) and the flare efficiency ($\eta_{flare,m}$), as follows:

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

Where:

$PE_{flare,y}$	=	Project emissions from flaring of the residual gas stream in year *y* (tCO_2e)
$F_{CH4,RG,m}$	=	Mass flow of methane in the LFG in the minute *m* (kg)
$\eta_{flare,m}$	=	Flare efficiency in minute *m*
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (tCO_{2e}/tCH_4)

Step (A.1.1): Ex ante estimation of $F_{CH4,PJ,y}$

An *ex ante* estimation of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from the SWDS in order to estimate the emission reductions during the 2nd crediting period. It is determined as follows:

$$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4} \quad (11)$$

Where:

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

$BE_{CH4,SWDS,y}$ is determined using the methodological tool "Emissions from solid waste disposal sites(Ver 06.0.1)".

According to the above tool, the amount of methane generated from disposal of waste at the SWDS is calculated on a first order decay (FOD) model. The model differentiates between the different types of waste *j* with respective constant decay rates (k_j) and fractions of degradable organic carbon (DOC_j). The model calculates the methane generation occurring in year *y* (a period of 12 consecutive months) or month *m* based on the waste streams of waste types *j* ($W_{j,x}$ or $W_{j,i}$) disposed in the SWDS over a specified time period (years or months). The amount of methane generated from disposal of waste at the SWDS is calculated for year *y* by equation below:

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

(12)

Where:

$BE_{CH4,SWDS,y}$	=	Baseline methane emissions occurring in year *y* generated from waste disposal at a SWDS during a time period ending in year y (tCO_2e/yr)
x	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (*x*=1) to year *y* (*x*=*y*)

y	=	Year of the crediting period for which methane emissions are calculated (y is a consecutive period of 12 months)
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)
$W_{j,x}$	=	Amount of solid waste type *j* disposed or prevented from disposal in the SWDS in the year *x* (t)
φ_y	=	Model correction factor to account for model uncertainties for year y
f_y	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
GWP_{CH4}	=	Global Warming Potential of methane
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
F	=	Fraction of methane in the SWDS gas (volume fraction)
MCF_y	=	Methane correction factor for year *y*
DOC_j	=	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
k_j	=	Decay rate for the waste type *j*(1 / yr)
j	=	Type of residual waste or types of waste in the MSW

Application (A) specified in the “Emissions from solid waste disposal sites” is selected to determine the parameters required above, that is, default values are adopted.

Step (A.2): Determination of $F_{CH4,BL,y}$

This step provides a procedure to determine the amount of methane that would have been captured and destroyed (by flaring) in the baseline due to regulatory or contractual requirements, or to address safety and odor concerns (collectively referred to as requirement in this step). The four cases in Table B-6 are distinguished as per ACM0001 Ver. 15. The appropriate case should be identified and the corresponding instructions followed.

<Table B–6> Cases for determining methane captured and destroyed in the baseline

Situation at the start of the project activity:	Requirement to destroy methane	Existing LFG capture and destruction system
Case 1	No	No
Case 2	Yes	No
Case 3	No	Yes
Case 4	Yes	Yes

Daegu Bangcheon-Ri landfill had installed simple flaring system for destruction methane as “Wastes Control Act”. In this situation, the project activity satisfies the case 4:

Hence; $F_{CH4,BL,y} = \max \{F_{CH4,BL,R,y}; F_{CH4,BL,sys,y}\}$

$F_{CH4,BL,R,y}$	=	Amount of methane in the LFG which is flared in the baseline due to a requirement in year y (t CH_4/yr).
$F_{CH4,BL,sys,y}$	=	Amount of methane in the LFG that would be flared in the Baseline in year y for the case of an existing LFG capture system (t CH_4/yr)

The regulatory requirement does not specify the amount or percentage of LFG that should be destroyed, and only requires the installation of LFG capture and treatment systems. For this reason, there is no historical or monitored data on amount of methane that was captured prior to the implementation of the project activity. Considering above situation, $F_{CH4,BL,y}$ will be calculated as follow;

$$F_{CH4,BL,y} = F_{CH4,BL,sys,y} = 0.2 \times F_{CH4,PJ,y} \quad (13)$$

Where:

$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be flared in the baseline in year *y* (t CH_4/yr).
$F_{CH4,PJ,y}$	=	Amount of methane in the LFG which is flared and/or used in the project activity in year *y* (t CH_4/yr)

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

The baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) is calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption (Version 01)". *$EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated using LFG in year y($EG_{PJ,y}$)*

$$BE_{EC,y} = \Sigma_k EC_{BL,k,y} \times EF_{EL,k,y} \times (1+TDL_{k,y}) \quad (14)$$

Where:

$BE_{EC,k,y}$	=	Baseline emissions from electricity generation in year *y* (tCO_2/yr)
$EC_{BL,k,y}$	=	Quantity of electricity that would be provided by this project activity to the baseline electricity consumption source in year *y* (MWh/yr)
$EF_{EL,k,y}$	=	Emission factor for electricity generation in year *y* (tCO_2/MWh)
$TDL_{k,y}$	=	Average technical transmission and distribution losses for providing electricity to source k in year y

No emission reduction for electricity generation are claimed so that $BE_{EC,y} = 0$.

Step (C): Baseline emissions associated with heat generation ($BE_{HG,,y}$)

The baseline emissions associated with heat generation in year *y* ($BE_{HG,y}$) are determined based on the amount of methane in the LFG which is sent to the heat generation equipment in the project activity.

$$BE_{HG,y} = NCV_{CH4} \times \sum_{j=1}^{n} \left(R_{efficiency,j,y} \times F_{CH4,HG,dest,j,y} \times EF_{CO2,BL,HG,j} \right) \quad (15)$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2/yr)
NCV_{CH4}	=	Net calorific value of methane at reference conditions (TJ/t CH_4)
$R_{efficiency,j,y}$	=	Ratio of the project and baseline efficiency of heat equipment type *j* in year *y*
$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by equipment type *j* in year *y* (t CH_4/yr)

$EF_{CO2,BL,HG,j}$	=	CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *j* in the baseline (t CO_2/TJ)
j	=	Heat generation equipment (boilers)
N	=	Number of different heat generation equipment used in the project activity

No emission reduction for heat generation are claimed so that $BE_{HG,y} = 0$.

Project emissions

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{DT,y} \quad (18)$$

PE_y	=	Project emissions in year y (tCO_2/yr)
$PE_{EC,y}$	=	Emissions from consumption of electricity due to the project activity in year y (tCO_2/yr)
$PE_{FC,y}$	=	Emissions from consumption of fossil fuels due to the project activity, for purpose other than electricity generation, in year y (tCO_2/yr)

$PE_{EC,y}$

The project emissions from consumption of electricity by the project activity ($PE_{EC,y}$) shall be calculated using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". When applying the tool:

- *$EC_{PJ,k,y}$ in the tool is equivalent to the amount of electricity consumed by the project activity in year y ($EC_{PJ,y}$); and*

Electricity consumption from gird is used for LFG treatment facility of Daegu Bangcheon-Ri landfill (i.e. refinery facilities, LFG fuel supply facilities, etc).

According to the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 01), $PE_{EC,gird,y}$ is determined as follows;

$$PE_{EC,y} = EC_{PJ,grid,y} * EF_{EL,grid,y} * (1+TDL_{grid,y}) \quad (19)$$

Where:

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

The combined margin emission factor is calculated for the emission factor for electricity generation ($EF_{EL,grid,y}$) as the option A1 mentioned in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption (Version 01)".

- Option A1 : Calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system"($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$)

Determination of CO_2 *$EF_{EL,k,y}$*

Recent version (Ver.04.0) of “Tool to calculate the emission factor for an electricity system” is used for calculating ***$EF_{EL,y}$***. The tool is used for calculating the following parameters;

<Table B-7> Parameters determined by “Tool for calculation of emission factor for electricity system”

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	tCO_2/MWh	Combined margin CO2 emission factor for the project electricity system in year *y*
$EF_{grid,BM,y}$	tCO_2/MWh	Build margin CO2 emission factor for the project electricity system in year *y*
$EF_{grid,OM,y}$	tCO_2/MWh	Operating margin CO2 emission factor for the project electricity system in year *y*

The combined margin CO_2 emission factors ($EF_{grid,CM,y}$) consists of operating margin CO_2 emission factors ($EF_{grid,OM,y}$) and build margin CO_2 emission factors ($EF_{grid,BM,y}$). $EF_{grid,CM,y}$ which here refers as ***$EF_{EL,y}$*** is calculated using “Tool to calculate the emission factor for an electricity system” and the six steps including one optional step in it are as follows:

STEP 1. Identify the relevant electricity systems;
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional);
STEP 3. Select a method to determine the operating margin (OM);
STEP 4. Calculate the operating margin emission factor according to the selected method;
STEP 5. Calculate the build margin (BM) emission factor;
STEP 6. Calculate the combined margin (CM) emissions factor.

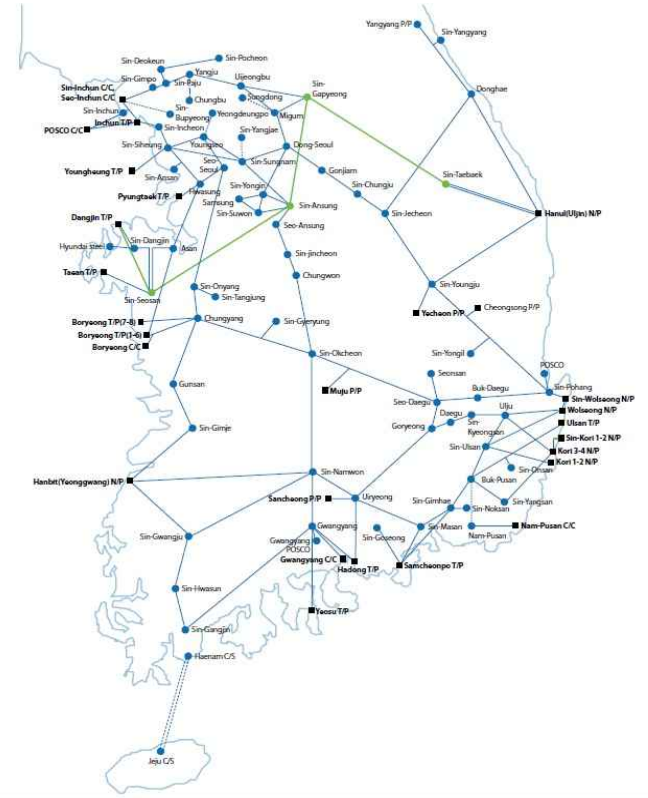
<Table B-8> Major parameter of emission factor

Parameter	Value	Source
$FC_{i,m,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by a relevant power source m in year(s) y, which supplies electricity to the grid, not including low-operating cost and must-run power plants.	Refer to <Table Annex 4-1>	Statistics of Electric Power in KOREA 2010-2012 (Source: KEPCO 2011-2013)
Net Calorific Values by Power Plant		Caloric value sourced from Statistics of Electric Power in 2010-2012 (Source: KEPCO 2011-2013) (Net Caloric Value = Caloric value net × caloric value conversion factor)
$EG_{m,y}$ (MWh) is the electricity delivered to the grid by source m		Statistics of Electric Power in KOREA 2010-2012 (Source: KEPCO 2011-2013)
Net Caloric Values Conversion Factor	Solid/Liquid fossil fuel : 0.95 Gaseous fuel : 0.90	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Fuel CO_2 Emission Factor($EF_{CO2,i,y}$)	Refer to <Table Annex 4-2>	2006 IPCC Guidelines for National Greenhouse Gas Inventories

Operating Margin Emissions Factor ($EF_{grid,OM,y}$) (ton CO_2/MWh)	0.6601	Calculated
Build Margin Emissions Factor ($EF_{grid,BM,y}$) (ton CO_2/MWh)	0.5027	Calculated
Baseline Emissions Factor ($EF_{grid,CM,y}$) (ton CO_2/MWh) for Second and third crediting period	0.5421	Calculated Calculated

STEP 1. Identify the relevant electricity systems

The electricity from the project activities is connected to KEPCO grid, which is the only one in Korea and so relevant electric power system is KEPCO grid.



