Project design document form for CDM project activities

(Version 06.0)

Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	Daegu Bangcheon-Ri Landfill gas CDM Project
Version number of the PDD	Version 09
Completion date of the PDD	05/02/2016
Project participant(s)	Daegu Metropolitan City Daesung Eco-Energy Co., Ltd. Korea District Heating Corporation Ecoeye Co., Ltd.
Host Party	Republic of Korea
Sectoral scope and selected methodology(ies), and where applicable, selected standardized baseline(s)	Scope 13 : Waste handling and disposal Methodology : ACM0001 ver.5 – Consolidated methodology for landfill gas project activities
Estimated amount of annual average GHG emission reductions	404,872 CO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>
-The project activity

Daegu Bangcheon-Ri Landfill gas CDM Project is located in 421, Bangcheon-Ri, Dasa-Eup, Dalsung-Gun, Daegu, Korea. Total project area is 596,760m2 and possible landfill capacity is 15,670,000ton. Municipal Solid Wastes (MSW) from Daegu City has been filled up since 1990 and 14,700,000tons of MSW is completed to fill up. This landfill site is designed to be expanded and 9,144,710 tons of MSW is expected to be filled up from 2005 until 2026.
The treatment of landfill gas from Daegu Bangcheon-Ri Landfill site has been managed as the 'simple on-site treatment' to prevent odour, air pollution and fire before operation of this project. In addition, to reduce methane otherwise which may be released to atmosphere, vertical collection gas pipes and refinery facility are going to be installed. Daegu Bangcheon-Ri Landfill gas CDM Project is the project which captures and refines LFG and refined LFG is supplied to Korea District Heating Corp. to produce thermal energy. Produced thermal energy utilizing LFG is supplied to users.

- 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 impact like odour emission;
• prevents global warming by controlling methane emission to atmosphere;
• reduces CO2 emission through alternating usage of fossil fuel;
• creates financial benefit from CERs.

-The view of the project participant of the contribution of the project activity to sustainable development

•To protect environment, this project:
- traps major landfill gas, CH4 and mitigates climate change
- solves environmental problem 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
- increases positive image of Daegu City

A.2. Location of project activity

A.2.1. Host Party

>>
Republic of Korea

A.2.2. Region/State/Province etc.

>>

Daegu Metropolitan City

A.2.3. City/Town/Community etc.

>>

Bangcheon-Ri, Dasa-Eup, Dalsung-Gun

A.2.4. Physical/Geographical location

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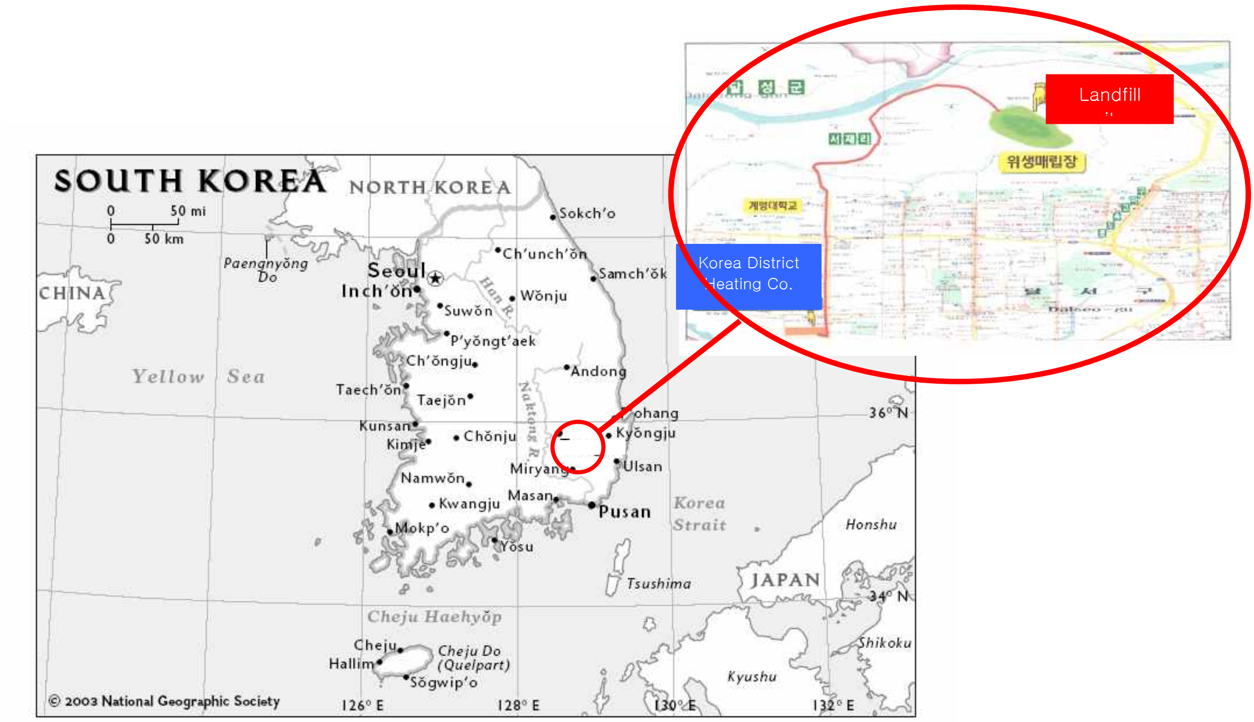
Daegu Bangcheon-Ri Ladfill site is located in 421, Bangcheon-Ri, Dasa-Eup, Dalsung-Gun, Daegu Metropolitan City, Korea and Daegu Metropolitan City, which the project site is located in, is located in the centre of Gyeongsangbuk-Do, which is the province located in the south-eastern part of Korea. The project site is located in the east longitude 123 °26´, the north latitude 35°52´ and surrounded by mountains except the north site of the project site. For the project site location, refer to <figure A-1> and <figure A-2>



<figure A-1> The location of Daegu Bangcheon-Ri Landfill site

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

A.3. Technologies and/or measures

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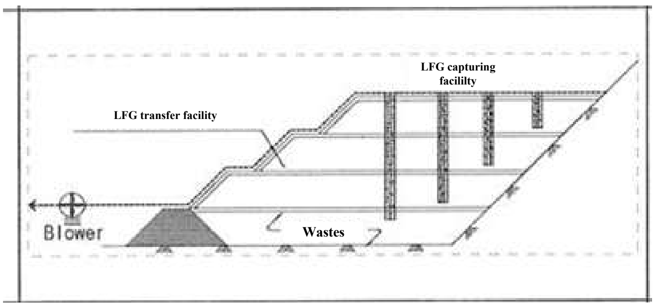
● LFG capturing system

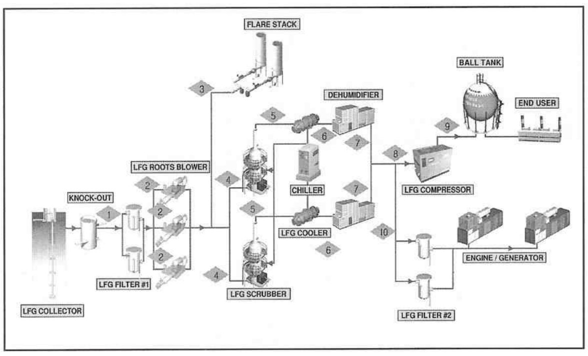
In order to capture LFG, vertical capturing pipes are under construction. Type of LFG capturing system was decided considering characteristic of a step-by-step filling operation. Also, this decision was for maintaining stable and optimum capturing efficiency. Comparing to horizontal capturing system, vertical capturing system has higher capturing efficiency and is easier to maintain and repair the system for each pipe.



<Figure A-3> Vertical LFG capturing equipment installation concept

● LFG utilization system

LFG utilization system mainly consists of 4 parts, blower, refinery facility, generation facility and gas storage.



<Figure A-4> LFG utilization system flow chart

► Blower

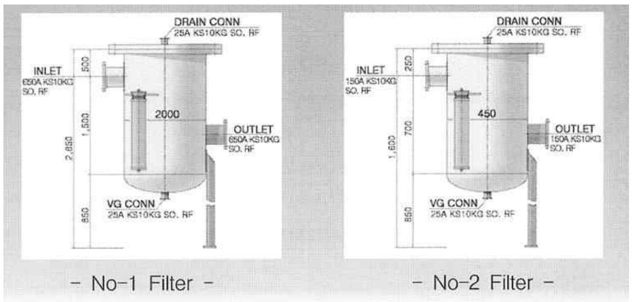
Blower delivers LFG capturing pressure and supplies LFG to utilization system. Blower type applied to this project, Turbo Blower, is non-friction type, therefore it causes less noise. Additionally, this blower has less efficiency fluctuation when it is used for long time.

<Figure A-5> Turbo Blower

- capacity : 75 Nm3/min for 1unit (3units will be installed. 2units for operation and 1unit for in case
- Pressure : -3,800 mmAqG (-2,300/+1,500)
- noise : less than 90dB (at intervals of a 1 meter)

► Filter

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

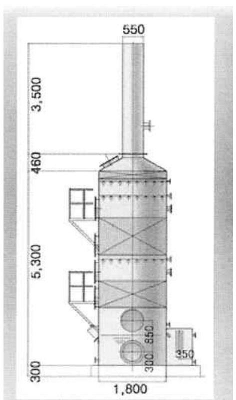


<Figure A-6> Filter

- No-1 Filter (before a blower) : smaller than 5μm-particles are able to pass.
- No-2 Filter (before gas engine) : smaller than 0.3 μm-particles are able to pass.

► Scrubber

Scrubber removes acid gas (H2S, NH3 etc.) of LFG using solubility, so that the problem of erosion of the facility and pollutant emission can be reduced.



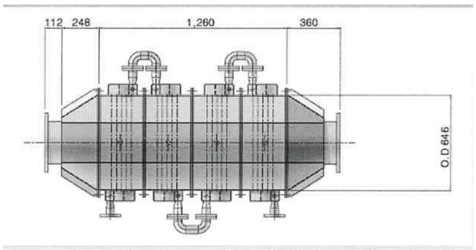
<Figure A-7> Scrubber

- capacity : 75 Nm3/min * 2sets
- type : Packed Tower Scrubber (attach Demister)

- inlet density : H_2S – 60 → 5 ppm (removal efficiency 90%)
  NH_3 – 50 → 5 ppm (removal efficiency 91.7%)

► Cooler

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

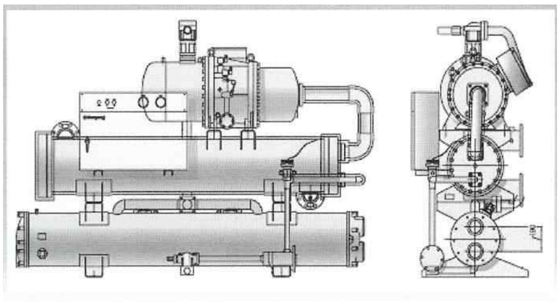


<Figure A-8> Cooler

- capacity : 75 Nm3/min * 2sets
- type : Fin Tube Cooler
- inlet/outlet condition : temperature – 40℃ → 5℃
- cooling medium : Chilled Water

► Chiller

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

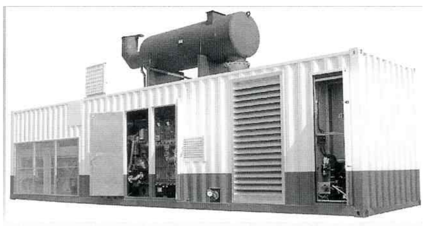


<Figure A-9> Chiller

- circulation flow : 108m3/hr
- thermal capacity : 147RT
- inlet/outlet temperature : 8/3℃

► Gas Engine

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

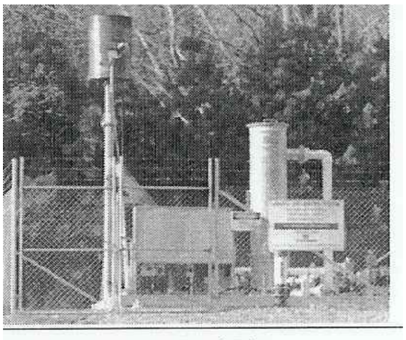


<Figure A-10> Gas Engine

- Output : 1,500kW (750kW x 2 sets, Container Type)
- Voltage : 3.3kV

► Flare Stack

Flare Stack normally treats remnant LFG, and in case of emergency treats LFG so that odour effect can be minimized. The type of flare stack applied to this project is Cylindrical Type. This type of flare stack is economically efficiency but influenced by climate and fire can be seen outside the stack.



<Figure A-11> Flare Stack

- type : Cylindrical Type

► Gas storage tank

Refined LFG is Medium Energy Content Gas. Produced Medium Energy Content Gas is stored in a gas storage tank and homogenized, so that LFG is supplied to users stably.

<Figure A-12> Gas storage tank

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (host)	• Public entity: Daegu Metropolitan City (project developer) •Private Entity: Daesung Eco-Energy Co., Ltd. (project executor) • Public entity: Korea District Heating Corp. •Private Entity: Ecoeye Co., Ltd. (project consultant)	

A.5. Public funding of project activity

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

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

>>
The baseline methodology, which is applied to this project, has already been approved methodology taken from ACM0001-"Consolidated baseline methodology for landfill gas project activities---Version 05" for landfill gas capture and flaring.

B.2. Applicability of methodology and standardized baseline

>>
ACM0001-"Consolidated baseline methodology for landfill gas project activities---Version 05" is applicable to landfill gas capture project activities, where the baseline scenarios are the partial or total atmospheric release of the gas and the project activities include situations the following:

a) The captured gas is flared; or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or
c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy from other sources.

The project activity captures LFG and provides captured and refined LFG as energy to users. Therefore, the project activity corresponds to situation a) and b) and ACM0001 is applicable to the project activity as baseline methodology.

B.3. Project boundary

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Landfill	CO_2	No	It can be emitted as a part of LFG.
		CH_4	Yes	It caused by the degradation of organic wastes.
		N_2O	No	Excluded for simplification. This is conservative.
	Simple burning system	CO_2	No	It is caused by oxidation of LFG. Additionally, it is assumed that LFG is combusted perfectly by simple burning system for conservativeness. Therefore, CH4 is not supposed to be emitted.
		N_2O	No	Minor source
	DH plant	CO2	No	Thermal generation by DH plants using fossil fuel (CERs for energy displacement component is not claimed by this project)
		CH4	No	Excluded for simplification. This is conservative.
		N2O	No	Excluded for simplification. This is conservative.
Project scenario	Landfill	CO_2	No	It can be emitted as a part of LFG.
		CH_4	Yes	It is caused by the degradation of organic wastes.
		N_2O	No	Minor source
	Incinerator in the landfill site	CO_2	No	It is caused by oxidation of CH4.
		CH_4	Yes	CH4 is emitted because of imperfect combustion of LFG(CH4).
		N_2O	No	Minor source
	DH plant	CO_2	No	Thermal energy generation by DH plants using fossil fuel and LFG (CERs for energy displacement component is not claimed by this project)
		CH_4	No	Loss from process and pipeline (released in baseline as well) Fugitive emission by fuel transportation (CERs for energy displacement component is not claimed by this project)
		N_2O	No	Minor source

B.4. Establishment and description of baseline scenario

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LFG was treated by simple burning system before the project activity and it is baseline scenario. In baseline scenario, LFG is captured naturally without any compulsory force and combusted by simple burning system which is kind of open flare stack. To estimate how much LFG was treated by simple burning system in baseline scenario, AF is applied. In this PDD, AF is calculated using data from research report about some of landfill sites in Korea temporarily and real AF which will be calculated using real measured data through monitoring procedure will be applied for calculation of emission reduction during crediting period. AF calculation method and baseline emissions are explained in section B.6.3. If reliable data can be used from government for calculation AF, it will be also applied for calculation of emission reduction during crediting period.