<Figure B-2> Transmission map of Korea (Source: Korea power exchange)

STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional)

According to "Tool to calculate the emission factor for an electricity system (Ver.04.0.0)", there are two options to calculate the operating margin and build margin emission factor:

Option I : Only grid power plants are include in the calculation.
Option II : Both grid power plants and off-grid power plants are included in the calculation.

This project chooses ***Option 1***. Only grid power plants are including in the calculation.

STEP 3. Select a method to determine the operating margin (OM)

As described in "Tool to calculate the emission factor for an electricity system(Ver.04.0)", the OM emission factor is calculated as the generation-weighed emissions per electricity unit of all generating units serving the system, excluding low-operating cost and must-run power plants. Low-operating cost and must run power plants include hydro, nuclear, low cost biomass, geothermal and domestic coal.

Operating Margin emission factor ($EF_{grid,OM,simple,y}$) shall be calculated basis on one of the four following methods:

Option (a) Simple OM
Option (b) Simple adjusted OM
Option (c) Dispatch Data Analysis OM
Option (d) Average OM

If low-cost/must-run resources constitute less than 50% of total grid generation in average of the five most recent years, ***Option (a) simple OM*** can be chosen.

<Table B-9> Gross electricity generation in the Republic of Korea during past 5 years (GWh)

Item / Year		2008	2009	2010	2011	2012	Total
Hydro		5,563	5,641	6,472	7,831	7,695	33,202
Thermal	Coal (Dom.)	5,010	5,559	4,613	3,269	6,489	24,940
	Coal (Bitum.)	168,498	187,657	189,156	196,855	174,263	916,429
	Oil	15,425	19,912	25,356	24,921	48,244	133,858
	Gas	75,809	65,273	96,483	101,702	113,984	453,251
Nuclear		150,958	147,771	148,596	154,723	150,327	752,375
Alternative		1,092	1,791	3,984	7,592	8,571	23,030
Total		**422,355**	**433,604**	**474,660**	**496,893**	**509,573**	**2,337,085**

Source : Korea electric power Corporation, 2012

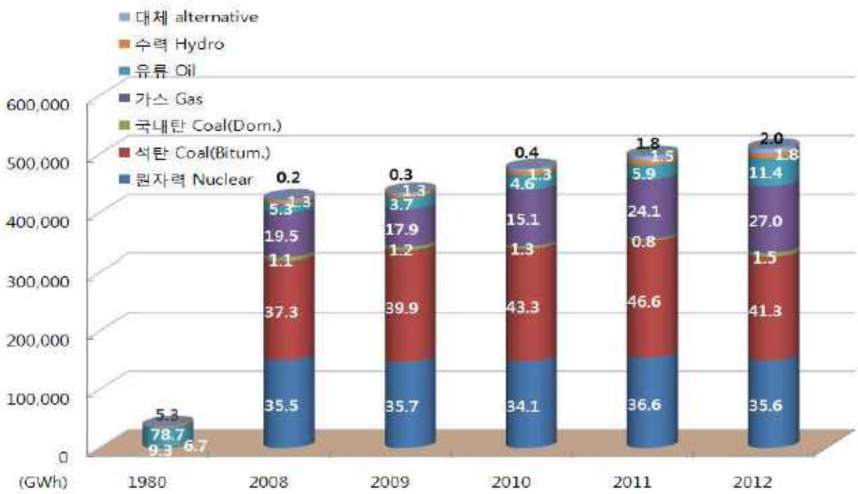
Referring to the gross electricity generation rate by energy sources of the host country (Republic of Korea), the rate of low cost/must run power generation does not exceed 50% of the total grid. Actually, the most recent 5-year (2008~2012) average data shows that the rate of low cost/must run is 35.67%. (Source: KEPCO) The low-cost/must-run plants –hydro, coal (dom), nuclear and alternative– are indicated in yellow.

Low-cost/ Must-run sources ratio

$$= \frac{[\text{ Hydro } (33{,}202) + \text{Coal-Dom } (24{,}940) + \text{Nuclear } (752{,}375) + \text{Alternative } (23{,}030)]}{\text{Total generation } (2{,}337{,}085)} \times 100$$

= 35.67%

Therefore, for this project case, "***Option (a) Simple OM***" is available.



<Figure B-3> Gross electricity generation by energy source in the Republic of Korea during past 5 years (Korea Electric Power Corporation, 2012)

For the simple OM, the emissions factor can be calculated using either of the two following data vintages:

- ***Ex ante option***: If the ex ante option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation. For off-grid power plants, use a single calendar year within the 5 most recent calendar years prior to the time of submission of the CDM-PDD for validation.

- ***Ex* post option**: If the ex post option is chosen, the emission factor is determined for the year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required calculating the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year y-1 may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year y-2 may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.

For this project, ***Ex-ante option*** is chosen.

Step 4. Calculate the operating margin emission factor according to the selected method
(a) *Simple OM option* is chosen for the project as described in STEP 3 above.
The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

The simple OM may be calculated using one of the following options;
Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit; or
Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

For this project, ***option A*** is chosen to calculate the simple OM.
Where Option A is used, the simple OM emission factor is calculated as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:
$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y(MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m = All power units serving the grid in year y except low-cost / must-run power units
y = the relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

For calculating $EF_{EL,m,y}$, Option A1 is chosen as follows;

Option A1. If for a power unit m data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}}$$

Where:
$EF_{EL,m,y}$ = CO_2 emission factor of power unit m in year y (tCO_2/MWh)
$FC_{i,m,y}$ = Amount of fossil fuel type i consumed by power unit m in year y (Mass or volume unit)
$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type i in year y (tCO_2/GJ)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
m = All power units serving the grid in year y except low-cost/must-run power units
i = All fossil fuel types combusted in power unit m in year y
y = The relevant year as per the data vintage chosen in Step 3

In the case of this project, the applied values of $EF_{CO2,i,y}$ are based on using conversion factor suggested in the 2006 IPCC Guidelines. And those of $NCV_{i,y}$ and $EF_{CO2,i,y}$ are country-specific. Actually, the calorific values are indicated as country-specific data of gloss calorific value (GCV), and this was recalculated for this PDD as net calorific value (NCV) using conversion factor suggested in the 2006 Revised IPCC Guidelines. The detailed information used in the calculation is presented at tables in Annex 4.

Determination of $EG_{m,y}$
- For grid power plants, $EG_{m,y}$ should be determined as per the provisions in the monitoring tables.
- Off-grid power plants are not considered in determination of $EG_{m,y}$.

As a result, the OM emission factor ($EF_{grid,OM,simple,y}$) is 0.6601 (tCO_2/MWh).

STEP 5. Calculate the build margin (BM) emission factor
According to “Tool to calculate the emission factor for an electricity system (version 04.0.0)”, there are two options to choose in order to calculate the BM.

- ***Option 1***. For the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the

crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

- ***Option 2***. For the first crediting period, the build Margin emission factor ($EF_{grid,BM,y}$)shall be updated annually, ex-post, including those unit built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated ex ant, as described in Option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

For this project case, ***Option 1*** is chosen to calculate the BM emission factor.

The sample group of power units m used to calculate the build margin should be determined as per the following procedure as described in the methodology, consistent with the data vintage selected in the steps above:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-units}}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) (SET≥20%) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);

(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample}); Identify the date when the power units in SETsample started to supply electricity to the grid.

If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. Ignore steps (d), (e) and (f).

Following the guidance above, the sample group of power unit *m* is established to calculate the build margin.

- Calculation of the Build Margin (BM) emission factor ***(Refer to <Table Annex 4-2>)***

<table>
<tr><th></th><th>Result</th></tr>
<tr><td>Step (a)</td><td>- Five power units that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$):
<table>
<tr><td>1. Namjeju solar</td><td>2012.10</td></tr>
<tr><td>2. Yeonggwang solar (#3)</td><td>2012.10</td></tr>
<tr><td>3. Yeonggwang-wind</td><td>2012.10</td></tr>
<tr><td>4. Busan solar</td><td>2012.10</td></tr>
<tr><td>5. Juam</td><td>2012.10</td></tr>
</table>
- Total electricity generation in 2012: 1,358 MWh</td></tr>
<tr><td>Step (b)</td><td>- AEG_{total}: 488,046,169 MWh
- The set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total}: Refer to the Annex 4
- $AEG_{SET\text{-}\geq 20\%}$: 101,644,356 MWh (20.83 % of AEG_{total})</td></tr>
</table>

Step (c)	- SET_{sample} : $SET_{\geq 20\%}$ because it is larger than $SET_{5\text{-}units}$. - Because none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, steps (d), (e) and (f) are ignored.
Step (d)~(f)	Skipped (Not applicable)

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where;
$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m = Power units included in the build margin
y = Most recent historical year for which power generation data is available

According to the BM calculation formula and variables of above tables, $EF_{BM,y}$ is 0.5027 (tCO_2/MWh).

STEP 6. Calculate the combined margin emissions factor
The calculation of the combined margin (CM) emission factor ($EF_{grid,CM,y}$) is based on one of the following methods:

(a) Weighted average CM; or
(b) Simplified CM.

The weighted average CM method (option A) is used for this project .

(a) Weighted average CM

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

Where,
$EF_{grid,CM,y}$ = Combined margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (tCO_2/MWh)
W_{OM} = Weighting of operating margin emissions factor (%)
W_{BM} = Weighting of build margin emissions factor (%)

2nd and 3rd crediting period:

According to "Tool to calculate the emission factor for an electricity system (Ver.04.0.0)", the project activities are w_{OM} =0.5 and w_{BM} = 0.5 (owing to intermittent and non-dispatchable nature) for the first crediting period. However, for the second and third crediting periods, the values of w_{OM} and w_{BM} should be 0.25 and 0.75 respectively.

And $EF_{grid,OM,y}$, $EF_{grid,BM,y}$ are calculated as described in Steps 4 and 5 above and are expressed in tCO_2/MWh. Therefore baseline emission factor (***$EF_{grid,CM,y}$***) for this project is 0.5421(tCO_2/MWh) as follows:

$EF_{grid, CM, y} = w_{OM} \cdot EF_{grid,OM\,y} + w_{BM} \cdot EF_{grid,BM,\,y}$
$= 0.25 \cdot 0.6601\ tCO_2/MWh + 0.75 \cdot 0.5027\ tCO_2/MWh$
$= \mathit{0.5421}\ tCO_2/MWh$

$PE_{FC,y}$

The amount of methane collection in the landfill fluctuate seasonally as the character of the project activity. For this reason, supplement of LNG(Liquefied Natural Gas) on LFG is important for continuous and efficient operating the LFG boilers which is a base-load units of KDHC. Other LNG use is to start up LFG boilers as ignition. As per ACM0001(Version 15.0), project emissions from fossil fuel consumption(i.e. LNG) will be calculated using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", when applying the tool.

- *Process j in the tool correspond to the sources of fossil fuel consumption due to the project activity other than for electricity generation or and any on-site transportation by trucks or cars;*

The tool is applicable because fossil fuel consumption is related with project activity.

As per "Tool to calculate project or leakage emissions from fossil fuel combustion(version 02)", determination of $PE_{FC,y}$ is followed;

$$PE_{FC,y} = FC_{LNG,y} * COEF_{LNG,y} \quad (20)$$

Where;

PE_y	=	Project emissions in year y (tCO_2/yr)
$FC_{LNG,y}$	=	Quantity of LNG combusted in process j during the year y (Nm^3/yr)
$COEF_{LNG,,y}$	=	CO_2 emission coefficient of LNG in year y (tCO_2/Nm^3)

Option B is selected as "Tool to calculate project or leakage emissions from fossil fuel combustion(version 02)".

$$COEF_{LNG,y} = NCV_{LNG} * EF_{CO2,\,LNG,y} \quad (21)$$

Where:

$NCV_{LNG,y}$	=	*Net calorific value of the LNG in year y (GJ/Nm^3)*
$EF_{CO2,\,LNG,y}$	=	*CO_2 emission factor of LNG in year y (tCO_2/GJ)*

$PE_{DT,y}$

The project emissions from the distribution of compressed/liquefied LFG using trucks ($PE_{DT,y}$) is determined by the sum of emissions arising from the transportation of LFG using trucks and possible leaks during the transportation, as follows:

$$PE_{DT,y} = PE_{TR,y} + PE_{leak,y} \quad (22)$$

Where:

$PE_{DT,y}$	=	Project emissions from the distribution of compressed/liquefied LFG using trucks, in year y (tCO_2/yr)
$FC_{TR,y}$	=	Emissions from the transportation of compressed/liquefied LFG using trucks, in year y (tCO_2/yr)
$PE_{Leaks,,y}$	=	Emissions from CH_4 leaks during the transportation of compressed/liquefied LFG, in year y (tCO_2/yr)

Daegu Bangcheon-Ri landfill is connected with the KDHC through the pipe. There are no trucks for transportation of LFG. Therefore, the project is not considered $PE_{DT,y}$ ($FC_{TR,y}$ and $PE_{Leaks,,y}$).

$PE_{DT,y} = 0$

B.6.2. Data and parameters fixed ex ante

Data/Parameter	***OX*** ***top_layer***
Data 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	-
Purpose of data	To determine the baseline emission
Additional comment	-

Data/Parameter	**GWP_{CH4}**
Data 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 (Updated according to decision 4 / CMP 7.)
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the baseline emission
Additional comment	-

Data/Parameter	**η_{PJ}**
Data unit	Dimensionless
Description	Efficiency of the LFG capture system that will be installed in the project activity
Source of data	Feasibility study report (Feb. 2005)
Value(s) applied	63.46%
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	Technical specifications of the LFG capture system to be installed

Data/Parameter	**NCV_{CH4}**
Data unit	TJ/tCH_4
Description	Net calorific value of methane at reference conditions
Source of data	2006 IPCC
Value(s) applied	0.0504
Choice of data or measurement methods and procedures	-
Purpose of data	-
Additional comment	-

Data and parameters required for the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (version 02.0.0):

Data/Parameter	R_u
Data unit	$Pa.m^3/kmol.K$
Description	Universal ideal gases constant
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version. 02.0.0)
Value(s) applied	8,314
Choice of data or measurement methods and procedures	-
Purpose of data	-
Additional comment	-

Data/Parameter	MM_i (MM_{CH4})
Data unit	kg/kmol
Description	Molecular mass of greenhouse gas *i* (CH_4)
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version. 02.0.0)
Value(s) applied	The CH_4 values of molecular mass is 16.04 Compound | Structure | Molecular mass(kg/kmol) Methane | CH_4 | 16.04
Choice of data or measurement methods and procedures	-
Purpose of data	-
Additional comment	-

Data and parameters required for the “Emissions from solid waste disposal sites” (Version 06.0.1):

<table>
<tr><td>Data/Parameter</td><td>$\varphi_{default}$</td></tr>
<tr><td>Data unit</td><td>-</td></tr>
<tr><td>Description</td><td>Default value for the model correction factor to account for model uncertainties</td></tr>
<tr><td>Source of data</td><td>“Emissions from solid waste disposal site”(version 6.0.1)</td></tr>
<tr><td>Value(s) applied</td><td>According to the above tool, one between the following Application A and B is chosen for calculating baseline emissions.

For baseline emissions: refer to the following table to identify the appropriate factor based on the application of the tool(A or B) and the climate where the SWDS is located.

Default values for the model correction factor
<table>
<tr><th></th><th>Humid/wet conditions</th><th>Dry conditions</th></tr>
<tr><td>Application A</td><td>0.75</td><td>0.75</td></tr>
<tr><td>Application B</td><td>0.85</td><td>0.80</td></tr>
</table>

As the project activity falls under Application A of the tool, 0.75 is the appropriate default value for $\varphi_{default}$</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>To determine the $F_{CH4,PJ,y}$ for ex-ante estimation</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data/Parameter	OX
Data unit	-
Description	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.1
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	-

Data/Parameter	F
Data unit	-
Description	Fraction of methane in the SWDS gas (volume faction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

Data/Parameter	$\mathbf{DOC_{f,default}}$
Data unit	Weight fraction
Description	Default value for the fraction of degradable organic carbon (DOC) in MSW that can decompose in the SWDS
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	0.5
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	As per “Emissions from solid waste disposal sites”(Version 6.0.1), the default value shall be applied to application A.

Data/Parameter	$\mathbf{MCF_{default}}$
Data unit	-
Description	Methane correction factor
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value(s) applied	The appropriate default value for MCF_y is 1.
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	As per the tool, for Application A : $MCF_y = MCF_{default}$ The project is an anaerobic managed solid waste disposal site, due to the fact that the landfill had controlled placement of waste, and included (i)cover materials; (ii)mechanical compacting; or (iii) levelling of the waste.

Data/Parameter	**DOC_j**
Data unit	%
Description	Fraction of degradable organic carbon in the waste type j(weight fraction)
Source of data	IPCC 2006 Guidelines for National Greenhouse Gas Inventories(adapted from Volume 5, Tables 2.4 and 2.5)
Value(s) applied	For MSW, the following values for the different waste types j should be applied **Default values for DOC_j** (see table below)
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	

Default values for DOC_j

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

Data/Parameter	**W_j**
Data unit	-
Description	Fraction of the waste type j(weight fraction)
Source of data	Fraction of each waste type is based on Feasibility Study which published by Daesung Eco-energy Co., Ltd.
Value(s) applied	The following value s for the different waste types j should be applied **Values for W_j** (see table below)
Choice of data or measurement methods and procedures	-
Purpose of data	To determine the $F_{CH4,PJ,y}$ for ex-ante estimation
Additional comment	-

Values for W_j

Waste type j	Value
Wood and wood product	8.4%
Pulp, paper and cardboard (other than sludge)	20.1%
Food, food waste, beverages and tobacco (other than sludge)	29.2%
Textiles	0%
Garden, yard and park waste	3.1%
Glass, plastic, metal, other inert waste	39.3%

<table>
<tr><td>Data/Parameter</td><td>k_j</td></tr>
<tr><td>Data unit</td><td>-</td></tr>
<tr><td>Description</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 3.3)</td></tr>
<tr><td>Value(s) applied</td><td>Apply the following default values for the different waste types j
Default values for the decay rate(kj)
<table>
<tr><td colspan="2" rowspan="2">Waste type j</td><td colspan="2">Boreal and Temperate (MAT)</td></tr>
<tr><td>Dry
(MAP/PET<1)</td><td>Wet
(MAP/PET>1)</td></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard(other than sludge), textiles</td><td>0.04</td><td>0.06</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td><td>0.03</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.1</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td><td>0.185</td></tr>
</table>
The region which the landfill is located in is summarized, as follows:

Mean annual temperature(MAT): 13.2 ℃
Mean Annual precipitation(MAP): 1,224.8 mm
Potential evapotranspiration(PET) : 1,069 mm

(Source: ‘Climate change report of Daegu & Gyeong Sang Buk-do’ published by Korea Meteorological administration)
The climate in the area of the project site is both Boreal & Temperate and Wet, Therefore, values provided by "Emissions from solid waste disposal site”(version 6.0.1) for Boreal and Temperate, wet climate were applied.</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>-</td></tr>
<tr><td>Purpose of data</td><td>To determine the $F_{CH4,PJ,y}$ for ex-ante estimation</td></tr>
<tr><td>Additional comment</td><td></td></tr>
</table>

Data and parameters required for the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (Version 01):

Data/Parameter	$EF_{grid,CM,y}$
Data unit	tCO_2e/MWh
Description	Combined margin CO_2 emission factor in year y
Source of data	Calculated
Value(s) applied	0.5421 (second crediting period)
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	To determine Project emission from electricity consumption ($PE_{EC,y}$)
Additional comment	-

B.6.3. Ex ante calculation of emission reductions

>>

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(t CO_2e)
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}	$BE_{CH4,y}$(t CO_2e)
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)

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

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}	$F_{CH4,PJ,y}$ *(t CO_2e)*
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 $F_{CH4,BL,y}$

Year	$F_{CH4,PJ,y}$	*20%*	$BE_{CH4,y}$*(t CO_2e)*
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) $BE_{EC,y} = \sum EC_{BL,k,y} \times EF_{EL,grid,y} \times (1+TDL_{grid,y})$

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

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

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*(t* CO_2*e)*
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}	$EF_{CO2,LNG,y}$	$PE_{FC,y}$
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.

B.6.4. Summary of ex ante estimates of emission reductions

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 year			
Annual average over the crediting period	182,430	4,507	0	177,923

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data and parameters required for the ACM 0001 “Flaring or use of landfill gas” (version 15.0):

Data/Parameter	Management of SWDS
Data unit	-
Description	Management of SWDS
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
Value(s) applied	
Measurement methods and procedures	Project participants should refer to the original design of the landfill to ensure that any practice to increase methane generation have been occurring prior to the implementation of the project activity. Any change in the management of the SWDS after the implementation of the project activity should be justified by referring to technical or regulatory specifications.
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	To determine the baseline emission
Additional comment	-

Data/Parameter	**$Op_{j,h}$**
Data unit	-
Description	Operation of the equipment that consumes the LFG
Source of data	Project participants
Value(s) applied	For each equipment unit *j* using the LFG monitor that the plant is operating in hour *h* by the monitoring any one or more of the following three as described in ACM0001 methodology (version 15). (a) Temperature; (b) Flame; (c) Products generated. $Op_{j,h}$ = 0 when: (a) One of the more temperature measurements are missing or below minimum threshold in hour h (instantaneous measurements are made at least every minute); (b) Flame is not detected continuously in hour h (Instantaneous measurements are made at least every minute); (c) No Products are generated in the hour h Otherwise , $Op_{j,h}$ = 1
Measurement methods and procedures	Hourly
Monitoring frequency	-
QA/QC procedures	To determine the baseline emission
Purpose of data	-
Additional comment	

Data/Parameter	**$EG_{EC,y}$**
Data unit	MWh
Description	Amount of electricity consumed by the activity in year y
Source of data	Electricity meter
Value(s) applied	
Measurement methods and procedures	Source of consumption shall include, where applicable, electricity consumed for the operation of the LFG capture system, for any processing and upgrading of the LFG, for transportation of the LFG to the flare or other applications.
Monitoring frequency	Continuous
QA/QC procedures	Electricity meter is subject to regular (in accordance with stipulation of KEPCO) maintenance and testing to ensure accuracy. Electricity meter is calibrated every 7 years in accordance with “Enforcement Decree of Measures ACT”. The value will be cross-checked with the invoice from KEPCO.
Purpose of data	To determine the project emission
Additional comment	This parameter is required for calculating project emissions from electricity consumption as the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”

Data/Parameter	$F_{CH4,BL,R,y}$
Data unit	tCH_4/yr
Description	Amount of methane in the LFG which is flared due to a requirement in year y

Source of data	Information of the host country's regulatory requirements relating to LFG, contractual requirements, or requirements to address safety and odour concerns.
Value(s) applied	-
Measurement methods and procedures	-
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	To determine the baseline emission
Additional comment	

Data/Parameter	$\rho_{reg,y}$
Data unit	-
Description	Fraction of LFG that is required to be flared due to a requirement in year y
Source of data	Information of the host country's regulatory requirements relating to LFG, contractual requirements, or requirements to address safety and odour concerns
Value(s) applied	0.2
Measurement methods and procedures	-
Monitoring frequency	Annually
QA/QC procedures	-
Purpose of data	To determine the baseline emission
Additional comment	There are no the regulatory requirement specifying any amount or percentage of LFG to be destroyed and monitored or historic data on the amount of methane to be captured in the year. So, the default value of 20% is selected according to the ACM 0001(ver.15)

Data and parameters required for the "Project emission from flaring" (Version 02):

Data/Parameter	**$Flame_m$**
Data unit	Flame on or flame off
Description	Flame detection of flare in the minute *m*
Source of data	Project participants
Value(s) applied	
Measurement methods and procedures	Measure using a fixed installation optical flame detector: Ultra Violet detector or Infra Red or both
Monitoring frequency	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures	Each flame detector is installed at each flare stacks. Equipment(i.g. flame detector) shall be maintained or calibrated in accordance with manufacturer's recommendations or local regulation. According to the manufacturer's specification, the below information was included. FD-103, 104 : (Durability) 40,000 hour
Purpose of data	To determine the baseline emission

Additional comment	According to ACM0001(Ver.15.0), it is newly added for 2nd crediting period.