B.5. Demonstration of additionality

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

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).

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

Scenario 2 : This project not undertaken as a CDM project activity. 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.

Scenario 3 : The project activity that deliver outputs and on services with comparable quality. 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 CH4 emission. However, it does not give positive influence to the environment more than reducing CH4 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 of this project is Daegu Bangcheon-Ri landfill site and contains income from sale of refined LFG to Korea District Heating Corporation.

Sub-step 2a. Determine appropriate analysis method

The CDM project contains income (from sale of 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 (Taegu Energy & Environment 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	-	-	-	-	-	-
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)	-	-	-	-	-	-	-	-	-	-	-
Other investment cost (except construction cost) (million Won)	-	-	-	-	-	-	-	-	-	-	-
Operation & Maintenance cost (million Won)	2,624	1,273	1,429	1,616	1,251	1,700	1,442	1,523	1,515	1,249	1,703
Other expenses (million Won)	294	285	274	264	254	245	240	231	222	214	155
Corporation tax (million Won)	387	750	702	646	744	612	677	649	649	714	318
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)	42,853,637,764	Accumulated from 2004 to 2026
Cash inflow (Current value)	38,947,294,252	Accumulated from 2004 to 2026
IRR (%)	4.754%	

*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 (%)	4.754	7.0

Based on result of analysis, IRR of the Project is 4.754% 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	4.754
+5% ; Growth of benefit (Increasing unit cost of LFG purchase)	5.791
-5% ; Decrease total cost of construction	5.291
-5% ; Decrease O&M cost	5.152

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. Emission reductions

B.6.1. Explanation of methodological choices

>>
The methodology will be applied by using option a) and b) of ACM0001.
The captured gas will be used as energy instead of fossil fuel but the emission reductions caused by displacing energy from other sources will not be claimed and the excess gas (if any) will be flared.

The way of the methodology applied to the project activity is described as follows:

(1) $ER_y = (MD_{project,y}-MD_{reg,y})*GWP_{CH4}+EL_y*CEF_{electricity,y}-ET_y*CEF_{thermal,y}$

where:

ER_y	is emissions reduction, in tonnes of CO2 equivalents (tCO2e)
$MD_{project,y}$	the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH4)
$MD_{reg,y}$	the amount of methane that would have been destroyed/combusted during the year in the absence of the project, in tonnes of methane (tCH4)
GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is 21tCO2e/tCH4
EL_y	net quantity of electricity exported during year y, in megawatt hours (MWh)
$CEF_{electricity,y}$	CO2 emissions intensity of the electricity displaced, in tCO2e/MWh. This can estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced, or AMS-I.A if captive electricity is used or displaced.
ET_y	Incremental quantity of fossil fuel, defined as difference of fossil fuel used in the baseline and fossil use during project, for energy requirement on site under project activity during the year y, in TJ
$CEF_{thermal,y}$	CO2 emissions intensity of the fuel used to generate thermal/mechanical energy, in tCO2e/TJ

In this project, captured LFG is utilized for producing thermal energy, but emission reductions are not claimed for displacing energy from other sources. Furthermore, because generated electricity using captured LFG is not exported to a grid in this project, this project is not sort of grid-connected electricity generation using LFG. Therefore, imported electricity to meet the project requirements can be considered as leakage and ER_y can be calculated as follow:

$$\mathbf{ER_y = (MD_{project,y}-MD_{reg,y})*GWP_{CH4} - leakage}$$

Leakage is explained in section B.6.3.

(2) $MD_{reg,y} = MD_{project,y} * AF$

ACM0001 states that:
"In case where regulatory or contractual requirement do not specify $MD_{reg,y}$ an "***Adjustment Factor(AF)***" shall be used and justified taking into account the project context."
In Korea, as for the management of LFG, regulation contains that facility for LFG treatment should be established in landfill site but quantitative regulation of LFG treatment is not specified. In the case of Daegu Bangcheon-Ri Landfill site, simple burning system is installed and operated to meet this regulation. Therefore, amount of captured and flared LFG by existing simple burning system is necessary to calculate AF. However, monitoring of captured and flared LFG amount by existing simple burning system has not been performed in every landfill site in Korea and the amount of treated CH4 by simple burning system has not been performed in Daegu Bangcheon-Ri landfill site either.

In 2002, survey for estimating GHG emission and establishing statistics in environmental sector was published. Measuring the amount of treated CH4 included in LFG by simple burning system was performed in 10 landfill sites in Korea in 2001~2002 and collecting data was possible in 8 sites of them.(Source : Survey for estimating GHG emission and establishing statistics in environmental sector, August 2002, Ministry of Environment) Also, the report which is same as the report in 2002 was published in October 2003, as the second survey for estimating GHG emission and establishing statistics and measuring the amount of treated CH4 included in LFG by simple burning system was performed in 5 landfill sites in Korea in 2002~2003.(Source : Survey for estimating GHG emission and establishing statistics in environmental sector (II), October 2003, Ministry of Environment) Collected data from the survey were used to calculate AF for this project. Calculated AF in the PDD is ex-ante value to estimate emission reduction and applied AF for certifying emission reduction will be calculated following monitoring procedure using real measured data in Daegu Bangcheon-Ri Landfill site.
AF was calculated as follows:

First of all, to apply the data from the survey to this project, it was assumed that facts which influence LFG generation have same condition in all landfill sites in Korea.
Collected data from the surveys were number of simple burning systems which were selected for the measurement and annual average of treated CH4 included in LFG by the system. Table below shows the data.

<Table B-5> Collected data from the survey

Content		Annual treated CH4 (CH4-Liter / yr)	number of simple burning system which were collected for the measurement (EA)	treated CH4 of each simple burning system (CH4-Liter/EA)
Report in 2002	Wonju	2,222,955,048	4	555,738,762
	Seosan	1,093,860,864	8	136,732,608
	Youngyang	2,435,789	3	811,930
	Jeonju	100,199,822	2	50,099,911
	Guri	181,925,194	4	45,481,298
	Nonsan	17,707,104	3	5,902,368
	Eumsung	10,483	4	2,621
	Eujeongbu	52,704	2	26,352
Report in 2003	Ulsan Seongam	5,142,838,982	49	104,955,898
	Yongin	1,132,756,243	3 (2 in autumn)	408,615,250
	Boreong	49,708,858	9	5,523,206
	Jecheon	304,378,459	7 in autumn and winter 12 in spring and summer	28,302,322
	Cheonan	1,004,657,098	10 in autumn and winter 7 in spring 28 in summer	72,200,174
Average				108,799,438

From those data, average amount of treated CH4 by a single simple burning system was calculated and the value is 108,799,438 CH4-Liter/EA. Because measurement of the data for ex-ante AF was performed from 2001 to 2003, average amount of generated LFG from 2001 to 2003 was used to calculate ex-ante AF and applied number of simple burning facilities in Daegu Bangcheon-Ri Landfill site for ex-ante AF calculation was number of simple burning facilities established before the project activity.

<Table B-6> AF for Daegu Bangcheon-Ri Landfill site

Content	Value	Unit	Comment
Average amount of captured CH4 by a simple burning system	108,799,438	CH4-Liter/EA	
Number of simple burning systems	41	EA	
Amount of treated CH4 included in LFG by simple burning system in baseline scenario	4,460,776,976	CH4-Liter/yr	For conservativeness applied destruction efficiency factor is 100%
	4,460,777	CH4-m3/yr	
Average amount of generated LFG from 2001 to 2003	113,983,243	LFG-m3/yr	
Average amount of generated CH4 from 2001 to 2003	56,991,621	CH4-m3/yr	CH4 content 50% of LFG
CH4 treatment efficiency before the project (baseline scenario)	7.83%		
The lowest value of expected CH4 treatment efficiency during the first crediting period	53%		
AF	14.79%		

Under the assumption that calculated average amount of treated CH4 by a single simple burning facility is applied in the project site, Daegu Bangcheon-Ri Landfill site, treatment efficiency by simple burning system in the baseline scenario is 7.83%. Additionally, expected treatment efficiency by the project facility is 53% and it is the lowest value of expected CH4 treatment efficiency during the first crediting period. Through this procedure, ex-ante AF for the project is calculated as 14.79%.

(3) $MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y}$

where:
$MD_{flared,y}$ is the quantity of methane destroyed by flaring;
$MD_{electricity,y}$ is the quantity of methane destroyed by generating electricity;
$MD_{thermal,y}$ is the quantity of methane destroyed for the generation of thermal energy.

(4) $MD_{flared,y} = \{LFG_{flared,y} * w_{CH4,y} * D_{CH4}\} - (PE_{flare,y}/GWP_{CH4})$

where :
$MD_{flared,y}$ is the quantity of methane destroyed by flaring, $LFG_{flare,y}$ is the quantity of landfill gas fed to the flare during the year measured in cubic meters (m3), w_{CH4},y is the average methane fraction of the landfill gas as measured (methane fraction of the landfill gas to be measured on wet basis.) during the year and expressed as a fraction (in m3 CH4/m3 LFG), D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH4/m3CH4) (at standard temperature and pressure, the density of methane is 0.0007168tCH4/m3CH4) and $PE_{flare,y}$ are the project emissions from flaring of the residual gas stream in year y (tCO2) determined following the procedure described in the “Tool to determine project emissions from flaring gases containing Methane”.

According to “Tool to determine project emissions from flaring gases containing Methane”, $PE_{flare,y}$ is determined and the tool suggests following steps to decided $PE_{flare,y}$.

STEP 1: Determination of the mass flow rate of the residual gas that is flared
STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas
STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis

STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency
Step 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiency.

Step 3 and 4 are only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

STEP 1. Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour h, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

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

Where:
$FM_{RG,h}$: Mass flow rate of the residual gas in hour h (kg/h)
$\rho_{RG,n,h}$: Density of the residual gas at normal conditions in hour h (kg/m3)
$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h (m3/h)

and:

$$\rho_{RG,n,h} = P_n / \{(R_u / MM_{RG,h}) * T_n\}$$

Where:
$\rho_{RG,n,h}$: Density of the residual gas at normal conditions in hour h (kg/m3)
P_n : Atmospheric pressure at normal conditions (101,325) (Pa)
R_u : Universal ideal gas constant (8.314) (Pa.m3/kmol.K)
$MM_{RG,h}$: Molecular mass of the residual gas in hour h (kg/kmol)
T_n : Temperature at normal conditions (273.15) (K)

and:

$$MM_{RG,h} = \Sigma(fv_{i,h} * MM_i)$$

Where:
$MM_{RG,h}$: Molecular mass of the residual gas in hour h (kg/kmol)
$fv_{i,h}$: Volumetric fraction of component I in the residual gas in the hour h
MM_i : Molecular mass of residual gas component I (kg/kmol)
i : The components CH_4, CO, CO_2, O_2, H_2, N_2
As a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2).

STEP 2. Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, calculated from the volumetric fraction of each component i in the residual gas as follows:

$$fm_{j,h} = (\Sigma fv_{i,h} * AM_j * NA_{j,i}) / MM_{RG,h}$$

Where:
$fm_{j,h}$: Mass fraction of element j in the residual gas in hour h
$fv_{i,h}$: Volumetric fraction of component I in the residual gas in the hour h
AM_j : Atomic mass of element j (kg/kmol)

$NA_{j,i}$: Number of atoms of element j in component i
$MM_{RG,h}$: Molecular mass of the residual gas in hour h (kg/kmol)
j : The elements carbon, hydrogen, oxygen and nitrogen
i : The components CH4, CO, CO2, O2, H2, N2

Step 3 and 4 are only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

STEP 5. Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

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

Where:
$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour h (kg/h)
$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m3/h)
$fv_{CH4,RG,h}$ h : Volumetric fraction of methane in the residual ga on dry basis in hour h (NB: this corresponds to $fv_{i,RG,h}$ where I refers to methane).
$\rho_{CH4,n,h}$: Density of methane at normal conditions (0.716) (kg/m3)

STEP 6. Determination of hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring).

In case of open flares, the flare efficiency in the hour h ($\eta_{flare,h}$) is
•0% if the flame is not detected for more than 20 minutes during the hour h.
•50%, if the flare is detected for more than 20 minutes during the hour h.

STEP 7. Calculation of annual project emissions from flaring

Project emission from flaring are calculated as the sum of emission from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h

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

<Table B-7> Constants used in equations

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecualr mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AMc	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AMh	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AMo	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AMn	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa.m3/kmol.K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15

GWP_{CH4}	tCO2/tCH4	Global warming potential of methane	21
$\rho_{CH4,n,h}$	Kg/m3	Density of methane gas at normal conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	

(5) $MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$

Where :
$LFG_{electricity,y}$ is the quantity of landfill gas fed into the gas engine to generate electricity.

(6) $MD_{thermal,y} = LFG_{thermal,y} * w_{CH4,y} * D_{CH4}$
where :
$LFG_{thermal,y}$ is the quantity of landfill gas fed into the boiler.

B.6.2. Data and parameters fixed ex ante

Data / Parameter	**k**
Unit	1/year
Description	Decay Constant
Source of data	EPA model
Value(s) applied	0.067
Choice of data or Measurement methods and procedures	LFG generation was calculated using EPA Landfill Air Emission Model(ver.2.01), one of well known EPA Model and default value of this model is k = 0.05/year. In this project, k is adjusted as 0.067/year considering contents of wastes in Korea.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	L_0
Unit	$m3_{CH4}/kg_{waste}$
Description	Methane Potential Generation
Source of data	Revised design report of Daegu Bangcheon-Ri sanitary landfill site
Value(s) applied	112.1
Choice of data or Measurement methods and procedures	To design the project facility, EPA Landfill Air Emission Model(ver.2.01) was applied for estimation of LFG generation and applied for the formula in this project L_0 = 112.1 $m3_{CH4}/kg_{waste}$ is conservative value for the project.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$EF_{EL,leakage}$
Unit	tonCO2/MWh
Description	CO2 emissions intensity of the electricity imported
Source of data	Calculated
Value(s) applied	0.5554

Choice of data or Measurement methods and procedures	This value was calculated according to ACM0002 (version 06). Applied value was calculated using Statistics of Electric Power in KOREA (2003,2004,2005) (KEPCO) and Status of Generation facility(2005) (Korea Power Exchange).
Purpose of data	Calculation of project emissions
Additional comment	-The same value will be applied during crediting period without updating. -This value is used for estimation of leakage. - Please refer to **3.** $\mathbf{EF_{EL,\,leakage}}$ of Annex 4 for detail calculation

Data / Parameter	$\mathbf{GWP_{CH4}}$
Unit	tonCO2/tCH4
Description	Regulatory requirements relating to landfill gas projects
Source of data	Revised 1996 IPCC Guideline for National Greenhouse Gas Inventory
Value(s) applied	21
Choice of data or Measurement methods and procedures	Parameter defined within the methodology ACM0001 version 05.
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	N/A

Data / Parameter	$\mathbf{D_{CH4}}$
Unit	tonCH4/m3CH4
Description	Methane density
Source of data	AM0001 version 04
Value(s) applied	0.0007168
Choice of data or Measurement methods and procedures	Parameter defined within the methodology ACM0001 version 04. This factor will be adjusted the on-site pressure and temperature conditions.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$\rho_{CH4,n,h}$
Unit	Kg/m3
Description	Density of methane gas at normal conditions
Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	0.716
Choice of data or Measurement methods and procedures	Parameter defined within the tool, “tool to determine project emissions from flaring gases containing methane”.
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$\eta_{flare,h}$
Unit	-
Description	Flare efficiency in hour h

Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	0.5
Choice of data or Measurement methods and procedures	Parameter defined within the tool, “tool to determine project emissions from flaring gases containing methane”.
Purpose of data	Calculation of project emissions
Additional comment	- This value is 0, if the flame is not detected for more than 20 minutes during the hour h. - This value is 0.5, if the flare is detected for more than 20 minutes during the hour h.