Data and parameters required for the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0):

Data/Parameter	$V_{t,db}$
Data unit	Nm^3 dry gas/h
Description	Volumetric flow of the gaseous stream in a time interval *t* on a dry basis
Source of data	Monitored data from on-site measurement
Value(s) applied	
Measurement methods and procedures	Volumetric flow measurement should always refer to the pressure and temperature of normal condition.
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Frequency of calibration is every 8 years in accordance with the “Enforcement Decree of Measures ACT*”. *Gas flow meter which the maximum flow is below $10m^3/h$ is calibrated every 5 years or the others are calibrated every 8 years.
Purpose of data	To determine the baseline emission
Additional comment	There are no changes for the volumetric flow meters during 1st and 2nd crediting period.

Data/Parameter	$v_{CH4,t,db}$
Data unit	Nm^3 CH_4 /Nm^3 dry gas (or %)
Description	Volumetric fraction of CH_4 in a time interval *t* on a dry basis
Source of data	Monitored data from on-site measurement
Value(s) applied	
Measurement methods and procedures	Continuous gas analyzer operating in dry-basis. Volumetric flow measurement should always refer to the pressure and temperature of normal condition.
Monitoring frequency	Continuous
QA/QC procedures	Calibration should include zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and the must be under their validity period. Gas analyzers will be calibrated every 5 years by an independent accredited laboratory as the 1st crediting period.
Purpose of data	To determine the baseline emission
Additional comment	There are 3 gas analysers as below ①Behind of the buffer tank (for reference) ②In front of the buffer tank : The data measured by this gas analyser will be used to calculate flaring. ③Behind 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.

Data/Parameter	P_t
Data unit	Pa
Description	Pressure of the gaseous stream in time interval *t*
Source of data	Monitored data from on-site measurement
Value(s) applied	
Measurement methods and procedures	Instruments with recordable electronic signal(analogical or digital) are required.
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure are regularly calibrated by an independent accredited laboratory in accordance with local regulation. Pressure transducers (either capacitive or resistive) will be calibrated monthly.
Purpose of data	To determine the baseline emission
Additional comment	This parameters is used for conversion of the normal condition during the monitoring process.

Data/Parameter	T_t
Data unit	℃ or K
Description	The temperature of the gaseous stream (LFG) in time interval *t*.
Source of data	Monitored data from on-site measurement
Value(s) applied	
Measurement methods and procedures	Instruments with recordable electronic signal(analogical or digital) are required.
Monitoring frequency	Continuous
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration for measuring equipment are complied with local regulation.
Purpose of data	To determine the baseline emission
Additional comment	The temperature is used for conversion of the normal condition and is also monitored continuously because the applicability condition related to the gaseous stream flow temperature being below 60 ℃ is adopted.

Data and parameters required for the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (Version 02):

Data/Parameter	$FC_{LNG,j,y}$
Data unit	Nm^3/yr
Description	Quantity of *LNG* combusted in process *j* during the year y
Source of data	Monitored data from onsite measurements or calculation
Value(s) applied	-
Measurement methods and procedures	LNG is supplied from local supplier. The amount of LNG consumption is measurable by flow meters installed at the project site and LNG consumption is automatically converted into normal condition(Nm^3).
Monitoring frequency	Continuously

QA/QC procedures	According to the "Enforcement Decree of Measures ACT", the main flow meters of LNG supplier are regularly calibrated every 8 years by an independent accredited laboratory. The total amount of LNG consumption will be cross-checked with the invoice. Sub flow meters of LFG boilers are especially calibrated in accordance with local regulation. Especially, amount of LNG consumption for ignition is calculated as deducting quantity of sub flow meters from quantity of main LNG flow meter.
Purpose of data	To determine the project emission
Additional comment	In case of LFG boilers, detail information of measurement at KDHC site is described in appendix 5 of this PDD.

<table>
<tr><td>Data/Parameter</td><td>$NCV_{LNG,y}$</td></tr>
<tr><td>Data unit</td><td>GJ/Nm^3</td></tr>
<tr><td>Description</td><td>Weighted average net calorific value of LNG in year y</td></tr>
<tr><td>Source of data</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values proved by the fuel supplier in invoices</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (Option A).</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If a) is not available

These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr>
<tr><td>d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If a) is not available</td></tr>
</table>
a) is preferred. c) or d) are also applicable for the project activity, if a) is not available.</td></tr>
<tr><td>Value(s) applied</td><td></td></tr>
<tr><td>Measurement methods and procedures</td><td>For a) : Measurements should be undertaken in line with national or international fuel standards.</td></tr>
<tr><td>Monitoring frequency</td><td>For a) : The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated.
For c) : Review appropriateness of the values annually.
For d) : Any future revision of the IPCC Guidelines should be taken into account.</td></tr>
</table>

QA/QC procedures	Verify if the values under a), c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol.2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data	To determine the project emission
Additional comment	Regarding a), net calories values are monthly posted each fuel supplier on KOCAS website (www.kogas.or.kr).

<table>
<tr><td>Data/Parameter</td><td>$EF_{CO2,LNG,y}$</td></tr>
<tr><td>Data unit</td><td>tCO_2/GJ</td></tr>
<tr><td>Description</td><td>Weighted average CO_2 emission factor of LNG in year y</td></tr>
<tr><td>Source of data</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If a) is not available

These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr>
<tr><td>d) 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</td><td>If a) is not available</td></tr>
</table>
a) is preferred. c) or d) are applicable for the project activity, if a) is not available.</td></tr>
<tr><td>Value(s) applied</td><td>-</td></tr>
<tr><td>Measurement methods and procedures</td><td>For a): Measurements should be undertaken in line with national or international fuel standards</td></tr>
<tr><td>Monitoring frequency</td><td>For a): The CO_2 emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated.
For c): Review appropriateness of the values annually.
For d): Any future revision of the IPCC Guidelines should be taken into account.
Any future revision of the IPCC Guidelines and national default values should be taken into account.</td></tr>
<tr><td>QA/QC procedures</td><td>-</td></tr>
</table>

Purpose of data	-
Additional comment	For a): If the fuel supplier does provide the NCV value and the CO_2 emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO_2 factor should be used. If another source for the CO_2 emission factor is used or no CO_2 emission factor is provided, Options b), c) or d) should be used.

Data and parameters required for the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (Version 01):

Data/Parameter	***$TDL_{j,y}$***
Data unit	-
Description	Average technical transmission and distribution losses for providing electricity to source *j* in year y.
Source of data	“Tool to calculate baseline, project and/or leakage emissions from electricity consumption”(Version 01)
Value(s) applied	-
Measurement methods and procedures	As per "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", “KEPCO in Brief” which is accurate and reliable data in Republic of Korea is selected.
Monitoring frequency	Annually, In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
QA/QC procedures	
Purpose of data	To determine the project emission
Additional comment	-

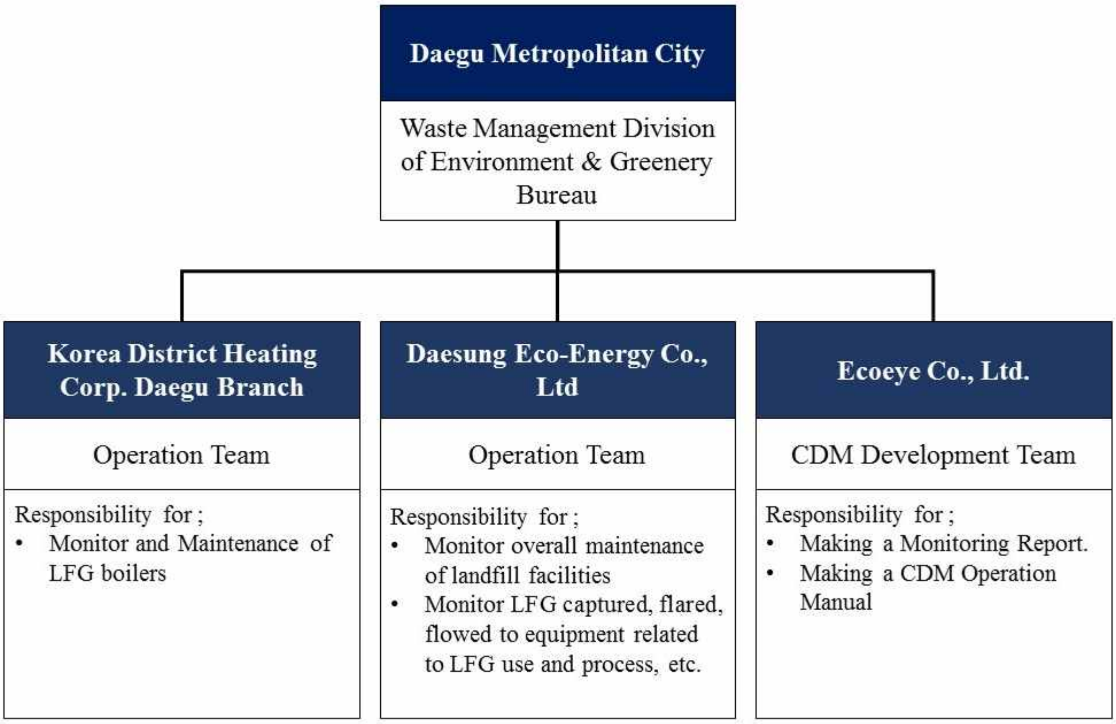
B.7.2. Sampling plan

>>
No sampling is required for this project activity.

B.7.3. Other elements of monitoring plan

>>
Data and parameter presented in section B.7.1 will be monitored and monitoring method for each data or parameter can be referred to section B.7.1 as well.

The following figure describes the operational and management structure that will operate project activity and monitor monitoring instruments/equipment.



<Figure B-4> Monitoring structure

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

In order to ensure the implementation of monitoring plan, QA/QC measures are carried out as the following procedures;

Monitoring equipment and calibration

Monitoring instruments/equipment will be set up and managed transparently for calculation of emission reduction as per applicable methodologies.

Calibration frequency of monitoring instruments/equipment will be determined and periodically performed in accordance with manufacturer's specifications and/or appropriate national/international standards and/or local regulation. If any monitoring equipment is performed abnormally(i.e. failure or malfunction), an immediate corrective actions and applicable repair or replacement will be carried out.

Data collection and management

The monitored data will be remained in electronic or hard copy format. All monitoring records will be kept for 2 years after the end of the crediting period.

Training program

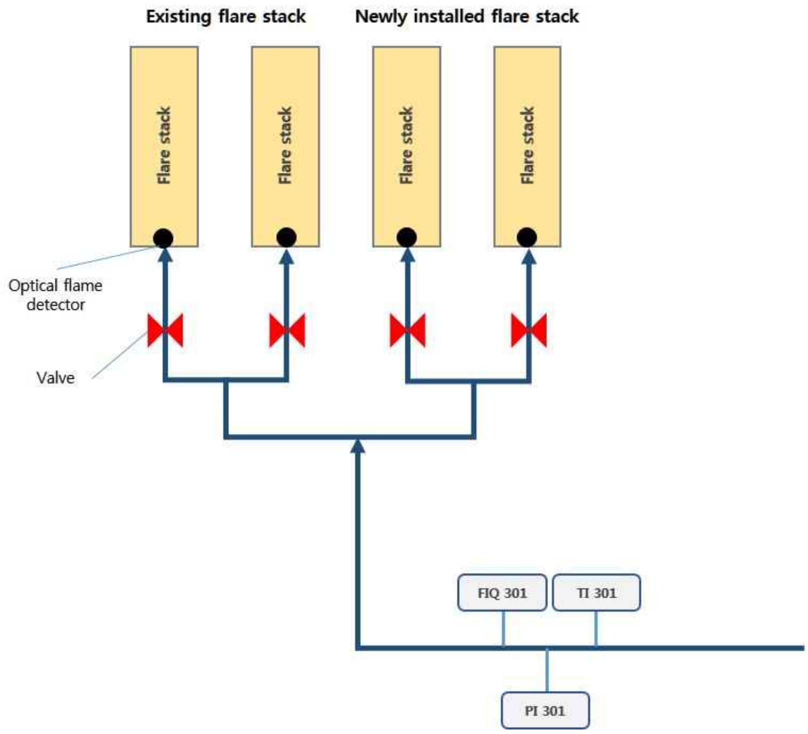
All employees directly involved in the monitoring process will be trained for appropriate monitoring and managing its data and equipment. The employees in charge of monitoring will enhance their comprehensive knowledge of CDM project and management for monitoring instruments/equipment. The CDM operation manual has included training program and its education.

New installation of enclosed flare stack.

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.



<Figure B-5> Detailed diagram of flare stacks monitoring

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.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

\>>
01/05/2005

C.2. Expected operational lifetime of project activity

\>>
According to an expected plan of Bangcheon-Ri landfill, disposal of waste at the landfill would be expected until 2050.

C.3. Crediting period of project activity

C.3.1. Type of crediting period

\>>
Renewable crediting period

C.3.2. Start date of crediting period

\>>

The 1st crediting period was started on 18/08/2007. The 2nd 7 year renewable crediting period starts on 19/08/2014 or the assumed renewal date of the crediting period renewal by UNFCCC, whichever is earlier.

C.3.3. Duration of crediting period

>>

The length of the second crediting period is 7 years.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>

The analysis of environmental impacts for the project activity was carried out prior the registration of project activity. Description and assessment about the environment impact of the project activity are presented in the latest version of PDD(15/05/2007) and Validation Report(25/05/2007) in detail.

D.2. Environmental impact assessment

>>

The analysis of environmental impacts for the project activity was carried out prior the registration of project activity. Description and assessment about the environment impact of the project activity are presented in PDD(15/05/2007) and Validation Report(25/05/2007) in detail.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

Information on solicitation of comments from local stakeholders for the project activity are presented in PDD(15/05/2007) and Validation Report(25/05/2007) in detail.

E.2. Summary of comments received

>>

Summary on comment received from local stakeholders for the project activity are presented in PDD(15/05/2007) and Validation Report(25/05/2007) in detail.

E.3. Consideration of comments received

>>

Information on consideration of comments received from local stakeholders for the project activity are presented in PDD(15/05/2007) and Validation Report(25/05/2007) in detail.

SECTION F. Approval and authorization

>>

As per the CDM Cycle Procedures, new letter of approval from the host party DNA is not necessary for the renewal crediting period.

- - - - -

Appendix 1. Contact information of project participants

Organization name	Daegu Metropolitan City
Country	Republic of Korea
Address	88, Gongpyeong-ro, Jung-Gu, Daegu, Republic of Korea
Telephone	+82-53-803-3636
Fax	+82-53-803-3609
E-mail	dgkim@daegu.go.kr
Website	http://www.daegu.go.kr
Contact person	Donggyeom Kim

Organization name	Daesung Eco-Energy Co., Ltd.
Country	Republic of Korea
Address	822, Dasa-ro, Dasa-Eup, Dalseong-Gun, Daegu, Republic of Korea
Telephone	+82-53-593-1890
Fax	+82-53-593-2121
E-mail	ddeeco@korea.com
Website	http://deeco.co.kr
Contact person	Suk-hyung Lee

Organization name	Korea District Heating Corp.
Country	Republic of Korea
Address	368, Bundang-ro, Bundang-gu, Seongnam, Gyeonggi-Do
Telephone	+82-31-780-4114
Fax	
E-mail	cdm@kdhc.co.kr
Website	www.kdhc.co.kr
Contact person	Tae-Sop Song

Organization name	Ecoeye Co., Ltd.
Country	Republic of Korea
Address	B dong, 70, Dusan-ro, Geumcheon-Gu, Seoul
Telephone	+82-2-6480-7300
Fax	+82-2-6480-7398
E-mail	sangsun_ha@ecoeye.com
Website	http://www.ecoeye.co.kr
Contact person	Sangsun Ha

Appendix 2. Affirmation regarding public funding

No public funding is involved in this project activity.

Appendix 3. Applicability of methodologies and standardized baselines

Mentioned in the involved section of the PDD.

Appendix 4. Further background information on ex ante calculation of emission reductions

The baseline information used to calculate emission reductions of the proposed project is as follows:

- Determination of Emission Factor

[Appendix 4-1] Calculation of Operating Margin emission factor

Year	Plant		Amount of fossil fuel(FCi,m,y)				Net Caloric value(NCVi,y)				Net electricity generated (EGm,y)	EF for each plant (tonCO2eq./MWh)
			Coal(t)	Heavy oil (kl)	Diesel oil (kl)	L.N.G(t)	Coal (kcal/kg)	Heavy oil (kcal/l)	Diesel oil (kcal/l)	L.N.G (kcal/kg)		
2010	Honam	#1	661,468	1,855	301	0	5,014	9,321	8,458	0	1,321,140	0.9454
		#2	722,994	897	350		5,057	9,322	8,482	0	1,462,407	0.9392
	Samchonpo	#1	1,899,819		518		5,385	0	8,466	0	4,433,574	0.8649
		#2	1,891,944		421		5,388	0	8,457	0	4,418,264	0.8647
		#3	1,581,512		1,261		5,373	0	8,478	0	3,766,380	0.8462
		#4	1,909,672		369		5,358	0	8,473	0	4,544,757	0.8439
		#5	1,949,826		293		4,714	0	8,563	0	4,174,333	0.8252
		#6	1,758,651		573		4,718	0	8,557	0	3,767,928	0.8256
	Yonghung	#1	2,201,446		2,189		5,432	0	8,387	0	5,558,681	0.8071
		#2	2,264,564		1,531		5,433	0	8,381	0	5,627,774	0.8199
		#3	2,778,041		739		5,386	0	8,391	0	6,887,344	0.8144
		#4	2,821,533		663		5,379	0	8,381	0	6,943,045	0.8193
	Boryeong	#1	1,771,953		732		5,176	0	8,402	0	4,012,817	0.8569
		#2	1,635,347		1,068		5,175	0	8,353	0	3,706,927	0.8562
		#3	1,618,460		464		5,206	0	8,321	0	3,855,846	0.8191
		#4	1,775,851		289		5,206	0	8,349	0	4,232,288	0.8188
		#5	1,604,934		911		5,201	0	8,313	0	3,817,181	0.8200
		#6	1,778,254		359		5,202	0	8,317	0	4,226,837	0.8203

		#7	1,670,727		662		5,244	0	8,322	0	4,189,558	0.7840
		#8	1,493,422		439		5,255	0	8,316	0	3,787,312	0.7767
	Taean	#1	1,512,930		865		5,458	0	8,428	0	3,817,336	0.8111
		#2	1,626,596		518		5,427	0	8,429	0	4,058,392	0.8154
		#3	1,506,479		476		5,433	0	8,436	0	3,776,949	0.8123
		#4	1,656,710		296		5,456	0	8,422	0	4,165,579	0.8133
		#5	1,450,465		680		5,491	0	8,437	0	3,657,234	0.8166
		#6	1,319,263		1,094		5,486	0	8,428	0	3,339,271	0.8130
		#7	1,521,262		879		5,469	0	8,430	0	3,940,580	0.7918
		#8	1,674,579		240		5,456	0	8,431	0	4,335,230	0.7899
	Hadong	#1	1,651,998		386		5,263	0	7,561	0	3,948,643	0.8253
		#2	1,758,216		133		5,262	0	8,421	0	4,181,012	0.8292
		#3	1,760,793		94		5,264	0	8,671	0	4,229,016	0.8213
		#4	1,623,350		610		5,260	0	8,416	0	3,877,595	0.8255
		#5	1,762,407		369		5,259	0	8,643	0	4,210,179	0.8251
		#6	1,642,064		367		5,263	0	8,423	0	3,972,047	0.8155
		#7	1,314,119		674		5,528	0	8,474	0	3,497,189	0.7789
		#8	1,586,695		34		5,525	0	8,578	0	4,221,464	0.7782
	Dangjin	#1	1,802,866		89		5,140	0	8,294	0	4,240,235	0.8190
		#2	1,812,592		168		5,133	0	8,522	0	4,271,208	0.8163
		#3	1,660,911		430		5,140	0	8,532	0	3,924,887	0.8153
		#4	1,593,667		974		5,134	0	8,469	0	3,757,184	0.8167
		#5	1,676,374		332		5,198	0	8,533	0	4,133,329	0.7902
		#6	1,722,658		157		5,195	0	8,520	0	4,242,960	0.7904
		#7	1,572,939		347		5,207	0	8,534	0	3,870,155	0.7932
		#8	1,729,056		90		5,191	0	8,497	0	4,272,886	0.7872
	Ulsan	#1		59,593	278	0	0	9,420	8,369	0	220,710	0.8072

		#2		50,627	249	0	0	9,423	8,382	0	185,534	0.8162
		#3		70,519	286	0	0	9,352	8,361	0	261,312	0.8006
		#4		229,069	4,116	0	0	9,511	8,350	0	927,792	0.7535
		#5		204,124	4,395	0	0	9,526	8,350	0	823,717	0.7597
		#6		217,795	3,058	0	0	9,506	8,350	0	887,331	0.7463
	Yeongnam	#1		91,050	1,170		0	9,705	8,785	0	354,224	0.7974
		#2		80,387	786		0	9,702	8,696	0	304,146	0.8174
	Yeosu	#1		118,289	370		0	9,539	8,350	0	481,530	0.7426
		#2		236,662	278		0	9,543	8,345	0	956,556	0.7471
	Pyeongtaek	#1		188,829	121	3,409	0	9,435	8,542	11,693	794,103	0.7210
		#2		172,352	102	6,484	0	9,430	8,485	11,691	742,439	0.7156
		#3		194,662	115	4,814	0	9,443	8,517	11,702	830,437	0.7155
		#4		158,042	91	3,646	0	9,443	8,540	11,651	669,443	0.7195
	Namjeju	#1		0	0	0	0	0	0	0	0	0.0000
		#2		0	0	0	0	0	0	0	0	0.0000
		#3		151,950	105	0	0	9,410	8,505	0	594,537	0.7607
		#4		146,544	134	0	0	9,410	8,472	0	580,342	0.7517
	Jeju	#1		0	0	0	0	0	0	0	0	
		#2		76,706	78	0	0	9,379	8,440	0	298,469	0.7626
		#3		89,373	82	0	0	9,379	8,492	0	344,920	0.7688
	Seoul	#4		0	0	77,219	0	0	0	11,746	356,493	0.5784
		#5		0	1	169,145	0	0	6,650	11,746	815,062	0.5542
	Incheon	#1		0	0	95,108	0	0		11,747	477,252	0.5322
		#2		0	0	105,649	0	0		11,748	544,351	0.5184
		#3		0	0	0	0	0		0	0	0.0000
		#4		0	0	0	0	0		0	0	
	Pyongtaek	C/C				237,805	0	0		11,691	1,472,808	0.4291
	Ilsan	C/C			0	755,305	0	0		11,745	4,306,850	0.4683

	Bundang	C/C			0	725,097	0	0		11,747	4,311,466	0.4491
	Ulsan	C/C			0	846,672	0	0		11,576	5,709,782	0.3902
	Seoincheon	C/C			76	1,633,316	0	0	8,750	11,745	11,756,041	0.3710
	Shinincheon	C/C			0	1,349,902	0	0		11,747	9,595,856	0.3757
	Boryeong	C/C			0	1,016,783	0	0		11,747	7,053,566	0.3850
	Incheon	C/C			0	1,035,486	0	0		11,745	7,789,931	0.3549
	Busan	C/C			12	1,666,675	0	0	4,275	11,748	12,489,596	0.3564
	Hallim	C/C			12,737	0	0	0	8,536	0	45,450	0.7271
	Anyang	C/C			0	308,918	0	0		12,447	1,824,654	0.4791
	Bucheon	C/C			0	303,789	0	0		12,454	1,806,919	0.4760
	POSCO POWER	C/C			0	809,100	0	0		11,411	4,297,788	0.4884
	GS Bugog	C/C	0		0	807,082	0	0		11,756	6,053,971	0.3563
	Yulchon	C/C	0		0	372,560	0	0		11,748	2,680,710	0.3712
	Kwangyang	C/C	0		0	0	0	0		0	-	0.0000
	Hyundai-Daesan	C/C	0		0	0	0	0		0	-	0.0000
	Kunsan	C/C			0	398,151	0	0		11,746	2,937,873	0.3619
	Yungwol	C/C			263	182,365	0	0	8,499	11,750	1,281,206	0.3807
	Namjeju	D/P		20,334	369		0	9,385	8,493	0	91,340	0.6709
	Jeju	G/T		0	697		0	0	8,550	0	1,115	1.6246
	Jeju	D/P	0	85,093	0		0	9,371	0	0	405,634	0.6214
	Total		74,729,407	2,644,752	54,403	12,914,480					279,038,209	0.6820
	Honam	#1	953,215	177	112	0	5,248	9,334	8,440	0	1,905,966	0.9839
		#2	879,567	1,210	214	0	5,249	9,321	8,395	0	1,747,338	0.9924
2011	Samchonpo	#1	1,948,868	0	475	0	5,206	0	7,770	0	4,359,352	0.8724
		#2	1,970,242	0	262	0	5,192	0	8,470	0	4,419,002	0.8676
		#3	1,986,001	0	105	0	5,191	0	10,025	0	4,573,786	0.8447