B.6.3. Ex ante calculation of emission reductions

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Ex-ante calculation of emission reductions can be shown as below table briefly:

<Table B-8> GHG reduction amount

Year	ER_y(tCO2e)	=($MD_{project,y}$ - $MD_{reg,y}$) * GWP_{CH4} - leakage
August 2007~July 2008	391,276	=(21,986 - 3,251) * 21 - 2,165
August 2008~July 2009	390,332	=(21,934 - 3,243) * 21 - 2,165
August 2009~July 2010	398,763	=(22,405 - 3,313) * 21 - 2,165
August 2010~July 2011	414,457	=(23,282 - 3,443) * 21 - 2,165
August 2011~July 2012	413,949	=(23,253 - 3,438) * 21 - 2,165
August 2012~July 2013	413,171	=(23,210 - 3,432) * 21 - 2,165
August 2013~July 2014	412,159	=(23,153 - 3,424) * 21 - 2,165

(1) Project emission

Project emission of this project is CH4 emission that is calculated by deducting the amount of CH4 which is captured for utilizing as energy from total amount of CH4 which is emitted from the landfill site.

The amount of captured CH4 for utilizing as energy can be calculated as follows:

(a) $MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y}$

where:

$MD_{flared,y}$ is the quantity of methane destroyed by flaring;

$MD_{electricity,y}$ is the quantity of methane destroyed by generating electricity;

$MD_{thermal,y}$ is the quantity of methane destroyed for the generation of thermal energy.

<Table B-9> Project methane treatment amount

Year	$MD_{project,y}$(tCH4)	= $MD_{flared,y}$ + $MD_{electricity,y}$ + $MD_{thermal,y}$
August 2007~July 2008	21,986	= 859 + 1,257 + 19,870
August 2008~July 2009	21,934	= 860 + 1,257 + 19,816
August 2009~July 2010	22,405	= 879 + 1,257 + 20,268
August 2010~July 2011	23,282	= 1,485 + 1,257 + 20,540
August 2011~July 2012	23,253	= 1,456 + 1,257 + 20,540
August 2012~July 2013	23,210	= 1,413 + 1,257 + 20,540
August 2013~July 2014	23,153	= 1,356 + 1,257 + 20,540

(b) $MD_{flared,y} = \{LFG_{flared,y} * w_{CH4,y} * D_{CH4}\} - (PE_{flare,y}/GWP_{CH4})$

where :

$MD_{flared,y}$ is the quantity of methane destroyed by flaring, $LFG_{flare,y}$ is the quantity of landfill gas fed to the flare during the year measured in cubic meters (m3), w_{CH4},y is the average methane fraction

of the landfill gas as measured (methane fraction of the landfill gas to be measured on wet basis.) during the year and expressed as a fraction (in m3 CH4/m3 LFG), D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH4/m3CH4) (at standard temperature and pressure, the density of methane is 0.0007168tCH4/m3CH4) and $PE_{flare,y}$ are the project emissions from flaring of the residual gas stream in year y (tCO2) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing Methane".

The flare stack installed at the project site is open type and applied flare efficiency is default value. Therefore, only step 5, 6 and 7 of the tool ("Tool to determine project emissions from flaring gases containing Methane") are applied for the project.

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

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

Where:
$TM_{RG,h}$: Mass flow rate of methane in the residual gas in the hour h (kg/h)
$FV_{RG,h}$: Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m3/h)
$fv_{CH4,RG,h}$ h : Volumetric fraction of methane in the residual gas on dry basis in hour h (NB: this corresponds to $fv_{i,RG,h}$ where I refers to methane).
$\rho_{CH4,n,h}$: Density of methane at normal conditions (0.716) (kg/m3)

To measure $fv_{CH4,RG,h}$, gas is analysed on dry basis. The Volumetric flow rate of residual gas ($FV_{RG,h}$) is also measured on dry because the moisture of residual gas is below 1 % and temperature is below 20℃ behind gas cooler.

<Table B-10> $TM_{RG,h}$

Year	$TM_{RG,h}$ (kg/h)	$= FV_{RG,h} * fv_{CH4,RG,h}$ h $* \rho_{CH4,n,h}$
August 2007~July 2008	196	= 546 * 0.5 * 0.716
August 2008~July 2009	196	= 547 * 0.5 * 0.716
August 2009~July 2010	200	= 559 * 0.5 * 0.716
August 2010~July 2011	338	= 945 * 0.5 * 0.716
August 2011~July 2012	332	= 927 * 0.5 * 0.716
August 2012~July 2013	322	= 899 * 0.5 * 0.716
August 2013~July 2014	309	= 863 * 0.5 * 0.716

Step 6. Determination of the hourly flare efficiency

In case of open flares, the flare efficiency in the hour h ($\eta_{flare,h}$) is
•0% if the flame is not detected for more than 20 minutes during the hour h.
•50%, if the flare is detected for more than 20 minutes during the hour h.

Flow rate of LFG fed into the flare stack and the temperature of flare stack with operation time are monitored in real-time and the data is stored in computer automatically. Therefore, project participant can monitor whether the flare stack is operated or not and can apply suitable flare efficiency.

Step 7. Calculation of annual project emissions from flaring

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

<Table B-11> $PE_{flare,y}$

Year	PE(tCO2)	$= \Sigma\ TM_{RG,h} * (1 - \eta_{flare,h}) * GWP_{CH4}/1000$
August 2007~July 2008	17,995	= (196 * (1 - 0.5) * 21 / 1000) * 8760

August 2008~July 2009	18,028	= (196 * (1 - 0.5) * 21 / 1000) * 8760
August 2009~July 2010	18,420	= (200 * (1 - 0.5) * 21 / 1000) * 8760
August 2010~July 2011	31,109	= (338 * (1 - 0.5) * 21 / 1000) * 8760
August 2011~July 2012	30,513	= (332 * (1 - 0.5) * 21 / 1000) * 8760
August 2012~July 2013	29,602	= (322 * (1 - 0.5) * 21 / 1000) * 8760
August 2013~July 2014	28,418	= (309 * (1 - 0.5) * 21 / 1000) * 8760

<Table B-12> Treatment Methane amount at the gas incinerator

Year	$MD_{flared,y}$(tCH4)	= {$LFG_{flared,y}$ * $w_{CH4,y}$ * D_{CH4}}- ($PE_{flare,y}$/GWP_{CH4})
August 2007~July 2008	859	= {4,787,110 * 0.5 * 0.0007168} – (17,955 / 21)
August 2008~July 2009	860	= {4,795,938 * 0.5 * 0.0007168} – (18,028 / 21)
August 2009~July 2010	879	= {4,900,188 * 0.5 * 0.0007168} – (18,420 / 21)
August 2010~July 2011	1,485	= {8,275,845 * 0.5 * 0.0007168} – (31,109 / 21)
August 2011~July 2012	1,456	= {8,117,380 * 0.5 * 0.0007168} – (30,513 / 21)
August 2012~July 2013	1,413	= {7,875,000 * 0.5 * 0.0007168} – (29,602 / 21)
August 2013~July 2014	1,356	= {7,559,871 * 0.5 * 0.0007168} – (28,418 / 21)

(c) $MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$

Where :
$LFG_{electricity,y}$ is the quantity of landfill gas fed into the gas engine to generate electricity.

<Table B-13> Treatment methane amount for electricity generation

Year	$MD_{electricity,y}$(tCH4)	= $LFG_{electricity,y}$ * $w_{CH4,y}$ * D_{CH4}
August 2007~July 2008	1,257	= 3,508,380 * 50% * 0.0007168
August 2008~July 2009	1,257	= 3,508,380 * 50% * 0.0007168
August 2009~July 2010	1,257	= 3,508,380 * 50% * 0.0007168
August 2010~July 2011	1,257	= 3,508,380 * 50% * 0.0007168
August 2011~July 2012	1,257	= 3,508,380 * 50% * 0.0007168
August 2012~July 2013	1,257	= 3,508,380 * 50% * 0.0007168
August 2013~July 2014	1,257	= 3,508,380 * 50% * 0.0007168

(d) $MD_{thermal,y} = LFG_{thermal,y} * w_{CH4,y} * D_{CH4}$

where :
$LFG_{thermal,y}$ is the quantity of landfill gas fed into the boiler.

<Table B-14> Treatment methane amount for the generation of thermal energy

Year	$MD_{thermal,y}$(tCH4)	= $LFG_{thermal,y}$ * $w_{CH4,y}$ * D_{CH4}
August 2007~July 2008	19,870	= 55,440,880 * 50% * 0.0007168
August 2008~July 2009	19,816	= 55,289,402 * 50% * 0.0007168
August 2009~July 2010	20,268	= 56,551,718 * 50% * 0.0007168

August 2010~July 2011	20,540	= 57,309,107 * 50% * 0.0007168
August 2011~July 2012	20,540	= 57,309,107 * 50% * 0.0007168
August 2012~July 2013	20,540	= 57,309,107 * 50% * 0.0007168
August 2013~July 2014	20,540	= 57,309,107 * 50% * 0.0007168

(2) Baseline emission
Baseline emission of this project is CH4 emission that is calculated by deducting the amount of CH4 which is treated by simple burning system, the system before the project activity from total amount of CH4 which is emitted from the landfill site. The amount of CH4 which is treated by simple burning system can be calculated using AF as shown in the methodology ACM0001.

Ex-ante AF for the project is calculated as 14.79%.

$MD_{reg,y} = MD_{project,y} * AF$

<Table B-15> Methane treatment amount based on the baseline scenario

Year	$MD_{reg,y}$(tCH4)	= $MD_{project,y}$ * AF
August 2007~July 2008	3,251	= 21,986 * 14.79%
August 2008~July 2009	3,243	= 21,934 * 14.79%
August 2009~July 2010	3,313	= 22,405 * 14.79%
August 2010~July 2011	3,443	= 23,282 * 14.79%
August 2011~July 2012	3,438	= 23,253 * 14.79%
August 2012~July 2013	3,432	= 23,210 * 14.79%
August 2013~July 2014	3,424	= 23,153 * 14.79%

(3) Leakage
Under ACM0001, no leakage effects need to be accounted.
However, in this project, generated electricity using captured LFG is not exported to a grid but electricity is imported to meet project requirement. Therefore, imported electricity is considered as leakage.

$EL_{leakage} = EL_{imp} * EF_{EL, leakage}$

EL_{imp} is the amount of imported electricity and will be monitored $EF_{EL, leakage}$ is CO2 emissions intensity of the electricity in tCO2e/MWh and estimated using ACM0002. Applied value of $EF_{EL, leakage}$ is 0.5554tCO2e/MWh in this project.
$EF_{EL,leakage}$ is the CO2 emission intensity and measured in tonnes of CO2 equivalents per megawatt hour (tCO2e/MWh). To calculate ACM0002.-"Consolidated baseline methodology for grid-connected electricity generation form renewable sources."(Version 06) is applied.

<Table B-16> Leakage caused by electricity importation

Year	$EL_{leakage}$	= EL_{imp} * $EF_{EL,leakage}$
August 2007~July 2008	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2008~July 2009	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2009~July 2010	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2010~July 2011	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2011~July 2012	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2012~July 2013	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh
August 2013~July 2014	2,165	= 3,898MWh * 0.5554tonCO2eq./MWh

For detail, refer to Annex 4.

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)
August 2007~ July 2008	461,711	68,270	2,165	391,276
August 2008~ July 2009	460,604	68,106	2,165	390,332
August 2009~ July 2010	470,497	69,569	2,165	398,763
August 2010~ July 2011	488,915	72,293	2,165	414,457
August 2011~ July 2012	488,318	72,204	2,165	413,949
August 2012~ July 2013	487,405	72,069	2,165	413,171
August 2013~ July 2014	486,218	71,894	2,165	412,159
Total	3,343,668	494,406	15,155	2,834,107
Total number of crediting years	7years			
Annual average over the crediting period	477,667	70,629	2,165	404,872

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	$LFG_{total,y}$
Unit	Nm3
Description	Total amount of landfill gas captured
Source of data	Read from flow-meter
Value(s) applied	66,769,774 Nm3/yr (average value of data during the crediting period)
Measurement methods and procedures	The data is read from flow-meter installed continuously.
Monitoring frequency	Data to be aggregated monthly and yearly.
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions

Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Flow-meter installed after LFG collector for monitoring this data is 'Vortex Flow meter'. - The data is the volume of wet gas and it will be used for reference. When this value is analysed, the volumetric fraction of moisture in the gas will be calculated and converted to the dry basis for reference (See, Annex 4. 4). - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$LFG_{flare,y}$
Unit	Nm3
Description	Amount of landfill gas flared
Source of data	Read from flow-meter
Value(s) applied	6,615,904Nm3/yr (average value of data during the crediting period)
Measurement methods and procedures	The data is read from flow-meter installed continuously.
Monitoring frequency	Data to be aggregated monthly and yearly.
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Flow-meter installed before the LFG incinerator for monitoring this data is 'Vortex Flow meter'. - Temperature and pressure of gas is measured after the gas is treated by gas cooler. - After the gas is treated by gas cooler, temperature and pressure of gas is maintained the same. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$LFG_{electricity,y}$
Unit	Nm3
Description	Amount of landfill gas combusted in power plant
Source of data	Read from flow-meter
Value(s) applied	3,508,380 Nm3/yr (average value of data during the crediting period)
Measurement methods and procedures	The data is read from flow-meter installed continuously.
Monitoring frequency	Data to be aggregated monthly and yearly.
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.

Purpose of data	Calculation of baseline emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Flow-meter installed before the gas engine generator for monitoring this data is ‘Vortex Flow meter’. - Temperature and pressure of gas is measured after the gas is treated by gas cooler. - After the gas is treated by gas cooler, temperature and pressure of gas is maintained the same. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$LFG_{thermal,y}$
Unit	Nm3
Description	Amount of landfill gas combusted in boiler
Source of data	Read from flow-meter
Value(s) applied	56,645,489.54 Nm3/yr (average value of data during the crediting period)
Measurement methods and procedures	The data is read from flow-meter installed continuously.
Monitoring frequency	Data to be aggregated monthly and yearly
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - The flow meter is installed right in front of the boiler. - This data is the amount of LFG fed into the boiler. - Flow-meter installed for monitoring this data is ‘Vortex Flow meter’. - Temperature and pressure of gas is measured after the gas is treated by gas cooler. - After the gas is treated by gas cooler, temperature and pressure of gas is maintained the same. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$PE_{flare,y}$
Unit	tCO2e
Description	Project emissions from flaring of the residual gas stream in year y
Source of data	Calculation
Value(s) applied	24,869 tCO2e (average value of data during the crediting period)
Measurement methods and procedures	N/A
Monitoring frequency	-

QA/QC procedures	According to “Tool to determine project emissions from flaring gases containing methane”, QA/QC procedure will be applied for the parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$).
Purpose of data	Calculation of project emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - The parameters used for determining the project emissions from flaring of the residual gas stream in year y ($PE_{flare,y}$) will be monitored as per the “Tool to determine project emissions from flaring gases containing Methane”.