		#4	1,690,312	0	1,035	0	5,179	0	8,717	0	3,865,121	0.8494
		#5	1,838,960	0	560	0	4,567	0	8,450	0	3,810,806	0.8262
		#6	1,846,398	0	251	0	4,575	0	8,444	0	3,835,815	0.8253
	Yonghung	#1	2,699,097	0	1,340	0	5,225	0	8,410	0	6,433,472	0.8219
		#2	2,683,956	0	1,759	0	5,227	0	8,832	0	6,426,393	0.8188
		#3	2,880,873	0	651	0	5,231	0	8,407	0	6,959,292	0.8116
		#4	2,543,874	0	2,002	0	5,194	0	8,651	0	5,993,268	0.8270
	Boryeong	#1	1,631,824	0	683	0	5,130	0	8,320	0	3,658,190	0.8579
		#2	1,862,926	0	514	0	5,129	0	8,430	0	4,152,770	0.8625
		#3	1,773,564	0	244	0	5,137	0	8,297	0	4,195,243	0.8140
		#4	1,622,205	0	537	0	5,139	0	8,295	0	3,855,254	0.8106
		#5	1,671,582	0	1,308	0	5,135	0	8,306	0	3,929,511	0.8193
		#6	1,514,320	0	3,349	0	5,156	0	8,312	0	3,592,960	0.8167
		#7	1,595,059	0	703	0	5,187	0	8,301	0	3,985,396	0.7784
		#8	1,684,495	0	608	0	5,193	0	8,347	0	4,230,455	0.7752
	Taean	#1	1,718,777	0	1,054	0	5,219	0	8,431	0	4,081,011	0.8243
		#2	1,686,651	0	968	0	5,216	0	8,427	0	3,981,618	0.8285
		#3	1,732,630	0	917	0	5,210	0	8,427	0	4,095,757	0.8265
		#4	1,579,296	0	1,132	0	5,218	0	8,427	0	3,730,898	0.8285
		#5	1,659,427	0	804	0	5,386	0	8,431	0	4,044,894	0.8285
		#6	1,660,393	0	766	0	5,385	0	8,428	0	4,036,939	0.8305
		#7	1,714,300	0	423	0	5,225	0	8,431	0	4,143,649	0.8102
		#8	1,676,411	0	620	0	5,218	0	8,434	0	4,052,165	0.8094
	Hadong	#1	1,800,151	0	193	0	5,168	0	8,442	0	4,201,848	0.8298
		#2	1,697,458	0	372	0	5,163	0	8,999	0	3,939,767	0.8338
		#3	1,690,815	0	267	0	5,168	0	8,322	0	3,948,628	0.8295
		#4	1,819,283	0	132	0	5,164	0	8,341	0	4,210,204	0.8363

		#5	1,679,060	0	522	0	5,172	0	8,381	0	3,955,693	0.8230
		#6	1,801,037	0	156	0	5,172	0	8,404	0	4,234,960	0.8243
		#7	1,547,047	0	583	0	5,449	0	8,346	0	3,989,890	0.7921
		#8	1,361,806	0	2,010	0	5,453	0	8,462	0	3,536,970	0.7881
	Dangjin	#1	1,656,563	0	953	0	5,046	0	8,338	0	3,722,484	0.8421
		#2	1,644,619	0	704	0	5,052	0	8,303	0	3,703,032	0.8412
		#3	1,874,479	0	0	0	5,050	0	0	0	4,260,116	0.8326
		#4	1,880,478	0	71	0	5,053	0	8,349	0	4,275,089	0.8328
		#5	1,601,149	0	337	0	5,119	0	8,310	0	3,822,712	0.8037
		#6	1,590,289	0	861	0	5,102	0	8,359	0	3,799,971	0.8007
		#7	1,683,155	0	545	0	5,110	0	8,548	0	3,990,467	0.8080
		#8	1,611,032	0	699	0	5,106	0	8,501	0	3,885,254	0.7938
	Ulsan	#1	0	65,421	320	0	0	9,399	8,357	0	241,206	0.8092
		#2	0	60,052	271	0	0	9,410	8,368	0	220,870	0.8119
		#3	0	71,455	231	0	0	9,409	8,365	0	263,718	0.8081
		#4	0	141,246	2,447	0	0	9,527	8,350	0	579,319	0.7450
		#5	0	195,802	3,498	0	0	9,526	8,360	0	811,709	0.7373
		#6	0	172,458	1,274	0	0	9,533	8,351	0	706,839	0.7398
	Yeongnam	#1	0	66,130	903	0	0	9,693	8,366	0	257,829	0.7948
		#2	0	57,618	481	0	0	9,705	8,374	0	218,307	0.8153
	Yeosu	#1	0	76,903	452	0	0	9,740	8,338	0	311,053	0.7649
		#2	0	0	6,167	0	0	0	8,314	0	873,675	0.0178
	Pyeongtaek	#1	0	139,046	85	26,800	0	9,533	8,516	12,448	700,456	0.7068
		#2	0	119,917	75	34,935	0	9,521	8,550	11,496	665,563	0.6797
		#3	0	125,416	39	17,618	0	9,571	8,501	11,770	606,066	0.7040
		#4	0	108,044	47	20,060	0	9,508	8,449	11,974	543,457	0.6982
	Namjeju	#1	0	0	0	0	0	0	0	0	0	0.0000

		#2	0	0	0	0	0	0	0	0	0	0.0000
		#3	0	141,259	116	0	0	9,392	8,444	0	551,178	0.7614
		#4	0	161,171	52	0	0	9,390	8,568	0	630,859	0.7585
	Jeju	#1	0	0	0	0	0	0	0	0	0	
		#2	0	78,003	128	0	0	9,390	3,229	0	307,320	0.7538
		#3	0	96,861	75	0	0	9,391	7,220	0	376,774	0.7636
	Seoul	#4	0	0	0	67,400	0	0	0	11,747	313,916	0.5734
		#5	0	0	0	145,131	0	0	0	11,748	705,553	0.5494
	Incheon	#1	0	0	0	105,615	0	0		11,746	542,437	0.5199
		#2	0	0	0	112,296	0	0		11,746	581,043	0.5161
		#3	0	0	0	0	0	0		0	0	0.0000
		#4	0	0	0	0	0	0		0	0	0.0000
	Pyongtaek	C/C	0	0	0	235,935	0	0		11,858	1,458,270	0.4361
	Ilsan	C/C	0	0	0	595,669	0	0		11,747	3,415,525	0.4657
	Bundang	C/C	0	0	0	632,263	0	0		11,755	3,762,236	0.4491
	Ulsan	C/C	0	0	0	1,021,561	0	0		11,647	7,011,947	0.3858
	Seoincheon	C/C	0	0	26	1,645,667	0	0	8,879	11,746	11,828,077	0.3715
	Shinincheon	C/C	0	0	0	1,225,449	0	0		11,747	8,470,640	0.3863
	Boryeong	C/C	0	0	0	925,348	0	0		11,757	6,463,535	0.3827
	Incheon	C/C	0	0	0	965,530	0	0		11,747	7,230,855	0.3566
	Busan	C/C	0	0	32	1,554,837	0	0	8,550	11,753	11,583,721	0.3587
	Hallim	C/C	0	0	12,493	0	0	0	8,510	0	43,828	0.7374
	Anyang	C/C	0	0	0	322,478	0	0		11,754	1,888,326	0.4563
	Bucheon	C/C	0	0	0	513,362	0	0		6,895	1,775,876	0.4531
	POSCO POWER	C/C	0	0	0	1,088,204	0	0		13,172	10,681,153	0.3051
	GS Bugog	C/C	0		0	770,789	0	0		15,685	5,794,391	0.4744

	Yulchon	C/C	0	0	0	368,468	0	0		11,752	2,667,408	0.3691
	Kwangyang	C/C	0	0	0	0	0	0		0	6,439,416	0.0000
	Hyundai-Daesan	C/C	0		0	0	0	0		0	167,685	0.0000
	Kunsan	C/C	0	0	0	648,722	0	0		11,754	4,926,279	0.3519
	Yungwol	C/C	0	0	65	564,915	0	0	8,535	11,756	4,107,372	0.3676
	Namjeju	D/P	0	22,894	381	0	0	9,357	8,550	0	103,234	0.6655
	Jeju	G/T	0	0	552	0	0	0	8,495	0	1,021	1.3960
	Jeju	D/P	0	97,504	0	0	0	9,395	0	0	469,240	0.6171
	Total		77,643,644	1,998,587	62,011	13,609,052					292,872,588	0.6592
2012	Honam	#1	838,567	841	248	0	5,199	9,379	8,079	0	1,623,103	1.0085
		#2	829,225	1,283	261	0	5,164	9,434	8,110	0	1,600,042	1.0057
	Samchonpo	#1	1,734,922	0	763	0	5,191	0	5,895	0	3,774,402	0.8945
		#2	1,781,209	0	570	0	5,182	0	8,247	0	3,840,534	0.9009
		#3	1,974,728	0	437	0	5,176	0	5,365	0	4,488,367	0.8535
		#4	1,954,610	0	973	0	5,175	0	7,360	0	4,447,087	0.8528
		#5	2,006,927	0	496	0	4,607	0	8,583	0	4,164,568	0.8322
		#6	2,009,746	0	367	0	4,611	0	8,607	0	4,182,729	0.8304
	Yonghung	#1	2,721,124	0	1,120	0	2,103	0	8,403	0	6,455,118	0.3327
		#2	2,674,172	0	1,223	0	5,365	0	4,805	0	6,396,899	0.8408
		#3	2,510,879	0	807	0	5,623	0	8,098	0	6,013,822	0.8801
		#4	2,861,599	0	1,470	0	4,634	0	7,692	0	6,892,623	0.7214
	Boryeong	#1	1,334,886	0	1,570	0	5,296	0	8,309	0	3,030,755	0.8754
		#2	1,252,224	0	1,340	0	5,271	0	8,289	0	2,876,061	0.8611
		#3	1,545,192	0	1,366	0	5,251	0	8,302	0	3,656,959	0.8324
		#4	1,750,799	0	542	0	5,256	0	8,299	0	4,166,818	0.8279
		#5	1,474,945	0	1,262	0	5,261	0	4,714	0	3,533,851	0.8233

		#6	1,728,995	0	641	0	5,255	0	8,298	0	4,190,531	0.8129
		#7	1,719,279	0	381	0	5,261	0	7,064	0	4,302,263	0.7881
		#8	1,527,458	0	753	0	5,260	0	6,711	0	3,836,658	0.7850
	Taean	#1	1,508,935	0	2,107	0	5,284	0	8,431	0	3,627,039	0.8252
		#2	1,517,356	0	1,179	0	5,279	0	8,433	0	3,642,931	0.8247
		#3	1,690,809	0	786	0	5,279	0	45,737	0	4,099,974	0.8184
		#4	1,716,489	0	544	0	5,282	0	118,317	0	4,144,634	0.8244
		#5	1,396,846	0	904	0	5,460	0	8,431	0	3,399,779	0.8413
		#6	1,618,494	0	419	0	5,465	0	23,414	0	4,019,762	0.8252
		#7	1,639,797	0	712	0	5,281	0	8,434	0	4,028,694	0.8059
		#8	1,733,778	0	322	0	5,277	0	8,417	0	4,265,401	0.8040
	Hadong	#1	1,638,729	0	391	0	5,225	0	9,310	0	3,859,776	0.8315
		#2	1,771,456	0	72	0	5,231	0	4,974	0	4,158,942	0.8349
		#3	1,771,981	0	107	0	5,233	0	9,349	0	4,170,037	0.8333
		#4	1,672,520	0	203	0	5,236	0	8,990	0	3,935,505	0.8340
		#5	1,769,468	0	147	0	5,233	0	885	0	4,227,277	0.8208
		#6	1,653,549	0	549	0	5,230	0	9,301	0	3,958,109	0.8191
		#7	1,439,432	0	273	0	5,395	0	10,795	0	3,695,547	0.7877
		#8	1,594,307	0	1,634	0	5,410	0	7,880	0	4,077,193	0.7937
	Dangjin	#1	1,722,103	0	516	0	5,239	0	8,359	0	4,068,599	0.8312
		#2	1,780,480	0	185	0	5,231	0	8,329	0	4,191,526	0.8328
		#3	1,661,873	0	514	0	5,237	0	7,513	0	3,933,489	0.8294
		#4	1,674,812	0	305	0	5,247	0	7,522	0	3,972,806	0.8291
		#5	1,664,249	0	267	0	5,261	0	8,322	0	4,051,030	0.8101
		#6	1,641,425	0	471	0	5,271	0	7,191	0	4,045,961	0.8015
		#7	1,543,249	0	1,278	0	5,261	0	7,822	0	3,776,402	0.8064
		#8	1,637,158	0	767	0	5,258	0	8,333	0	4,006,729	0.8055

	Yeosu	#2	1,229,535	0	1,940	0	3,508	0	9,331	0	2,274,787	0.7129
	Ulsan	#1	0	163,415	477	0	0	9,413	8,650	0	603,071	0.8084
		#2	0	149,879	174	0	0	9,413	8,004	0	557,038	0.8014
		#3	0	149,107	99	0	0	9,417	8,416	0	554,326	0.8012
		#4	0	384,933	949	0	0	7,128	8,302	0	1,562,381	0.5566
		#5	0	281,963	2,559	0	0	6,767	7,768	0	1,151,279	0.5292
		#6	0	373,452	1,019	0	0	8,070	8,431	0	1,520,725	0.6282
	Yeongnam	#1	0	138,335	1,012	0	0	9,665	8,999	0	531,092	0.8010
		#2	0	154,315	582	0	0	9,665	8,509	0	570,891	0.8284
	Yeosu	#1	0	43,622	154	0	0	9,677	8,297	0	175,385	0.7631
	Pyeongtaek	#1	0	196,853	261	10,982	0	7,849	28,354	17,893	893,684	0.5990
		#2	0	184,862	268	15,181	0	7,043	25,023	16,672	864,939	0.5447
		#3	0	159,065	147	15,170	0	6,542	42,362	15,964	756,367	0.5102
		#4	0	212,574	210	11,999	0	7,077	35,449	15,282	952,099	0.5456
	Namjeju	#1	0	0	0	0	0	0	0	0	0	0
		#2	0	0	0	0	0	0	0	0	0	0
		#3	0	156,209	78	0	0	9,397	7,429	0	609,639	0.7614
		#4	0	152,664	138	0	0	9,397	8,137	0	601,048	0.7550
	Jeju	#1	0			0	0	-	-	0	0	0
		#2	0	104,942	84	0	0	9,403	5,338	0	415,703	0.7506
		#3	0	110,098	27	0	0	9,405	4,293	0	421,808	0.7761
	Seoul	#4	0	0	0	115,755	0	0	0	11,749	539,083	0.5735
		#5	0	0	1	206,444	0	0	0	11,749	1,041,311	0.5295
	Incheon	#1	0	0	0	158,188	0	0	0	11,693	814,151	0.5165
		#2	0	0	0	140,897	0	0	0	12,833	919,853	0.4469
		#3	0	0	0	0	0	0	0	0	0	0
		#4	0	0	0	0	0	0	0	0	0	0

Pyongtaek	C/C	0	0	0	241,313	0	0	0	12,146	1,512,259	0.4406
Ilsan	C/C	0	0	0	750,595	0	0	0	11,737	3,936,084	0.5088
Bundang	C/C	0	0	12	756,685	0	0	0	10,297	4,484,056	0.3950
Ulsan	C/C	0	0	0	952,514	0	0	0	11,632	6,851,724	0.3676
Seoincheon	C/C			44	1,729,987	0	0	15,092	11,752	12,402,910	0.3727
Shinincheon	C/C	0	0	0	1,581,664	0	0	0	11,752	11,391,183	0.3710
Boryeong	C/C	0	0	0	874,408	0	0	0	11,719	6,152,029	0.3787
Incheon	C/C	0	0	0	924,514	0	0	0	11,751	6,902,460	0.3578
Busan	C/C	0	0	14	1,498,509	0	0	9,025	11,760	11,215,239	0.3572
Hallim	C/C	0	0	33,161	0	0	0	7,336	-	117,697	0.6283
Anyang	C/C	0	0	0	416,235	0	0	0	12,092	2,670,487	0.4285
Bucheon	C/C	0	0	0	345,146	0	0	0	11,756	1,990,957	0.4633
POSCO POWER	C/C	0	0	0	1,992,710	0	0	0	11,742	13,308,692	0.3997
GS Bugog	C/C	0	0	0	906,572	0	0	0	11,786	6,734,658	0.3607
Yulchon	C/C	0	0	0	425,712	0	0	0	18,471	3,024,133	0.5911
Kwangyang	C/C	0	0	0	0	0	0	0	0	6,485,208	0
Hyundai-Daesan	C/C	0	0	0	0	0	0	0	0	365,186	0
Kunsan	C/C	0	0	0	712,561	0	0	0	11,992	5,504,259	0.3529
Yungwol	C/C	0	0	138	528,146	0	0	8,660	11,756	3,816,318	0.3700
Namjeju	D/P	0	9,322	235	0	0	9,405	7,624	0	47,586	0.5938
Jeju	G/T	0	0	3,412	0	0	0	3,101	0	2,223	1.4469
Jeju	D/P	0	94,349	0	0	0	9,412	0	0	448,535	0.6258
Total		76,920,316	3,222,083	78,437	15,311,887					306,524,875	0.6411

**** Operating Margin emission factor**

Year	Electricity generation by OM plants	CO_2 emissions by OM plants
2010	279,038,209	190,305,054
2011	292,872,588	193,066,862
2012	306,524,875	196,508,105
Total	**878,435,672**	**579,880,021**

EF_{OM} = 0.6601 tonCO_2/MWh

[Appendix 4- 2] Sample group plants used in the Build Margin calculation and CO2 Emission Factor of the Build Margin

Year	3	Plant name		Technology	Type of Fossil Fuel	Year operation	Net electricity generated (EGm,y)	CO2 emission factor (tCO2/MWh)	EF for each plant (tCO2eq./MWh)
2012	1	Namjeju solar		Solar		2012.10	101		
	2	Sejong waste solar		Solar		2012.10			
	3	Yecheon solar	#1	Solar		2012.10			
	4	Yeonggwang solar	#3	Solar		2012.10	762		
	5	Yeonggwang-wind		wind		2012.10	435		
	6	Busan solar		Solar		2012.10	37		
	7	Juam		small hydro power		2012.10	23		
	8	Sinwolsong	#1	Nuclear		2012.08	4,964,709		
	9	Sinkori	#2	Nuclear		2012.07	5,400,279		
	10	BON solar		Solar		2012.06	-		
	11	Samcheonpo solar	#3	Solar		2012.06	328		
	12	Samcheonpo solar	#4	Solar		2012.06	1,335		
	13	Sejong solar	#1	Solar		2012.06			
	14	Sejong solar	#2	Solar		2012.06			
	15	Sejong solar	#3	Solar		2012.06			
	16	Water-quality restore center solar		Solar		2012.06			
	17	Yeongdong solar		Solar		2012.06	794		
	18	Jeju University solar		Solar		2012.06			

	19	Sangjubo		small hydro power		2012.06			
	20	Dalseongbo		small hydro power		2012.06			
	21	Nakdanbo		small hydro power		2012.06			
	22	Hapcheon,Changnyeongbo		small hydro power		2012.06			
	23	Chilgokbo		small hydro power		2012.06			
	24	Yeosu Expo		Solar		2012.04			
	25	Dangjin solar	#2	Solar		2012.03	1,387		
	26	Hadong solar	#4	Solar		2012.03	406		
	27	Hadong solar	#3	Solar		2012.03	76		
	28	Hadong solar	#2	Solar		2012.03	99		
	29	Hadong solar	#1	Solar		2012.03	52		
	30	Hamanbo		small hydro power		2012.03			
	31	Yeojubo		small hydro power		2012.03			
	32	Sihwa lake tidal		tidal		2012.03	465,924		
	33	WP solar		Solar		2012.02	-		
2011	1	Kwangyanghang solar		Solar		2011.12	2,464		
	2	KC susan solar		Solar		2011.12	1,333		
	3	Seoul solar		Solar		2011.09			
	4	Hadong S/S solar		Solar		2011.09	63		
	5	Busan sinhang solar		Solar		2011.08	120		

	6	Ulsan solar		Solar		2011.08	625		
	7	Tangjeong solar		Solar		2011.08	1,434		
	8	Hoengseongdaem		small hydro power		2011			
	9	Kangjeong		small hydro power		2011			
	10	Kangcheonbo		small hydro power		2011			
	11	Kumibo		small hydro power		2011			
	12	Keumkangbo		small hydro power		2011	8,139		
	13	Keumnambo		small hydro power		2011	7,393		
	14	Baekjebo		small hydro power		2011			
	15	Seungchonbo		small hydro power		2011			
	16	Epobo		small hydro power		2011			
	17	Juksanbo		small hydro power		2011			
	18	Pankyo		small hydro power		2011	2,502		
	19	Yeoicheon pumping	#1	pumping		2011	788,997		
	20	Yeoicheon pumping	#2	pumping		2011			
2010	1	Haengwon solar park		solar		2010.11			
	2	Gunwi		small hydro power		2010.11	-		
	3	Dangjin solar park		solar		2010.10	1,226		
	4	Yeoicheon solar park		solar		2010.10	2,004		
	5	Yeongheung-wind power		wind		2010.10			
	6	Hangwon		small hydro power		2010.10	86		
	7	Seolibo		small hydro power		2010.08	-		
	8	Kyeongcheon	#2	small hydro power		2010.07	-		

	9	Gunsan		Combined		2010.06	5,504,259	0.3529	0.0191
	10	Tapjeong		small hydro power		2010.03	-		
	11	Sinkori	#1	nuclear		2010.02	7,091,408		
	12	Pangweo		small hydro power		2010	-		
	13	Yeongwol		Combined		2010	3,816,318	0.3700	0.0139
	14	Dangjin		small hydro power		2010			
	15	Rural community corp.		small hydro power		2010	-		
	16	New solar energy and others				2010			
2009	1	Gosan		small hydro power		2009.12			
	2	Ilsan fuel cell		fuel cell		2009.09	33,885		
	3	Gosado solar		solar		2009.07			
	4	Pyeongsado solar		solar		2009.07			
	5	Yukdo solar		solar		2009.07			
	6	Yuldo solar		solar		2009.07			
	7	Hadong	#8	steam power	Bituminous coal	2009.06	4,077,193	0.7937	0.0318
	8	Daehanboryeong		small hydro power		2009.05	-		
	9	Hankukhaeyang		small hydro power		2009.05	-		
	10	Wooldolmok		small hydro power		2009.05	-		
	11	Dangsado solar		solar		2009.04			
	12	Hahwado solar		solar		2009.04			
	13	Hwangjedo solar		solar		2009.04			

	14	Seongsan-wind		wind		2009.04			
	15	Yeongwol solar		solar		2009.01	59		
	16	Boseong		small hydro power		2009	-		
	17	Seongju		small hydro power		2009	-		
	18	New solar energy and others				2009			
2008	1	Boryeong	#8	steam power	Bituminous coal	2008.12	3,836,658	0.7850	0.0296
	2	Hadong	#7	steam power	Bituminous coal	2008.12	3,695,547	0.7877	0.0286
	3	Yeongheung	#4	steam power	Bituminous coal	2008.12	6,892,623	0.7214	0.0489
	4	Kyeongcheon		small hydro power		2008.11	-		
	5	Seongnam 2		small hydro power		2008.10			
	6	Nulokdo solar		solar		2008.09			
	7	Jeju solar		solar		2008.09	37		
	8	Boryeong fuel cell		fuel cell		2008.09	1,885		
	9	Naebyeong solar		solar		2008.08			
	10	Yulhyeon		small hydro power		2008.07	-		
	11	Busan C/C solar		solar		2008.07			
	12	Hadong solar		solar		2008.07			
	13	Hongikdongjin		small hydro power		2008.06			
	14	Daecheongdaem		small hydro power		2008.06			
	15	Boryeong	#7	steam power	Bituminous coal	2008.06	4,302,263	0.7881	0.0334
	1	Yeongheung	#3	steam power	Bituminous	2008.06	6,013,822	0.8801	0.0521