Data / Parameter	$fv_{CH4,RG,h}$
Unit	%
Description	Volumetric fraction of methane in the residual gas on dry basis in hour h
Source of data	Measurement by gas analyser
Value(s) applied	50%
Measurement methods and procedures	Gas analyser will be measure this value on dry basis.
Monitoring frequency	Hourly
QA/QC procedures	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Gas Analyser installed for monitoring this data is ‘Infrared Gas Analyzer’ and installed behind the buffer tank.. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high.

Data / Parameter	$FV_{RG,h}$
Unit	m3/h
Description	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h
Source of data	Measurements by a flow meter
Value(s) applied	755 m3/h (average value of data during the crediting period)
Measurement methods and procedures	Flow meter will be measure this value on dry basis. Also, the volumetric fraction of methane in the gas will be analysed on dry basis.
Monitoring frequency	Hourly
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of project emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Flow-meter installed for monitoring this data is ‘Vortex Flow meter’.

Data / Parameter	$TM_{RG,h}$
Unit	Kg/h
Description	Mass flow rate of methane in the residual gas in the hour h

Source of data	Calculation
Value(s) applied	270 kg/h (average value of data during the crediting period)
Measurement methods and procedures	N/A
Monitoring frequency	Hourly
QA/QC procedures	N/A
Purpose of data	Calculation of project emissions
Additional comment	- This value is calculated according to step 5 of "tool to determine project emissions from flaring gas containing methane". - Archived data are to be kept during the crediting period and two years after.

Data / Parameter	T
Unit	℃
Description	Temperature in the exhaust gas of the flare
Source of data	Measurement by thermocouple (-200℃ ~ 1200℃)
Value(s) applied	NA
Measurement methods and procedures	Temperature in the exhaust gas of the flare with operation time is monitored in real-time and the data is stored in computer automatically. Therefore, project participant can monitor whether the flare stack is operated or not and can apply suitable flare efficiency.
Monitoring frequency	Hourly
QA/QC procedures	Thermocouples should be replaced or calibrated every year.
Purpose of data	Calculation of baseline emissions
Additional comment	The temperature will be measured and recorded with operation time.

Data / Parameter	**Flame detector**
Unit	-
Description	In case of open flares, decision of the flare efficiency in the hour h ($\eta_{flare,h}$) is •0% if the flame is not detected for more than 20 minutes during the hour h. • 50%, if the flare is detected for more than 20 minutes during the hour h.
Source of data	Inspection by project participant in central room
Value(s) applied	N/A
Measurement methods and procedures	Flame detector is installed in flare stack. Project participant can monitor by CCTV whether the flare stack is operated or not and can apply suitable flare efficiency with operation temperature in flare stack.
Monitoring frequency	-
QA/QC procedures	N/A
Purpose of data	Calculation of baseline emissions
Additional comment	N/A

Data / Parameter	$w_{CH4,y}$
Unit	m3 CH4/m3 LFG
Description	Methane fraction in the landfill gas

Source of data	Read from gas analyzer
Value(s) applied	50%
Measurement methods and procedures	The data is read from gas analyzer installed continuously.
Monitoring frequency	Hourly
QA/QC procedures	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Gas Analyzer installed for monitoring this data is 'Infrared Gas Analyzer'. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2. - The data measured by the gas analyser installed in front of the buffer tank will be used to calculate $MD_{flared,y}$. - The data measured by the gas analyser installed behind the gas storage tank (right before supplying gas to user) will be used to calculate $MD_{thermal,y}$ and $MD_{electricity,y}$ - Methane fraction of the landfill gas to be measured on dry basis.

Data / Parameter	Operation time of gas engine generator(electricity generator)
Unit	Hours
Description	This is monitored to ensure claimed methane destruction caused by methane combustion in the electricity generator when it is operational.
Source of data	Electricity generator operation record
Value(s) applied	N/A
Measurement methods and procedures	This data will be recorded in a computer automatically.
Monitoring frequency	Daily
QA/QC procedures	If necessary, the equipment for monitoring operation time of gas engine generator should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	-
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	Operation time of boiler
Unit	Hours
Description	This is monitored to ensure claimed methane destruction caused by methane combustion in the boiler when it is operational.
Source of data	Boiler operation record
Value(s) applied	N/A

Measurement methods and procedures	This data will be recorded in a computer automatically.
Monitoring frequency	Daily
QA/QC procedures	If necessary, the equipment for monitoring operation time of the boiler should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	-
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$CH4_{simple}$
Unit	CH4m3/EA
Description	Amount of treated CH4 by a simple burning system
Source of data	calculated
Value(s) applied	108,799 CH4-m3/EA
Measurement methods and procedures	Captured LFG by each simple burning system and methane fraction in the captured landfill gas will be measured quarterly for the first crediting period. By using measured data, number of simple burning systems and other default value etc., this data will be calculated. For detail calculation method, refer to Annex 4.
Monitoring frequency	-
QA/QC procedures	N/A
Purpose of data	Calculation of baseline emissions
Additional comment	- This is monitored to decide AF. - Archived data are to be kept during the crediting period and two years after - The accuracy of the measurement method is medium. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	P
Unit	kg/ cm^2
Description	Outlet pressure of LFG
Source of data	measured
Value(s) applied	N/A
Measurement methods and procedures	The data will be measured by pressure gauge which is installed behind the buffer tank. For detail, refer to Annex 4.
Monitoring frequency	Hourly
QA/QC procedures	The pressure indication and transfer equipment should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline

Additional comment	- This is monitored to decide the LFG volume for normal condition. - Archived data are to be kept during the crediting period and two years after - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	T
Unit	℃
Description	Temperature of Gas cooler
Source of data	measured
Value(s) applied	N/A
Measurement methods and procedures	The data will be measured by temperature gauge which is installed behind the gas cooler. For detail, refer to Annex 4.
Monitoring frequency	Hourly
QA/QC procedures	The temperature indicating and transfer equipment should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of baseline emissions
Additional comment	- This is monitored to decide the LFG volume for normal condition. - Archived data are to be kept during the crediting period and two years after - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	EL_{IMP}
Unit	MWh
Description	Total amount of electricity imported to meet project requirement
Source of data	Read from watt-hour meter or Electric charge bill
Value(s) applied	3,898
Measurement methods and procedures	This data is read from watt-hour meter and can be double-checked with electric charge bill.
Monitoring frequency	Monthly
QA/QC procedures	N/A
Purpose of data	Calculation of project emissions
Additional comment	- Achieved data are to be kept during the crediting period and two years after. - This date is required to determine CO2 emission from use of electricity to operate the project activity. - This value is considered as leakage. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	Regulatory requirements relating to landfill gas projects
Unit	Test
Description	Regulatory requirements relating to landfill gas projects

Source of data	N/A
Value(s) applied	Regulatory requirements relating to landfill gas projects have been checked and the project is in compliance with them.
Measurement methods and procedures	N/A
Monitoring frequency	-
QA/QC procedures	N/A
Purpose of data	-
Additional comment	The information though recorded annually, is used for changes to the adjustment factor(AF) or directly $MD_{reg,y}$ at renewal of the crediting period. Achieved data are to be kept during the crediting period and two years after. It will be recorded at the renewal of crediting period.

To monitor the project, gas analyzers and flow meters are installed.
Specifications of gas analyzers and flow meters are:

(1) Gas Analyser
•Product : Infrared Gas Analyzer
•Manufacturer : Fuji Electric Systems Co., Ltd.
•Measurable gas components and measuring range:

	Minimum range	Maximum range
CO2	0-500ppm	0-100vol%
CH4	0-1000ppm	0-100vol%
O2 (Built-in paramagnet)	0-5vol%	0-100vol%

•Operating conditions:
- Ambient temperature : -5℃ to 45℃
- Ambient humidity : 90% RH max., non-condensing

•Dimensions (H x W x D) :
- 19-inch rack mounting type : 177 x 483 x 493mm

•Repeatability : ±0.5% of fullscale
•Gas analysers are installed at three points.
- behind the buffer tank
- in front of the buffer tank : The data measured by this gas analyser will be used to calculate $MD_{flared,y}$.
- behind the gas storage tank (right before supplying gas to user) : The data measured by this gas analyser will be used to calculate $MD_{thermal,y}$ and $MD_{electricity,y}$

(2) Flow meter
•Product : Vortex Flow meter
•Manufacturer : Oval Korea Limited
•Dimensions (H x W x D) :
- Flange : 200 x 250 x 300mm

•Operating temperature : -30 ~ +300℃
•Design pressure : 5.0MPa
•Accuracy : within ±1% of indicating quantity
•Repeatability : within ±0.2%
•Measuring unit : Nm3 (The flow meter automatically measures temperature and pressure and expresses gas volumes in normalized cubic meters.)

(3) Flare stack
• Type of flare : Open type
• Capacity: 35 m^3/min x 2
• Type of ignition: Pilot ignition with LPG fuel
• Composition: Body/ignition system, Burner, Damper, Purge Blower, Flare arrestor, and so on
• The quality of material: STS304

	Type	specification	Capacity
Flame arrestor	Protection of backfire	Pressure : 5~45kg/cm^2	12m^3/min~60m^3/min
Automatic Safety	Open-Close	10.5 kg	20m^3/min
Burner	Perfect combustion	Pressure : 100mmAq	20m^3/min

According to "the City Gas Enterprises Act", gas analyzers and flow meters will be re-calibrated every 5 years after installation.

B.7.2. Sampling plan

>>
N/A

B.7.3. Other elements of monitoring plan

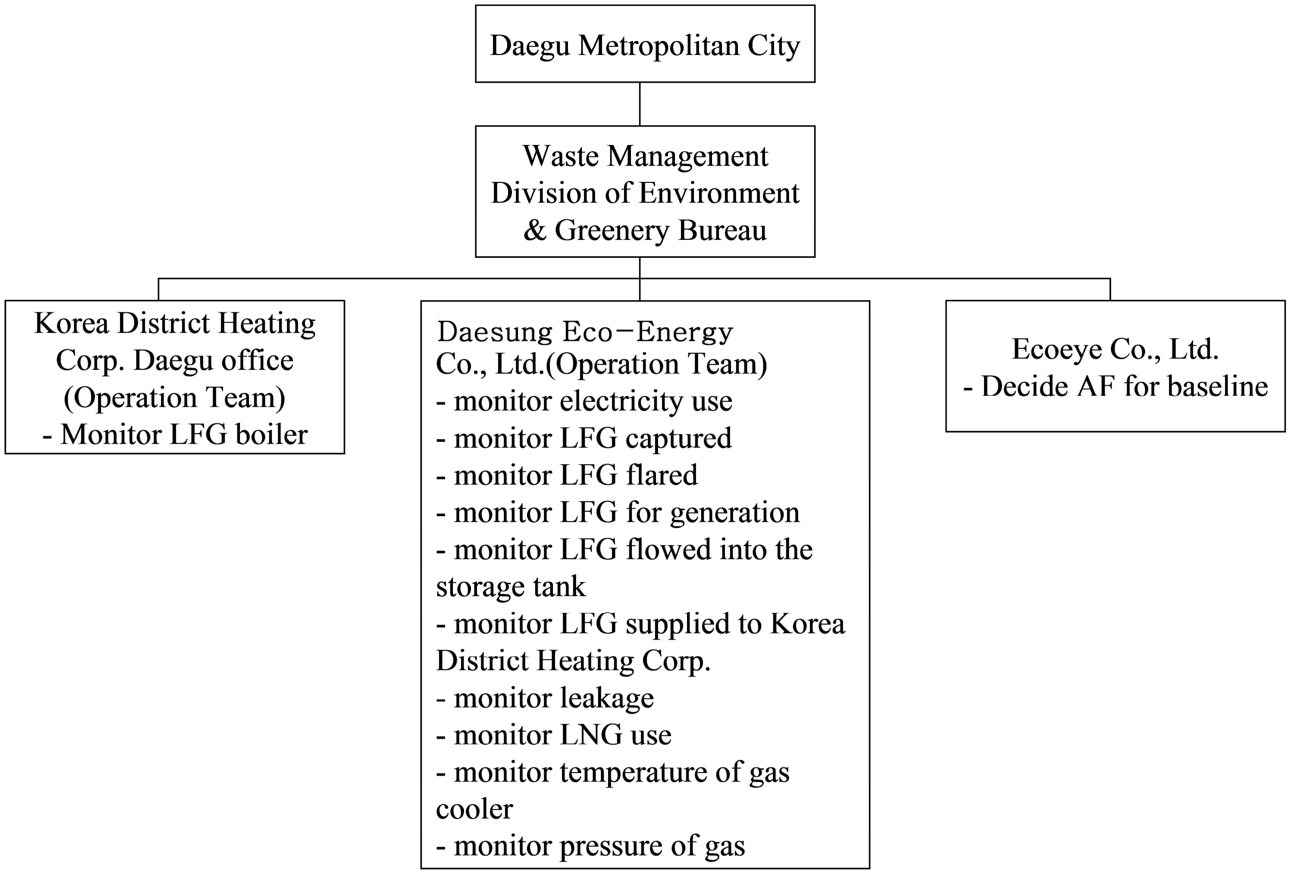
>>
To monitor this project activity, monitoring methodology ACM0001 is applied.
ACM 0001 – "Consolidated monitoring methodology for landfill gas project activities (Version 5)" is applicable to landfill gas capture project activities, where the baseline scenarios the partial or total atmospheric release of the gas and the project activities include situations the following :

a) The captured gas is flared; or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or
c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy from other sources.

The project activity corresponds to situation a) and b). Through this project activity, LFG is captured, flared and utilized. LFG is supplied to users and used as energy instead of fossil fuel. Therefore, above methodology is applicable to monitoring methodology of this project and monitoring for emission reduction and any other concerns will be performed following the monitoring methodology ACM0001.

Data and parameter provided 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 monitor emissions reductions generated by the project activity.



<Figure B-1> monitoring structure

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

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

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

- AF for the baseline calculating :
  Ecoeye. Co., Ltd.

B.8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

>>

● date of completion of the application of the methodology
: 01/05/2006
● responsible person / entity
: Dr. Jung, Jae-soo / Ecoeye Co., Ltd.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

>>
01/05/2005 (the date on construction of the project activity begins.)

C.1.2. Expected operational lifetime of project activity

>>
The estimated operational lifetime is approximately 20 years.

C.2. Crediting period of project activity

C.2.1. Type of crediting period

>>
Renewable

C.2.2. Start date of crediting period

>>
01/08/2007
If the project is not registered in this time, crediting period will be started after registration by UNFCCC

C.2.3. Length of crediting period

7 years

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>
This project activity does not belong to the category of performing environmental impacts assessment according to the Korean Law. Furthermore, when object site, Daegu Bangcheon-Ri landfill site, was designed and developed in 1990, the analysis of the environmental impacts did not exist. Therefore, document of the analysis of the environmental impacts of the site and project activity does not exist.

Although environmental impacts assessment is not enforcement for this project, project participant assessed possible environmental impacts caused by the project or the facility.

● Air
: When the work that is dropping wastes or hardening the ground is performed, airborne particulate is produced, and cars which are for transferring waste or for servicing on site etc. are able to be a source of air pollution. However, residential area does not exist inside relevant area.

● Water
: It is concerned that discharged waste water is satisfied with the regulation, and waste water is transferred to leachate treatment facility and it is treated.

● Noise and Vibration

: The level of noise around the landfill site is below the regulation level, and the landfill site is surrounded by mountain. Even though there is residential area which is possibly influenced by the landfill site directly, bad influence by the landfill site is little. Considering those facts, it is concerned that the problem does not arise from noise or vibration caused in the landfill site.