	6				coal				
	17	Kori-wind power		wind		2008.05			
	18	Samlangjin solar		solar		2008.04			
	19	Boryeong solar		solar		2008.04			
	20	Boryeong		small hydro power		2008.03			
	21	Yeongheung		small hydro power		2008.03			
	22	Yeonggwang solar park				2008.03			
	23	Boryeong 2		small hydro power		2008.03	-		
	24	POSCO fuel cell		fuel cell		2008.03			
	25	Gunjang heat & power		combined		2008.01			
	26	Seocheon solar		solar		2008.01			
	27	New solar energy and others		solar		2008			
2007	1	Taean		small hydro power		2007			
	2	Hanbit Sungsan the second solar		solar		2007.12			
	3	Taein gangjin solar		solar		2007.12			
	4	Suni gangjin solar		solar		2007.12			
	5	Korea yeongcheon solar		solar		2007.12			
	6	Solar yungam solar		solar		2007.12			
	7	Changwhan yeongduk solar		solar		2007.12			
	8	Samsung jindo		solar		2007.12			
	9	Hwaseong heat & power		combined		2007.12			
	10	Dangjin	#8	steam power	Bituminous coal	2007.12	4,006,729	0.8055	0.0318

11	SP solar yonggwang		solar		2007.11			
12	Dongyang energy sinan		solar		2007.11			
13	Ef yungam solar		solar		2007.11			
14	Dongwon gangjin solar		solar		2007.11			
15	Solec yonggwang solar		solar		2007.11			
16	Solar jungeub solar		solar		2007.11			
17	Sinbuk yungam solar		solar		2007.11			
18	Hyein haenam solar		solar		2007.11			
19	Samlangjin solar		solar		2007.11			
20	Hyosung daegi-wind power		wind		2007.11			
21	Nonhyun heat & power		combined		2007.10			
22	Wuriyungam solar		solar		2007.08			
23	Hwasung solar		solar		2007.08			
24	Yeongju the first solar		solar		2007.08			
25	Muan solar		solar		2007.08			
26	Jangheung solar		solar		2007.08			
27	Gomun		small hydro power		2007.08			
28	Taean	#8	steam power	Bituminous coal	2007.08	4,265,401	0.8040	0.0337
2	Dangjin	#7	steam power	Bituminous	2007.06	3,776,402	0.8064	0.0300

	9				coal				
	30	Munkyung solar		solar		2007.06			
	31	Younggwang solar park		solar		2007.06			
	32	Yungam Solar		solar		2007.06			
	33	Wonjungsu		small hydro power		2007.05			
	34	Baekgok		small hydro power		2007.05	-		
	35	damyangho		small hydro power		2007.05	-		
	36	Juam		small hydro power		2007.05			
	37	Namjeju	#4	thermal	heavy oil	2007.03	601,048	0.7550	0.0045
	38	Eco energy		solar		2007.03			
	39	hapcheon		small hydro power		2007.02	7,633		
	40	Jeonju-resource recovery facility				2007.02			
	41	Seoul Marin(suncheon)		solar		2007.02			
	42	Mirae energy		solar		2007.02			
	43	samcheonpo		small hydro power		2007.02			
	44	dalbang		small hydro power		2007.02			
	45	Taean	#7	steam power	Bituminous coal	2007.02	4,028,694	0.8059	0.0319
	46	Yeongju the second solar		solar		2007.01			
	47	Hyundaedaesan		combined		2007.01			

2006	1	Cheongsong pumping	#2	pumping		2006.12	-		
	2	S&P Solar		solar		2006.10			
	3	Bundang fuel cell		fuel cell	LNG	2006.10	2,447		
	4	Namhae Solar		solar		2006.10			
	5	HanlaJeunggong Solar		solar		2006.10			
	6	Yungam Solar		solar		2006.09			
	7	Enepark		solar		2006.09			
	8	Yeongheung solar		solar		2006.09	1,167		
	9	Cheongsong pumping	#1	pumping		2006.09	559,191		
	10	Namjeju	#3	thermal	heavy oil	2006.09	609,639	0.7614	0.0046
	11	yangyang(pumping)	#4	pumping		2006.08	689,556		
	12	Donghae Solar		solar		2006.08			
	13	Kangwon-wind power		wind		2006.07			
	14	Woljeong-wind power		wind		2006.07			
	15	yangyang pump windpower		wind		2006.06			
	16	Hadongho		small hydro power		2006.06	-		
	17	yangyang (pumping)	#3	pumping		2006.06	-		
	18	Goheung Solar		solar		2006.06			
	19	Jangseong		small hydro power		2006.05	-		
	20	yangyang (pumping)	#2	pumping		2006.04	-		
	21	Dangjin	#6	thermal	Bituminous coal	2006.04	4,045,961	0.8015	0.0319
	22	Sinchang-wind power		wind		2006.03			

	23	yangyang (pumping)	#1	pumping		2006.02	-		
2005	1	Janghengdam		small hydro power		2005.12			
	2	Suncheon Solar		solar		2005.12			
	3	Samcheonpo solar energy		solar		2005.12			
	4	Dangjin	#5	steam power	Bituminous coal	2005.10	4,051,030	0.8101	0.0323
	5	yangyang pump small hydro		small hydro power		2005.10			
	6	Taean solar energy		solar		2005.10	130		
	7	Jeju DP		internal combustion	heavy oil	2005.07	448,535	0.6258	0.0028
	8	WunjeongLFG		internal combustion	LFG	2005.07			
	9	Yulchon		combined	LNG	2005.07	3,024,133	0.5911	0.0176
	10	Incheon		combined	LNG	2005.07	6,902,460	0.3578	0.0243
	11	Daegok		small hydro power		2005.07	1,965		
	12	Donghwa		small hydro power		2005.07	-		
	13	Ulchin	#6	nuclear		2005.04	7,703,145		
Total							101,644,356		0.5027

[Appendix 4- 3] Default Values of Carbon content

Fuel	Default carbon content (kg/GJ)	Fuel	Default carbon content (kg/GJ)
Crude oil	20	Oil shale and Tar sands	29.1
Orimulsion	21	Brown Coal Briquettes	26.6
Natural gas liquids	17.2	Patent Fuel	26.6
Motor Gasoline	18.9	Coke Oven Coke and Lignite Coke	29.2
Aviation Gasoline	19.1	Gas Coke	29.2
Jet Gasoline	19.1	Coal Tar	22.0
Jet kerosene	19.5	Gas Works Gas	12.1
Other Kerosene	19.6	Coke Oven Gas	12.1
Shale oil	20	Blast Furnace Gas	70.8
Gas/Diesel oil	20.2	Oxygen Steel Furnace Gas	49.6
Residual fuel oil	21.1	Natural Gas	15.3
LPG	17.2	Municipal Wastes (non-biomass fraction)	25.0
Ethane	16.8	Industrial Wastes	39.0
Naphtha	20.0	Waste Oils	20.0
Bitumen	22.0	Peat	28.9
Lubricants	20.0	Wood/Wood Waste	30.5
Petroleum coke	26.6	Sulphite lyes (black liquor)	26.0
Refinery Feedstocks	20.0	Other Primary Solid Biomass	27.3
Refinery gas	15.7	Charcoal	30.5
Paraffin Waxes	20.0	BioGasoline	19.3
White Spirit & SBP	20.0	Biodiesels	19.3
Other Petroleum Products	20.0	Other Liquid Biofuels	21.7
Anthracite	26.8	Land fill Gas	14.9
Coking coal	25.8	Sludge Gas	14.9
Other bituminous coal	25.8	Other Biogas	14.9
sub-bituminous coal	26.2	Municipal Wastes (biomass fraction)	27.3
gnite	27.6		

Appendix 5. Further background information on monitoring plan

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.

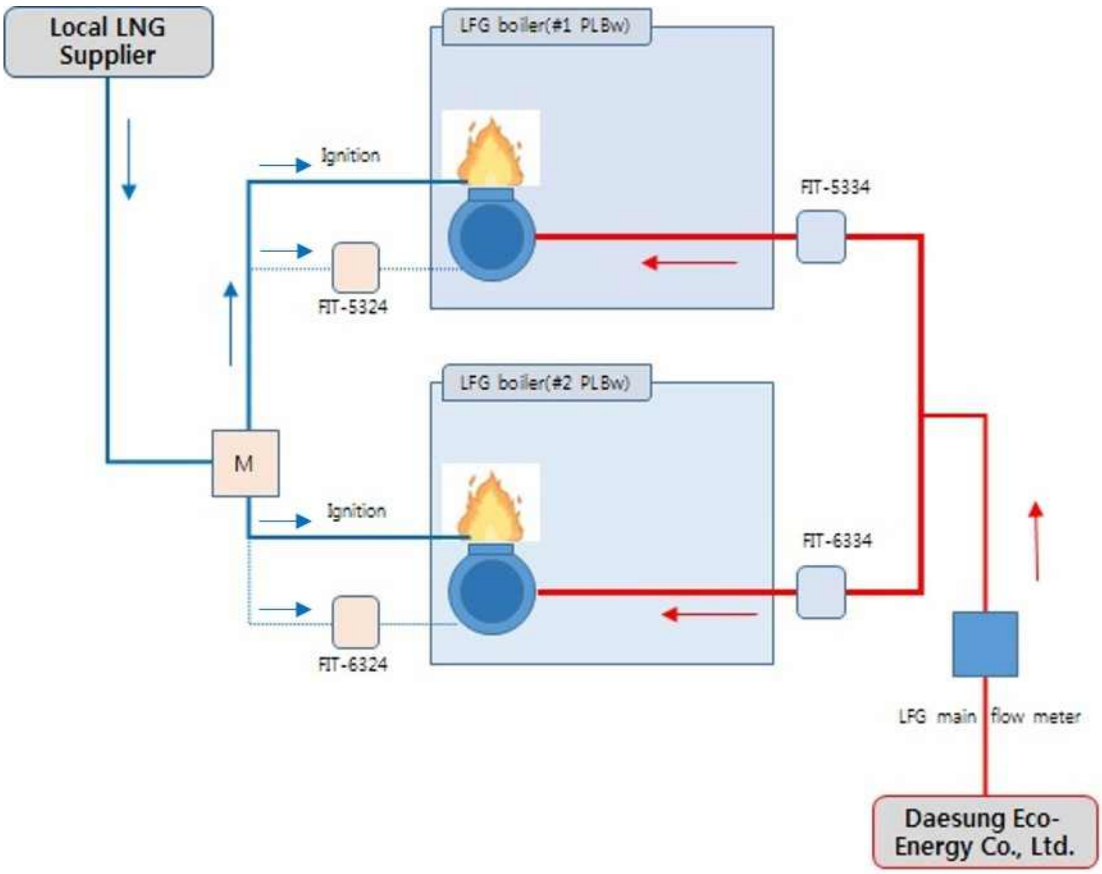


Figure 1. Monitoring diagram of LFG boilers

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

<u>Monitoring equipment and calibration</u>

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 $\mathbf{FC}_{LNG,j,y}$.

Appendix 6. Summary report of comments received from local stakeholders

Not received.

Appendix 7. Summary of post-registration changes

There are some correction of registered PDD in 1st crediting period. One is a technical specifications of installed equipment, the other is a gas analyser as monitoring point.

There are difference between specifications of basic design in the feasibility study and actual adjustment during installation. For measuring $MD_{flared,y}$ under the actual operation, gas analyser AT-101 is appropriate as monitoring point in order to analyse methane density of FIQ-301 for flaring.

Detail information is as follows ;

※ Corrections

- Correction of main equipment due to different between preparation specification(Preliminary design) and actual specification(Working design)

※ Corrections

- Gas analyser monitoring point was revised.
- (Behind the buffer tank : The data measured by this gas analyser will be used to calculate $MD_{flared,y}$ → In front of the buffer tank : The data measured by this gas analyser will be used to calculate $MD_{flared,y}$)

※ Corrections

- The company name was changed from Taegu Energy & Environment Co., Ltd. to Daesung Eco-Energy Co., Ltd.

※ Corrections

- The monitoring structure was changed as the company name is changed. And the name of person in charge was omitted because it is often changed.

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.