● Odour
: After the project is performed, it is concerned that odour problem is little.

● Declaration of air emission of LFG utilization facility

● Prevention of odour problem under construction

● Prevention of dust problem under excavation for constructing facility

● Safety of gas storage tank

● Safety of gas facility

● Safety of LFG transfer pipeline to Korea District Heating Corp.

● The building and facilities which were constructed and installed in the project site had fire inspection on the process of construction permission.

● This LFG facility is installed in the existing landfill site and the pipeline from the landfill site to LFG user(Korea District Heating Corporation) is constructed under the existing road. Therefore, the project does not effect any deforestation or damage of land.

D.2. Environmental impact assessment

>>

● To construct LFG utilization facility (electricity generator, refinery facility etc.), constructing air emission facility should be permitted or declared on the Air Environment Conservation Act. In this project case, the concentration of NOx is below the standard. Therefore, the facility was declared.

● Daegu local Environment Administration suggested that odour which is possibly occur temporarily under construction of LFG utilization facility should be diminished to minimize odour damage around the landfill site. Project participant did work considering suggestion above and popular complaint caused by odour problem was not occurred.

● For dust problem which may happen under excavation for constructing the facility, project participant declared to Dalseong-gun County Council and had permission to do work with performing proper management. The council directed several things including establishment of watering facility to prevent dust problem and the project participant followed the direction.

● According to City Gas Enterprises Act, when a gas storage tank was constructed, the gas storage tank (pressure vessel) was tested for safety. The project participant acquired a notice of success in test for safety by Korea Gas Safety Corporation. To maintain the gas storage tank safely, the tank will be tested every 5 years. According to the Liquefied Petroleum Gas (LPG) Control Law and the High Pressure Gas Control Law, the pressure vessel which has pressure over 10kg/cm2 should be tested every 5 years for safety. However, the designed maximum pressure of the gas storage tank which is installed in the project site is 9kg/cm2. Therefore, even though the law is not compulsory for this gas storage tank, the project participant is going to let the gas storage tank be tested every 5 years for safety and it is project participant's additional effort for safety.

● Whole gas facilities have close safety examination from 13 March 2006 to 18 September 2006 by Korea Gas Safety Corporation and the report about the examination was out on 28 September

2006. The content of report is that whole gas facilities were installed with application of City Gas Enterprises Act. Furthermore, the gas facilities will have close safety examination every year for safety.

● According to City Gas Enterprises Act, when LFG transfer pipeline was constructed, Korea Gas Safety Corporation supervised the construction from 29 July 2005 to 4 July 2006. The reported result was that the pipeline was constructed following the act well. To maintain the pipeline safely, a car which has sensor will follow the pipeline and trace leakage of gas everyday. To prevent leakage and for safety regular examination of pipeline will be performed every year.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>>

In order to collect stakeholders' comment for this project, followed activities were performed.

-December 2001 : On the first step of planning, feasibility study is made out by Korea Society of Waste Management and opened to stakeholders. <Figure E-1>

-12 January 2005 : The project participant requested relevant organizations (Daegu local Environment Administration, Daegu Dalseo-gu District Council and Dalseong-gun County Council) to give them organizations' opinion about establishing Daegu Bangcheon-Ri LFG utilization facility by 18 January 2005. <Figure E-2>

-26 January 2005 : The project participant collected comment from Daegu local Environment Administration in relation to <Figure E-2>. Their comments were mainly 1. project should be promoted considering change of LFG component and decrease of LFG produced. 2. odour which is possibly occur temporarily under construction of LFG utilization facility should be diminished to minimize odour damage around the landfill site. 3. safety of facility which is able to be influenced by increase of filled MSW should be considered. etc. <Figure E-3.1><Figure E-3.2>

- 20 January 2005 : The project participant collected comment from Daegu Dalseo-gu District Council in relation to <Figure E-2>. They suggested that to minimize transportation inconvenience and to prevent safety problem, the purpose of construction and notice should be publicized and countermeasure should be established. <Figure E-4>

-25 January 2005 : The project participant collected comment from Dalseong-gun County Council in relation to <Figure E-2>. Their comments were two parts, one is construction permission and the other is permission of road excavation. In construction permission part, they suggested the project participant should be permitted for facility construction after submitting related documents considering the regulation. In permission of road excavation part, they mentioned that excavation was possible and noticed several conditions of permission which were technical and related to safety and procedure. <Figure E-5.1> <Figure E-5.2>

-25 April 2005 : The project participant noticed that construction company was Taegu Energy & Environment Co., Ltd. and designed plan had been changed.
The notification about construction company was included in an official report of Daegu Metropolitan City on 30 April 2005 and the notification about change of designed plan was included in an official report of Daegu Metropolitan City on 30 May 2005 as well. An official report of Daegu Metropolitan City is out everyday and anybody can read it on the internet. To notice that public reading for change of designed plan of the project, public announcement was offered through local newspaper (The Yeongnam Ilbo, page 19) on 26 April 2005. According to an article of newspaper, related documents were provided for public reading and related opinion was able to submitted in Wastes Management Department of Daegu

Metropolitan City from 26 April 2005 to 20 May 2005 . <Figure E-6> <Figure E-7> <Figure E-8>

-4 July 2005 : The project participant asked the Ministry of Commerce, Industry and Energy the matter of applying the City Gas Enterprises Act to LFG utilization. <Figure E-9>
Relating to <Figure E-9>, replied answer was as follow :
LFG project is not included in permission project of the City Gas Enterprises Act, but Industrial Safety hygienic Law was applied for facility and technology, and the City Gas Enterprises Act was applied for other gas facility. <Figure E-10>

-The project participant announced their project through internet news, newspapers (Mae-Il newspaper, Daegu newspaper, Daegu Ilbo etc.) and broadcast (KBS, MBC, TBC). <Figure E-11> <Figure E-12> <Figure E-13>

The content of each news introduced in next page is as follow:

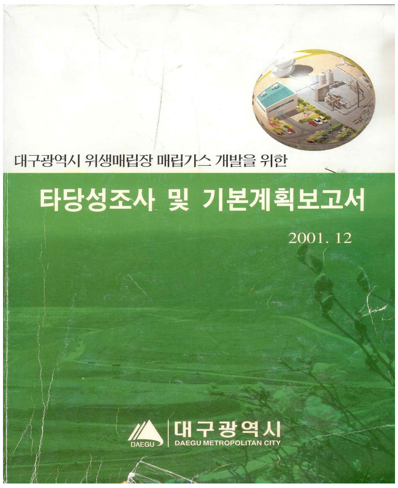
<Figure E-11> Mai-Il newspaper (19 January 2006)
: "290,000 t-CO2 per annum of GHG emission will be reduced and 2 billion won worth sales of emission reduction credit is expected with landfill gas utilization project." Daegu metropolitan city government announced that Bangcheon-ri Landfill gas recovery facility being constructed in Build-Operate-Transfer agreement would be proceeded with as CDM project in order to create economic value and project Daegu city's environmental image.
Metropolitan city government will have the project registered at the UNFCCC and trade the CERs generated, which will be consulted by Ecoeye Co., Ltd. The consulting fee is to be paid from the CERs' sales.
Bangcheon-ri CDM project is planned to be registered by September this year and emission reductions are to be monitored from October 2006 in which the commercial operation begins.
Mr. Jae-Kyung Lee, Manager of Waste manage Department commented that 290,000 t-CO2 per annum of emission reductions could be reduced and 2 billion won worth sales of emission reductions could be created if the CDM project was successfully registered."

<Figure E-12> Daegu newspaper (19 January 2006)
: "Daegu Metropolitan City government announced on 18 January that Bangcheon-ri Landfill gas recovery facility being constructed in Build-Operate-Transfer agreement by Daegu City Gas Company would be proceeded with as CDM project.
Under UNFCCC (1992) and Kyoto protocol (2005), Developed country invests capital or transfer technology to developing country to reduce the greenhouse gas emissions in CDM project and secures CERs which can be traded in the market.
City government designated ECOEYE Ltd. as CDM Project consultant and consulting fee would be paid from CERs' sales. Bangcheon-ri CDM project is planned to be registered by September this year and emission reductions are to be monitored from October 2006 in which the commercial operation begins.
290,000 t-CO2 per annum of emission reductions could be certified and 2 billion won worth sales of emission reduction could be created if the CDM project was successfully registered.
A city government officer added that we could proactively prepare the international environmental regulation and project Daegu city's environmental image with CDM project. In addition, economic values can be created."

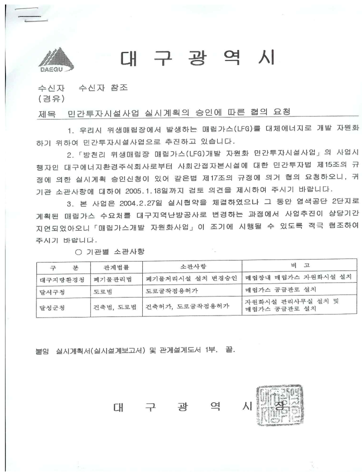
<Figure E-13> Daegu Ilbo (20 April 2005)
: "Daegu City Gas company announced on 19 April that the gas collection and auxiliary facilities for Bangcheonri landfill gas recovery project would be kicked off located at Dasa-eup, Dalseong-gun.
About 22.98 billion won will be invested in the project. The facility will be completed in May 2006 which consists of 130 Nm3/min capacity collection system, medium quality gas refinery system and LFG supply system, 1.5 MW capacity electricity generator and pipelines.
LFG collected and treated at the Bangcheon-ri Landfill will be supplied to the boiler of Korea District Heating Corporation located at Seongseo industrial complex though 2.7Km pipeline.

53million Nm3 per annum of LFG generation is expected with Bangcheon-ri LFG project which can replace the import of 27 ton crude oil, city government officer said.
Landfill gas recovery is widely performed in Europe and a lot of researches have been carried out as well in Korea which is lack of energy resources in general."

Some content of news above has been changed as the project was performed.



<Figure E-1>


대 구 광 역 시

수신자 수신자 참조
(경유)
제목 민간투자시설사업 실시계획의 승인에 따른 협의 요청

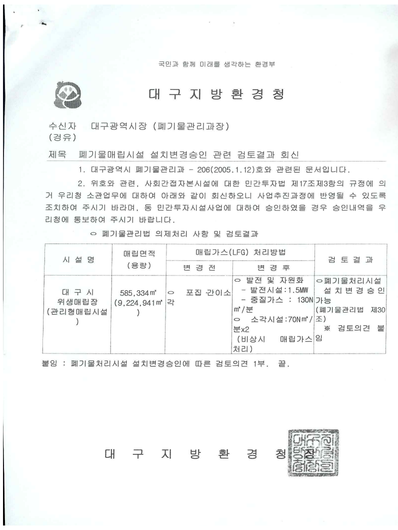
1. 우리시 위생매립장에서 발생하는 매립가스(LFG)를 대체에너지로 개발 자원화하기 위하여 민간투자시설사업으로 추진하고 있습니다.

○ 기관별 소관사항

붙임 실시계획서(실시설계보고서) 및 관계설계도서 1부. 끝.

대 구 광 역 시

<Figure E-2>


대 구 지 방 환 경 청

수신자 대구광역시장 (폐기물관리과장)
(경유)
제목 폐기물매립시설 설치변경승인 관련 검토결과 회신

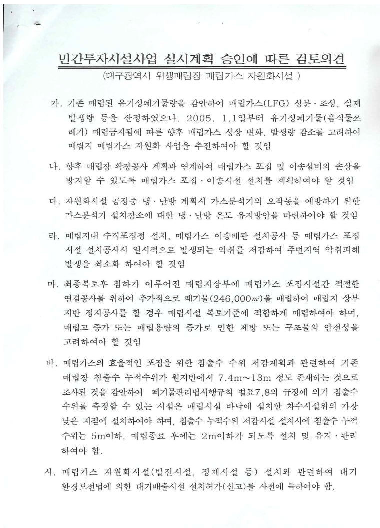
1. 대구광역시 폐기물관리과 - 206(2005.1.12)호와 관련된 문서입니다.

○ 폐기물관리법 의제처리 사항 및 검토결과

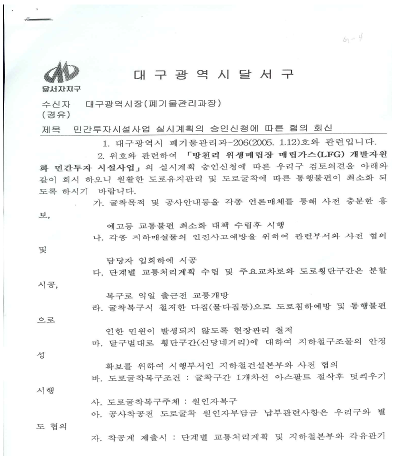
붙임 : 폐기물처리시설 설치변경승인에 따른 검토의견 1부. 끝.

대 구 지 방 환 경 청

<Figure E-3.1>


민간투자시설사업 실시계획 승인에 따른 검토의견
(대구광역시 위생매립장 매립가스 자원화시설)

<Figure E-3.2>


대 구 광 역 시 달 서 구

수신자 대구광역시장(폐기물관리과장)
(경유)
제목 민간투자시설사업 실시계획의 승인신청에 따른 협의 회신

1. 대구광역시 폐기물관리과-206(2005. 1.12)호와 관련입니다.

<Figure E-4>


달 성 군

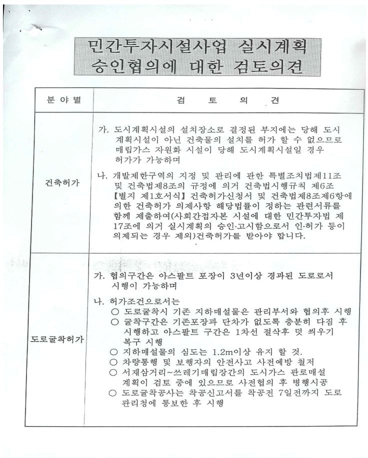
수신자 대구광역시장(폐기물관리과장)
(경유)
제목 민간투자시설사업 실시계획 승인협의에 대한 검토의견 제출

1. 시 폐기물관리과-206(2005.01.12)호와 관련입니다.

붙임 민간투자시설사업 검토의견. 끝.

달 성 군

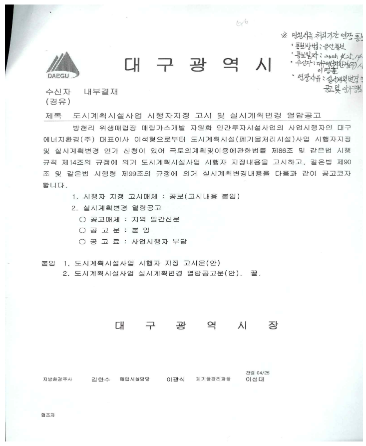
<Figure E-5.1>



민간투자시설사업 실시계획 승인협의에 대한 검토의견

분 야 별	검 토 의 견
건축허가	가. 도시계획시설의 설치장소로 결정된 부지에는 당해 도시계획시설이 아닌 건축물의 설치를 허가 할 수 없으므로 매립가스 자원화 시설이 당해 도시계획시설일 경우 허가가 가능하며 나. 개발제한구역의 지정 및 관리에 관한 특별조치법제11조 및 건축법제8조의 규정에 의거 건축법시행규칙 제6조 【별지 제1호서식】 건축허가신청서 및 건축법제8조제6항에 의한 건축허가 의제사항 해당법률이 정하는 관련서류를 함께 제출하여(사회간접자본 시설에 대한 민간투자법 제17조에 의거 실시계획의 승인·고시함으로서 인·허가 등이 의제되는 경우 제외)건축허가를 받아야 합니다.
도로굴착허가	가. 협의구간은 아스팔트 포장이 3년이상 경과된 도로로서 시행이 가능하며 나. 허가조건으로서는 ○ 도로굴착시 기존 지하매설물은 관리부서와 협의후 시행 ○ 굴착구간은 기존포장과 단차가 없도록 충분히 다짐 후 시행하고 아스팔트 구간은 1차선 절삭후 덧 씌우기 복구 시행 ○ 지하매설물의 심도는 1.2m이상 유지 할 것. ○ 차량통행 및 보행자의 안전사고 사전예방 철저 ○ 서재삼거리~쓰레기매립장간의 도시가스 관로매설 계획이 검토 중에 있으므로 사전협의 후 병행시공 ○ 도로굴착공사는 착공신고서를 착공전 7일전까지 도로관리청에 통보한 후 시행

<Figure E-5.2>



DAEGU 대 구 광 역 시

수신자 내부결재
(경유)

제목 도시계획시설사업 시행자지정 고시 및 실시계획변경 열람공고

방천리 위생매립장 매립가스개발 자원화 민간투자시설사업의 사업시행자인 대구에너지환경(주) 대표이사 이석형으로부터 도시계획시설(폐기물처리시설)사업 시행자지정 및 실시계획변경 인가 신청이 있어 국토의계획및이용에관한법률 제86조 및 같은법 시행규칙 제14조의 규정에 의거 도시계획시설사업 시행자 지정내용을 고시하고, 같은법 제90조 및 같은법 시행령 제99조의 규정에 의거 실시계획변경내용을 다음과 같이 공고코자 합니다.

1. 시행자 지정 고시매체 : 공보(고시내용 붙임)
2. 실시계획변경 열람공고
   - ○ 공고매체 : 지역 일간신문
   - ○ 공 고 문 : 붙 임
   - ○ 공 고 료 : 사업시행자 부담

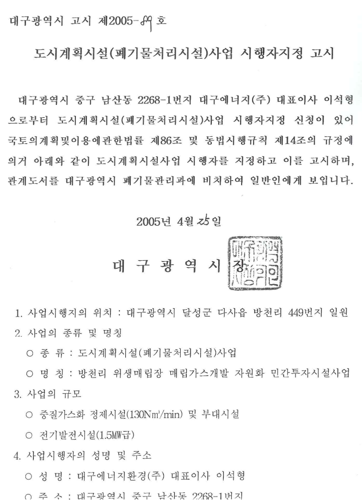
붙임 1. 도시계획시설사업 시행자 지정 고시문(안)
2. 도시계획시설사업 실시계획변경 열람공고문(안). 끝.

대 구 광 역 시 장

지방환경주사 김한수 매립시설담당 이광식 폐기물관리과장 전결 04/25 이성대

협조자

<Figure E-6>



대구광역시 고시 제2005-89호

도시계획시설(폐기물처리시설)사업 시행자지정 고시

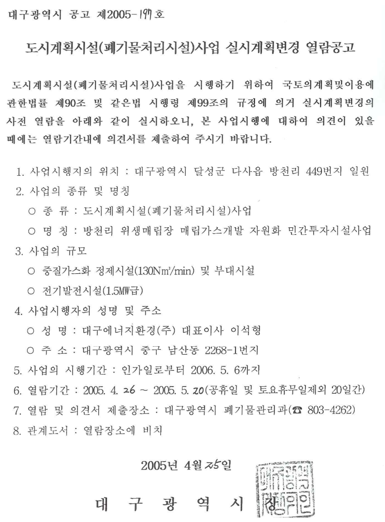
대구광역시 중구 남산동 2268-1번지 대구에너지(주) 대표이사 이석형으로부터 도시계획시설(폐기물처리시설)사업 시행자지정 신청이 있어 국토의계획및이용에관한법률 제86조 및 동법시행규칙 제14조의 규정에 의거 아래와 같이 도시계획시설사업 시행자를 지정하고 이를 고시하며, 관계도서를 대구광역시 폐기물관리과에 비치하여 일반인에게 보입니다.

2005년 4월 25일

대 구 광 역 시 장

1. 사업시행지의 위치 : 대구광역시 달성군 다사읍 방천리 449번지 일원
2. 사업의 종류 및 명칭
   - ○ 종 류 : 도시계획시설(폐기물처리시설)사업
   - ○ 명 칭 : 방천리 위생매립장 매립가스개발 자원화 민간투자시설사업
3. 사업의 규모
   - ○ 중질가스화 정제시설(130Nm³/min) 및 부대시설
   - ○ 전기발전시설(1.5MW급)
4. 사업시행자의 성명 및 주소
   - ○ 성 명 : 대구에너지환경(주) 대표이사 이석형
   - ○ 주 소 : 대구광역시 중구 남산동 2268-1번지

<Figure E-7>



대구광역시 공고 제2005-197호

도시계획시설(폐기물처리시설)사업 실시계획변경 열람공고

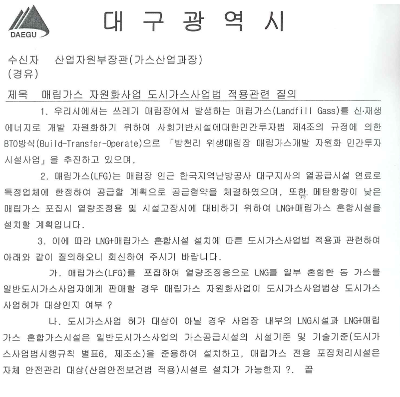
도시계획시설(폐기물처리시설)사업을 시행하기 위하여 국토의계획및이용에관한법률 제90조 및 같은법 시행령 제99조의 규정에 의거 실시계획변경의 사전 열람을 아래와 같이 실시하오니, 본 사업시행에 대하여 의견이 있을 때에는 열람기간내에 의견서를 제출하여 주시기 바랍니다.

1. 사업시행지의 위치 : 대구광역시 달성군 다사읍 방천리 449번지 일원
2. 사업의 종류 및 명칭
   - ○ 종 류 : 도시계획시설(폐기물처리시설)사업
   - ○ 명 칭 : 방천리 위생매립장 매립가스개발 자원화 민간투자시설사업
3. 사업의 규모
   - ○ 중질가스화 정제시설(130Nm³/min) 및 부대시설
   - ○ 전기발전시설(1.5MW급)
4. 사업시행자의 성명 및 주소
   - ○ 성 명 : 대구에너지환경(주) 대표이사 이석형
   - ○ 주 소 : 대구광역시 중구 남산동 2268-1번지
5. 사업의 시행기간 : 인가일로부터 2006. 5. 6까지
6. 열람기간 : 2005. 4. 26 ~ 2005. 5. 20(공휴일 및 토요휴무일제외 20일간)
7. 열람 및 의견서 제출장소 : 대구광역시 폐기물관리과(☎ 803-4262)
8. 관계도서 : 열람장소에 비치

2005년 4월 25일

대 구 광 역 시 장

<Figure E-8>



DAEGU 대 구 광 역 시

수신자 산업자원부장관(가스산업과장)
(경유)

제목 매립가스 자원화사업 도시가스사업법 적용관련 질의

1. 우리시에서는 쓰레기 매립장에서 발생하는 매립가스(Landfill Gass)를 신·재생에너지로 개발 자원화하기 위하여 사회기반시설에대한민간투자법 제4조의 규정에 의한 BTO방식(Build-Transfer-Operate)으로 「방천리 위생매립장 매립가스개발 자원화 민간투자시설사업」을 추진하고 있으며,

2. 매립가스(LFG)는 매립장 인근 한국지역난방공사 대구지사의 열공급시설 연료로 특정업체에 한정하여 공급할 계획으로 공급협약을 체결하였으며, 또한 메탄함량이 낮은 매립가스 포집시 열량조정용 및 시설고장시에 대비하기 위하여 LNG+매립가스 혼합시설을 설치할 계획입니다.

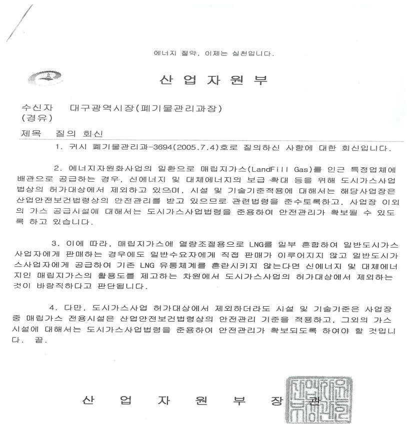
3. 이에 따라 LNG+매립가스 혼합시설 설치에 따른 도시가스사업법 적용과 관련하여 아래와 같이 질의하오니 회신하여 주시기 바랍니다.

가. 매립가스(LFG)를 포집하여 열량조정용으로 LNG를 일부 혼합한 동 가스를 일반도시가스사업자에게 판매할 경우 매립가스 자원화사업이 도시가스사업법상 도시가스사업허가 대상인지 여부 ?

나. 도시가스사업 허가 대상이 아닐 경우 사업장 내부의 LNG시설과 LNG+매립가스 혼합가스시설은 일반도시가스사업의 가스공급시설의 시설기준 및 기술기준(도시가스사업법시행규칙 별표6, 제조소)을 준용하여 설치하고, 매립가스 전용 포집처리시설은 자체 안전관리 대상(산업안전보건법 적용)시설로 설치가 가능한지 ?. 끝

붙임 매립가스 [illegible] 및 LNG [illegible]. 끝

<Figure E-9>



에너지 절약, 이제는 실천입니다.

산 업 자 원 부

수신자 대구광역시장(폐기물관리과장)
(경유)

제목 질의 회신

1. 귀시 폐기물관리과-3694(2005.7.4)호로 질의하신 사항에 대한 회신입니다.

2. 에너지자원화사업의 일환으로 매립지가스(LandFill Gas)를 인근 특정업체에 배관으로 공급하는 경우, 신에너지 및 대체에너지의 보급 확대 등을 위해 도시가스사업법상의 허가대상에서 제외하고 있으며, 시설 및 기술기준적용에 대해서는 해당사업장은 산업안전보건법령상의 안전관리를 받고 있으므로 관련법령을 준수토록하고, 사업장 이외의 가스 공급시설에 대해서는 도시가스사업법령을 준용하여 안전관리가 확보될 수 있도록 하고 있습니다.

3. 이에 따라, 매립지가스에 열량조절용으로 LNG를 일부 혼합하여 일반도시가스사업자에게 판매하는 경우에도 일반수요자에게 직접 판매가 이루어지지 않고 일반도시가스사업자에게 공급하여 기존 LNG 유통체계를 혼란시키지 않는다면 신에너지 및 대체에너지인 매립지가스의 활용도를 제고하는 차원에서 도시가스사업의 허가대상에서 제외하는 것이 바람직하다고 판단됩니다.

4. 다만, 도시가스사업 허가대상에서 제외하더라도 시설 및 기술기준은 사업장 중 매립가스 전용시설은 산업안전보건법령상의 안전관리 기준을 적용하고, 그외의 가스시설에 대해서는 도시가스사업법령을 준용하여 안전관리가 확보되도록 하여야 할 것입니다. 끝.

산 업 자 원 부 장 관

<Figure E-10>

每日新聞 2006년 01월 19일 008면

온실가스 연간 29만t 줄이고 20억원 수익 창출 예상

방천매립장 가스자원화

청정개발용역사업자 선정

<Figure E-11>

대구신문 2006년 01월 19일 004면

방천리 매립장 CDM사업 추진

용역 사업자 선정…배출권도 거래

<Figure E-12>

2005년 4월20일 수요일 대구일보 17

쓰레기 매립가스 자원화 사업 착공

229억 투입…130N㎥/min 가스포집 시설 등 공사

대구도시가스

대구도시가스는 달성군 다사읍 방천리 쓰레기 매립장의 매립가스 자원화 사업을 위한 가스 포집시설 및 부대시설 공사를 이달말 착공한다고 19일 밝혔다.

총 229억8천여만원의 사업비가 투입되는 이 시설은 130N㎥/min규모의 가스포집 시설 및 부속시설, 증질가스화 정제시설, 가스공급시설 및 부속시설, 1.5MW급 전기발전시설, 파이프라인 등이 들어서며, 2006년 5월 완공 예정이다.

이 시설을 통해 방천리 매립장에서 포집 및 정제된 LFG(매립가스)는 2.7㎞의 배관망을 통해 성서공단내 한국지역난방공사로 보내져 난방 보일러 연료로 사용된다.

방천리 매립가스 자원화 사업을 통해 연간 5천300만N㎥의 매립가스 생산이 가능할 것으로 예상된다. 또 열량으로 환산했을 경우 2만7천여톤의 원유와 맞먹는 에너지 수입대체효과도 가져온다는 게 관계자의 설명이다.

한편 매립가스 자원화사업은 유럽 등지에서 이미 폭 넓게 활용되고 있는 것은 물론 에너지자원이 빈약한 우리나라에서도 그동안 상당한 연구와 실험이 진행돼 실용화 단계에 있다.

김종엽기자

<Figure E-13>

E.2. Summary of comments received

>>

- ● Relevant organizations suggested announcing the project enough.
- ● Relevant organizations also emphasized safety during construction period and managing construction area thoroughly to minimize popular complaints.
- ● Composition of MSW should be considered when the project was promoted.
- ● About applying the City Gas Enterprises Act to LFG utilization, the Ministry of Commerce, Industry and Energy mentioned that LFG project is not included in permission project of the City Gas Enterprises Act, but Industrial Safety hygienic Law was applied for facility and technology, and the City Gas Enterprises Act was applied for other gas facility.

E.3. Report on consideration of comments received

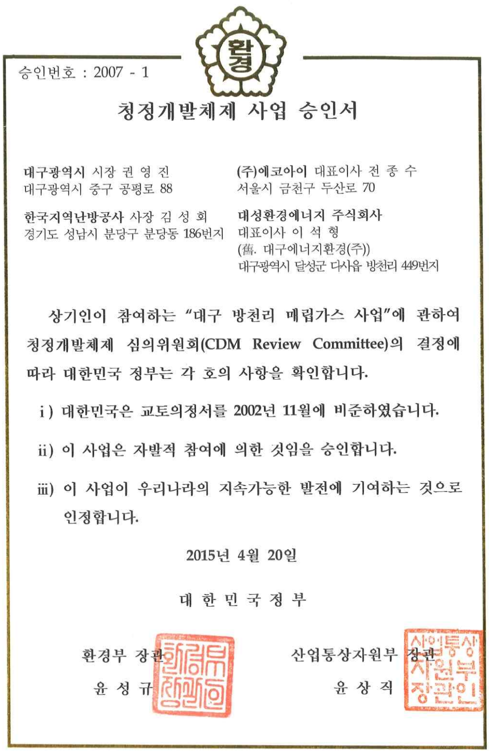
>>

- ● The project participant announced their project through internet news, newspapers and broadcast.
- ● The project participant let passing cars and passersby know the area is under construction through attention board etc.
- ● Composition of MSW was considered when the project participant designed the facility.
- ● The project was constructed and is operated following relevant regulation and received comments fully.

SECTION F. Approval and authorization

>>

Approval of CDM project for the project activity is issued by Korea Ministry of Environment and Ministry of Trade, Industry & Energy (It was called of Ministry of Knowledge Economy) at April 20, 2015.



승인번호 : 2007 - 1

청정개발체제 사업 승인서

대구광역시 시장 권 영 진
대구광역시 중구 공평로 88

(주)에코아이 대표이사 전 종 수
서울시 금천구 두산로 70

한국지역난방공사 사장 김 성 회
경기도 성남시 분당구 분당동 186번지

대성환경에너지 주식회사
대표이사 이 석 형
(舊. 대구에너지환경(주))
대구광역시 달성군 다사읍 방천리 449번지

상기인이 참여하는 "대구 방천리 매립가스 사업"에 관하여 청정개발체제 심의위원회(CDM Review Committee)의 결정에 따라 대한민국 정부는 각 호의 사항을 확인합니다.

i) 대한민국은 교토의정서를 2002년 11월에 비준하였습니다.

ii) 이 사업은 자발적 참여에 의한 것임을 승인합니다.

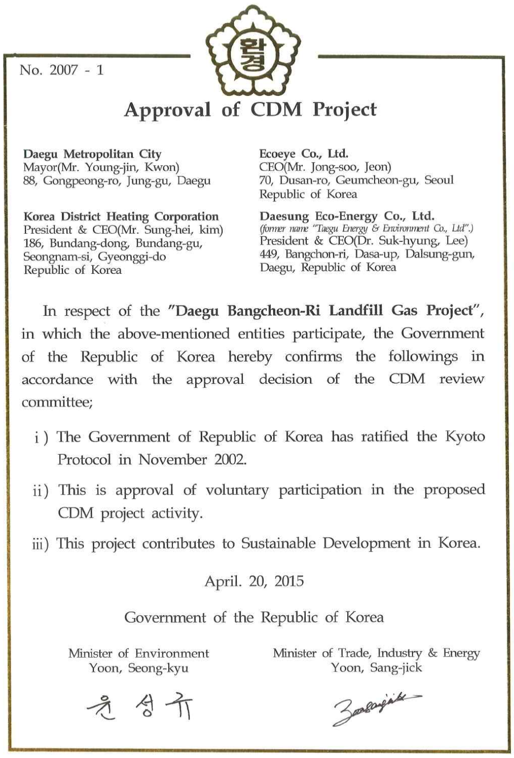
iii) 이 사업이 우리나라의 지속가능한 발전에 기여하는 것으로 인정합니다.

2015년 4월 20일

대 한 민 국 정 부

환경부 장관
윤 성 규

산업통상자원부 장관
윤 상 직



No. 2007 - 1

Approval of CDM Project

Daegu Metropolitan City
Mayor(Mr. Young-jin, Kwon)
88, Gongpeong-ro, Jung-gu, Daegu

Ecoeye Co., Ltd.
CEO(Mr. Jong-soo, Jeon)
70, Dusan-ro, Geumcheon-gu, Seoul
Republic of Korea

Korea District Heating Corporation
President & CEO(Mr. Sung-hei, kim)
186, Bundang-dong, Bundang-gu,
Seongnam-si, Gyeonggi-do
Republic of Korea

Daesung Eco-Energy Co., Ltd.
(former name "Taegu Energy & Environment Co., Ltd".)
President & CEO(Dr. Suk-hyung, Lee)
449, Bangchon-ri, Dasa-up, Dalsung-gun,
Daegu, Republic of Korea

In respect of the "**Daegu Bangcheon-Ri Landfill Gas Project**", in which the above-mentioned entities participate, the Government of the Republic of Korea hereby confirms the followings in accordance with the approval decision of the CDM review committee;

i) The Government of Republic of Korea has ratified the Kyoto Protocol in November 2002.

ii) This is approval of voluntary participation in the proposed CDM project activity.

iii) This project contributes to Sustainable Development in Korea.

April. 20, 2015

Government of the Republic of Korea

Minister of Environment
Yoon, Seong-kyu

Minister of Trade, Industry & Energy
Yoon, Sang-jick

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Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Daegu Metropolitan City
Street/P.O. Box	130, Gongpeongno, Jung-Gu
Building	
City	Daegu
State/Region	
Postcode	700-714
Country	The Republic of Korea
Telephone	+82-53-803-0114
Fax	+82-53-803-3030
E-mail	
Website	http://www.daegu.go.kr
Contact person	
Title	Mayor
Salutation	Mr.
Last name	Kim
Middle name	
First name	Bum-il
Department	
Mobile	
Direct fax	+82-53-803-4229
Direct tel.	+82-53-803-4262
Personal e-mail	hskim@daegumail.net

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Daesung Eco-Energy Co., Ltd.
Street/P.O. Box	455, Bangcheon-Ri, Dasa-Eup, Dalsung-Gun
Building	
City	Daegu
State/Region	
Postcode	711-811
Country	The Republic of Korea
Telephone	+82-53-593-1890
Fax	+82-53-593-2121
E-mail	tkjung@teeco.co.kr

Website	http://www.daesung.com
Contact person	
Title	President & CEO
Salutation	Dr.
Last name	Lee
Middle name	
First name	Suk-hyung
Department	
Mobile	+82-16-207-1640
Direct fax	+82-53-593-2121
Direct tel.	+82-53-593-1893
Personal e-mail	cfc2002@naver.com

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Korea District Heating Corp.
Street/P.O. Box	186 Bundang-Dong, Bundang-Gu
Building	
City	Seongnam
State/Region	Gyeonggi-Do
Postcode	463-908
Country	The Republic of Korea
Telephone	+82-31-780-4114
Fax	
E-mail	
Website	www.kdhc.co.kr
Contact person	
Title	President & CEO
Salutation	Mr.
Last name	Kim
Middle name	
First name	Young-Nam
Department	
Mobile	
Direct fax	+82-31-701-3171
Direct tel.	+82-31-780-4272
Personal e-mail	Jwlee99@kdhc.co.kr

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	Ecoeye Co., Ltd.
Street/P.O. Box	153 Gumi-Dong, Bundang-Gu
Building	Lordland
City	Seongnam
State/Region	Gyeonggi-Do
Postcode	463-810
Country	The Republic of Korea
Telephone	+82-31-716-2108
Fax	+82-31-716-1848
E-mail	
Website	http://www.ecoeye.co.kr
Contact person	
Title	CEO
Salutation	Dr.
Last name	Jung
Middle name	
First name	Jae-soo
Department	
Mobile	
Direct fax	+82-31-716-1848
Direct tel.	+82-31-716-2108
Personal e-mail	civilenvi@ecoeye.com

Appendix 2. Affirmation regarding public funding

There is no public funding invested for this project.

Appendix 3. Applicability of methodology and standardized baseline

Applicability of methodology and standardized baseline is described in B.2. above

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

BASELINE INFORMATION

GHG emission reduction for this project is calculated by reduction from LFG captured plus reduction from producing thermal energy.

Step 1. Information for GHG reduction calculation from LFG captured

Sub-step 1-1. Estimation for landfill amount of MSW

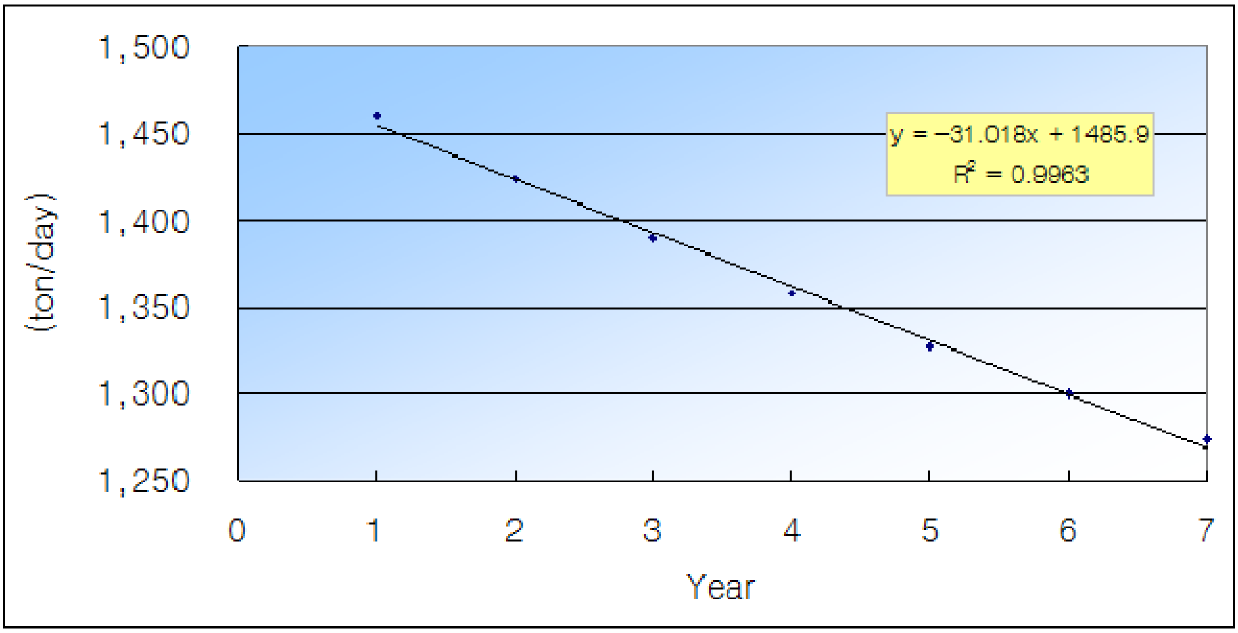
Regression analysis is performed by using previous landfill data for estimation landfill amount for this LFG project. After the regression analysis, result of estimation for landfill amount of MSW is followed.

<Table Annex 3-1> Planned total landfill amount

*Planned total landfill amount	
Planned total landfill amount (ton)	15,670,000
Total wasted landfill amount filled up (ton)	14,570,000
Expected expansion amount of landfill (2005~2024) (ton)	9,144,710

<Table Annex 3-2> Result of estimation for landfill amount

Content / Year	Value using on LFG estimation (ton/yr)	Real filled waste amount (ton/day)	Expected filled MSW amount _ Expected regression analysis (ton/day)	Expected amount of LFG generation (m3/yr)
1990	1,008,042	4,440.0		0
1991	1,622,919	4,446.4		14,646,079.98
1992	1,461,016	4,002.8		37,276,716.64
1993	1,191,009	3,263.0		56,088,452.59
1994	1,242,634	3,404.5		69,758,102.38
1995	881,027	2,413.8		83,993,428.63
1996	789,585	2,163.2		91,350,900.48
1997	831,098	2,277.0		96,902,990.46
1998	701,653	1,922.3		102,698,430.54
1999	725,653	1,988.1		106,237,561.35
2000	682,611	1,865.1		109,896,041.17
2001	587,052	1,608.4		112,692,066.57
2002	605,891	1,660.0		113,918,496.85
2003	611,849	1,676.3		115,339,164.84
2004	500,378	1,367.2		116,754,331.92
2005	499,028		1,544.7	116,458,200.93
2006	499,028		1,500.8	116,161,646.18
2007	499,028		1,460.6	115,884,309.60
2008	499,028		1,423.6	115,624,945.76
2009	499,028		1,389.3	115,382,389.94
2010	495,451		1,357.4	115,155,552.91
2011	484,647		1,327.8	114,891,444.92
2012	474,500		1,300.0	114,487,478.54
2013	465,010		1,274.0	113,962,262.96



<Figure Annex 3-1> Result of regression analysis (During the first crediting period)

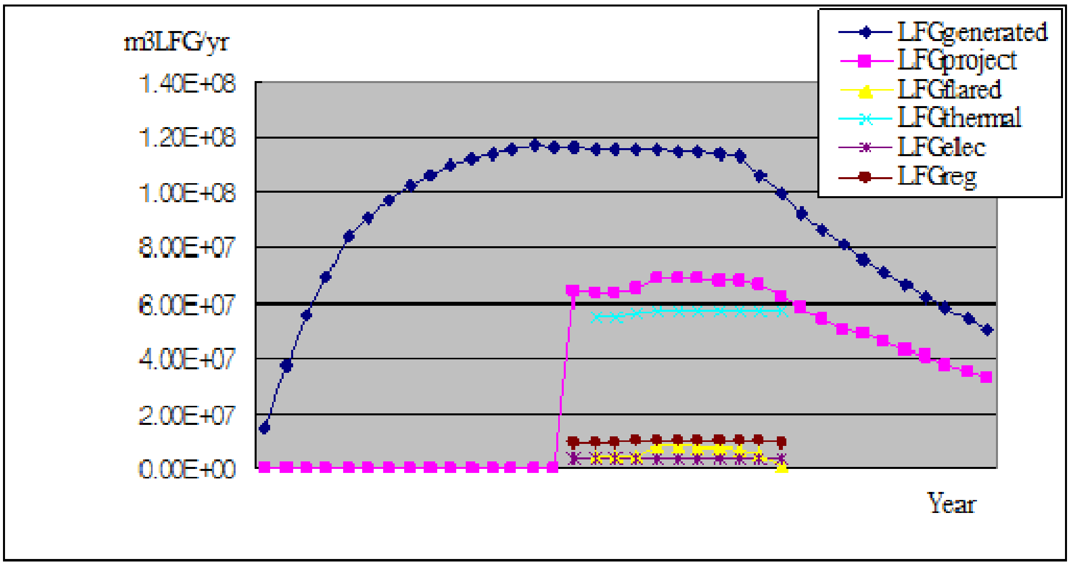
Sub-step 1-2. Estimation of LFG generated, captured and treated amount

International methodology for calculation of GHG emission amount is indicated on IPCC guideline(1997) WRI/WBCSD-GHG Protocol. Between Tier 1 and Tier 2, which is suggested on international wide-used IPCC guideline, Tier 2 is selected and estimate LFG generation amount because of its accuracy. LFG generation formulation by Tier 2 is followed;
yr^{-1}
<Table Annex 3-3> Formulation of LFG (Methane) generation and result of estimation

Applied formulation
$Q_m = L_0 R (e^{-kc} - e^{-kt})$ Q_m : Annual methane generation amount (m3-CH4/yr) Lo : Methane emission factor of applicable year (m3-CH_4/ton-waste) R : Filled waste amount of applicable year (ton-waste/yr) k : methane generation velocity constant (yr^{-1}) c :Time of filling completion (years) t : Filling-up period (years)

The formula above which is applied to this project to estimate expected amount of CH4 generation is EPA Landfill Air Emission Model(ver.2.01), one of well known EPA Model. To estimate expected amount of LFG generation which is shown in the table above, <Table Annex 3-2>, considering the average methane fraction in the landfill gas is 50%, the amount of LFG generated is calculated by multiplying 2 by the amount of methane generation calculated using EPA model which is introduced above.
Constants applied for the formula in this project are Lo = 112.1 m3-CH_4/ton-waste which is conservative value used for design this project and k = 0.067/year which is adjusted value from default value of EPA Model considering the contents of wastes in Korea.

Graph below shows expected LFG generation and result of expected treatment amount from 1990 to 2026.



<Figure Annex 3-2> Expected LFG generated and result of expected treatment amount

Sub-step 1-3. Estimation for GHG reduction

Please refer to A.4.4, B.6.3 and B.6.4.

$EF_{EL,\ leakage}$

$EL_{leakage} = EL_{imp} * EF_{EL,\ leakage}$

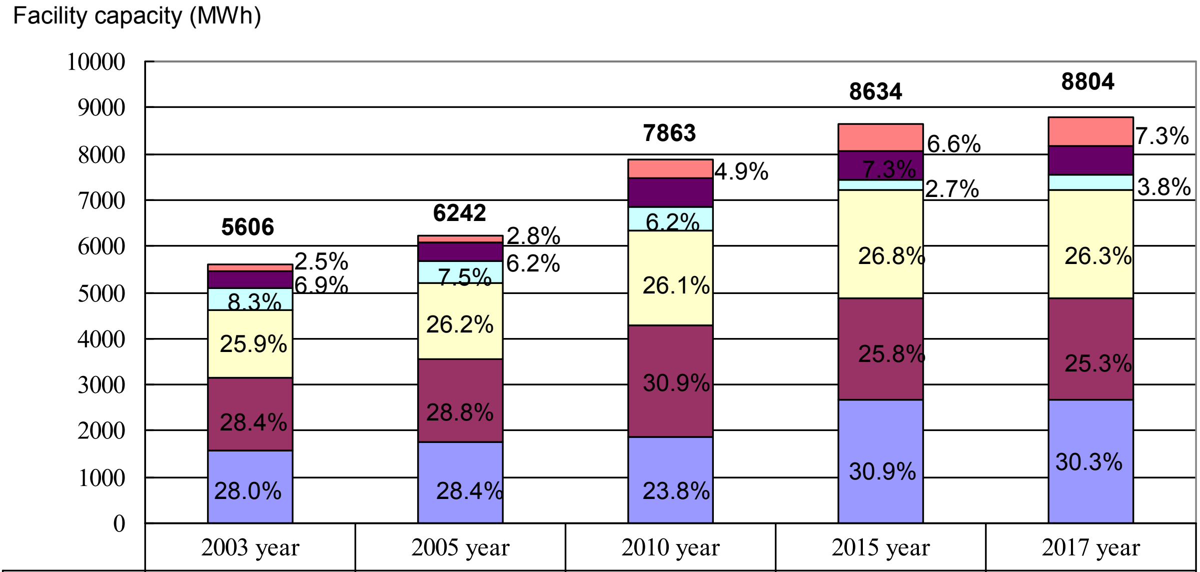
To calculate $EF_{EL,\ leakage}$, EL_{imp} is monitored in real-time and $EF_{EL,\ leakage}$ should be calculated. $EF_{EL,\ leakage}$ is CO2 emissions intensity of the electricity in tCO2e/MWh and calculated applying ACM0002. The way to calculate $EF_{EL,\ leakage}$ (EF_y in ACM0002 is $EF_{EL,\ leakage}$ in this project.)is as follows:

To calculate the baseline emission factor (EF_y), ACM0002.-"Consolidated baseline methodology for grid-connected electricity generation form renewable sources."(Version 06) is applied and sources of data are Statistics of Electric Power in KOREA (2004, 2005, 2006) (KEPCO) and Current status of power generating facility(2006, Korea power exchange) considering there is one grid, national grid, in Korea. Also, IPCC 1996 Revised Guidelines were applied.

The baseline emission factor (EF_y) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps. Calculations for this combined margin must be based on data from an official source and made publicly available. To calculate EFy for this project activity, data from Statistics of Electric Power in KOREA which is provided by KEPCO and Current status of power generating facility which is provided by Korea power exchange was applied.

EF_y can be calculated as follows.:

Electricity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources.



	2003 year	2005 year	2010 year	2015 year	2017 year
renewable	138	177	389	571	641
hydro	388	388	629	629	629
oil	463	471	491	233	333
LNG	1452	1637	2055	2313	2313
coal	1593	1797	2427	2224	2224
nuclear	1572	1772	1872	2664	2664

<Figure Annex 4-3> Forecast for the Electricity Composition based on the Source of Energy (Source: the 2nd demand-supply program of electricity from 2004 to 2017, December 2004, MOCIE)

<Table Annex 4-2> Key information and data used to determine EFy

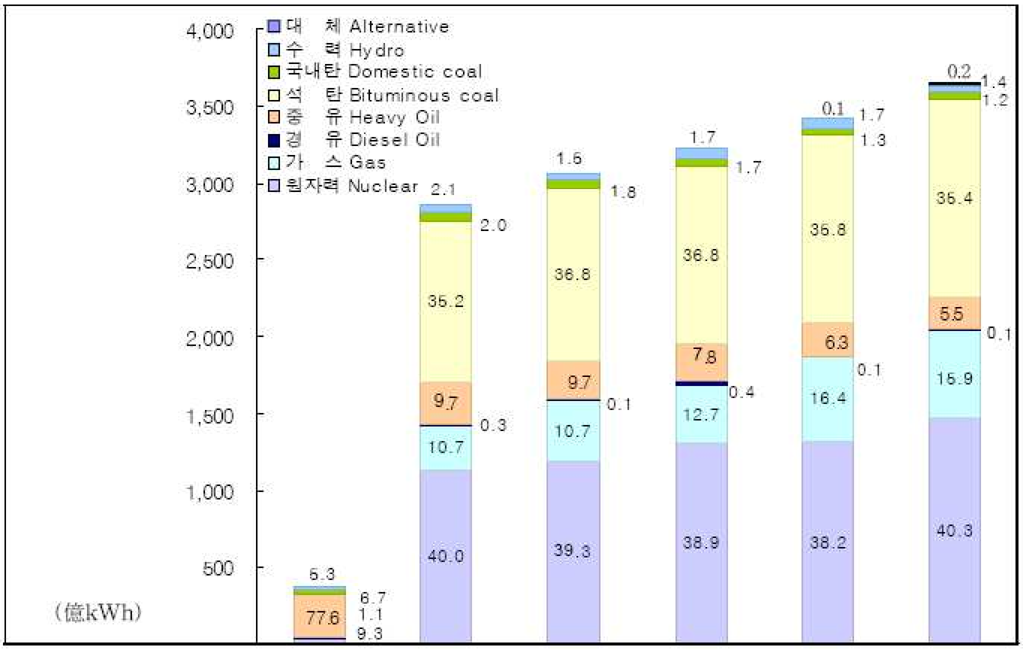
Parameter	Value	Source
$GEN_{j,y}$ (MWh) is the electricity delivered to the grid by source *j*.	Refer to <Table Annex 4-9>, <Table Annex 4-10>, <Table Annex 4-11>	Statistics of Electric Power in KOREA (2004, 2005, 2006) (KEPCO)
$F_{i,j,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y*, *j* refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid	Refer to <Table Annex 4-3>, <Table Annex 4-4>, <Table Annex 4-5>	Statistics of Electric Power in KOREA (2004, 2005, 2006) (KEPCO)
Net Calorific Values by Power Plant	Refer to <Table Annex 4-6>, <Table Annex 4-7>, <Table Annex 4-8>	Statistics of Electric Power in KOREA (2004, 2005, 2006) (KEPCO)
Fuels Carbon Emission Factor (tC/TJ)	Refer to <Table Annex 4-12>	IPCC 1996 Revised Guidelines
Fraction of Carbon Oxidised (OXID)	Coal : 0.98 Oil and Oil product : 0.99 Gas : 0.995	IPCC 1996 Revised Guidelines
Operating Margin Emissions Factor (in ton CO_2/MWh)	0.7187	Calculated
Build Margin Emissions Factor (in ton CO_2/MWh)	0.3920	Calculated
Baseline Emissions Factor (in ton CO_2/MWh)	0.5554	Calculated

OM (Operating Margin) and BM (Build Margin) are calculated by using data from existing power plants that provide electricity to the current grid-connected electricity generation, and with this result, the EF_y (Emission Factor) can be calculated. The steps for the Baseline calculation methodology is as follows

Step 1. Calculation of the Operating Margin emission factor (OM)

Calculation of Operating Margin emission factor is based on one of the four following methods:
(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch Data Analysis OM, or
(d) Average OM.

The rate of low cost/must run power generation does not exceed 50% of the total grid (the most recent 5-year (2001~2005) average data shows that the rate of low cost/must run is 42.65%) referred to the host country's gross electricity generation rate by energy sources (Source: KEPCO), and an hourly dispatched data is not available. Therefore, Option (a) (Simple OM) has been chosen.



（單位 Unit：百萬kWh million kWh）

年度 Year / 區分 Item		1980	2001	2002	2003	2004	2005
水 力 Hydro		1,984	4,151	5,311	6,887	5,744	5,015
火 力 Thermal	國內炭Coal(Dom.)	2,481	5,235	5,144	5,398	4,603	4,484
	石 炭Coal(Bitum.)	–	105,098	112,877	114,878	122,556	129,174
	重油 Oil(Heavy)	28,876	27,770	23,940	23,656	21,595	20,074
	輕油 Oil(Diesel)	421	386	1,155	2,870	474	412
	가 스 Gas	–	30,451	38,943	39,091	55,999	58,118
原子力 Nuclear		3,477	112,133	119,103	129,672	130,715	146,779
代替에너지 (alternative)		–	–	–	–	463	583
計 Total		37,239	285,224	306,474	322,452	342,148	364,639

<Figure Annex 4-4> Ratios of sub-total (Source: KEPCO in brief, 2006)

As described in ACM0002, the OM 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. The OM is calculated as follows, using a 3-year average:

$$EF_{OM,\,simple,\,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}}$$

$F_{i,j,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y*,
j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid,
$COEF_{i,j,y}$ ($COEF_i = NCV_i \cdot EF_{co2i} \cdot OXID_i$) is the CO_2 emission coefficient of fuel *i* (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y, and
$GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source *j*.

The date used for the formula and the result are as follows.

<Table Annex 4-3> Data on fuel consumption for plants in the Operating Margin(2003)

Plant name		Coal (t)	Heavy oil(kl)	Diesel oil(kl)	LNG(t)
Honam	#1	633,609	3,528	409	-
	#2	832,014	641	366	-
Samchonpo	#1	1,535,849	-	1,144	-
	#2	1,680,305	-	657	-
	#3	1,634,224	-	838	-
	#4	1,710,195	-	299	-
	#5	1,430,182	-	2,118	-
	#6	1,436,503	-	1,570	-
Boryeong	#1	1,263,072	-	968	-
	#2	1,311,401	-	934	-
	#3	1,478,200	-	59	-
	#4	1,355,767	-	307	-
	#5	1,468,153	-	152	-
	#6	1,343,310	-	356	-
Taean	#1	1,466,761	-	319	-
	#2	1,333,563	-	730	-
	#3	1,459,118	-	193	-
	#4	1,358,587	-	628	-
	#5	1,243,228	-	994	-
	#6	1,335,853	-	1,011	-
Hadong	#1	1,476,164	-	390	-
	#2	1,377,617	-	445	-
	#3	1,362,366	-	613	-
	#4	1,483,166	-	302	-
	#5	1,375,276	-	435	-
	#6	1,473,500	-	223	-
Dangjin	#1	1,369,223	-	926	-
	#2	1,360,761	-	787	-
	#3	1,488,422	-	510	-
	#4	1,501,207	-	746	-
Ulsan	#1	-	113,103	484	-
	#2	-	104,734	1,061	-
	#3	-	109,039	500	-
	#4	-	361,447	1,450	-
	#5	-	484,842	1,740	-
	#6	-	327,005	1,525	-
Youngnam	#1	-	250,280	1,024	-
	#2	-	223,269	270	-
Yosu	#1	-	173,830	370	-
	#2	-	85,905	86	-
Pyongtaek	#1	-	343,765	167	2,727

	#2	-	325,723	195	2,402
	#3	-	329,779	111	2,238
	#4	-	361,331	123	2,370
Namjeju	#1	-	12,520	20	-
	#2	-	12,216	24	-
Jeju	#1	-	10,363	23	-
	#2	-	107,856	65	-
	#3	-	124,954	-	-
Seoul	#4	-	-	0.03	32,670
	#5	-	-	4	126,211
Incheon	#1	-	22,390	6	25,930
	#2	-	22,656	6	28,612
	#3	-	24,998	247	34,035
	#4	-	23,774	170	24,093
Pyongtaek	C/C	-	-	96,032	76,012
Ilsan	C/C	-	-	40,006	530,874
Bundang	C/C	-	-	-	598,396
Ulsan	C/C	-	-	63,295	189,997
Seoincheon	C/C	-	-	44,792	1,012,670
Shinincheon	C/C	-	-	47,393	1,405,724
Boryeong	C/C	-	-	97,106	571,742
Busan	C/C	-	-	1,213	234,533
Hallim	C/C	-	-	16,286	-
Anyang	C/C	-	-	-	325,207
Bucheon	C/C	-	-	-	266,577
K I E Co.	C/C	-	-	103,057	381,684
L G Bugog	C/C	-	-	67,273	121,037
Namjeju	D/P	-	56,401	84	-

Source : Statistics of Electric Power in KOREA (2004) (KEPCO)

<Table Annex 4-4> Data on fuel consumption for plants in the Operating Margin(2004)

Plant name		Coal (t)	Heavy oil(kl)	Diesel oil(kl)	LNG(t)
Honam	#1	885,758	606	300	-
	#2	783,300	1,714	335	-
Samchonpo	#1	1,624,500	-	1,674	-
	#2	1,564,986	-	744	-
	#3	1,467,177	-	814	-
	#4	1,538,768	-	785	-
	#5	1,707,777	-	230	-
	#6	1,734,977	-	652	-
Yonghung	#1	1,114,254	-	27,916	-
	#2	459,217	-	18,314	-
Boryeong	#1	1,599,557	-	311	-
	#2	1,555,055	-	616	-
	#3	1,427,263	-	574	-
	#4	1,560,014	-	179	-
	#5	1,397,343	-	422	-
	#6	1,559,785	-	350	-
Taean	#1	1,438,094	-	999	-
	#2	1,509,379	-	310	-
	#3	1,415,585	-	390	-
	#4	1,539,502	-	254	-
	#5	1,547,217	-	329	-
	#6	1,531,751	-	230	-
Hadong	#1	1,389,739	-	533	-
	#2	1,515,681	-	145	-
	#3	1,501,027	-	670	-
	#4	1,397,482	-	737	-
	#5	1,501,672	-	318	-
	#6	1,379,396	-	689	-
Dangjin	#1	1,502,885	-	294	-
	#2	1,523,605	-	211	-
	#3	1,404,465	-	605	-
	#4	1,434,844	-	528	-
Ulsan	#1	-	73,408	114	-
	#2	-	65,316	82	-
	#3	-	71,305	554	-
	#4	-	420,739	1,238	-
	#5	-	513,497	931	-
	#6	-	527,083	1,603	-
Youngnam	#1	-	347,107	837	-
	#2	-	248,049	274	-
Yosu	#1	-	181,712	571	-
	#2	-	316,523	436	-
Pyongtaek	#1	-	204,664	247	2,095
	#2	-	209,664	232	2,515
	#3	-	179,921	240	3,791
	#4	-	192,294	225	3,217
Namjeju	#1	-	16,510	6	-
	#2	-	16,040	13	-
Jeju	#1	-	15,306	7	-
	#2	-	118,473	73	-
	#3	-	124,160	41	-
Seoul	#4	-	-	1.46	22,409

	#5	-	-	3	117,908
Incheon	#1	-	-	-	10,523
	#2	-	-	-	11,094
	#3	-	-	149	4,235
Pyongtaek	C/C	-	-	21	98,846
Ilsan	C/C	-	-	-	593,548
Bundang	C/C	-	-	-	653,880
Ulsan	C/C	-	-	-	347,076
Seoincheon	C/C	-	-	88	1,209,806
Shinincheon	C/C	-	-	-	1,587,638
Boryeong	C/C	-	-	-	988,548
Busan	C/C	-	-	2,687	1,298,418
Hallim	C/C	-	-	28,796	-
Anyang	C/C	-	-	-	270,559
Bucheon	C/C	-	-	-	258,596
K I E Co.	C/C	-	-	-	467,583
L G Bugog	C/C	-	-	-	260,653
Yulchon	C/C	-	-	596	7,388
Namjeju	D/P	-	57,808	80	-

Source : Statistics of Electric Power in KOREA (2005) (KEPCO)

<Table Annex 4-5> Data on fuel consumption for plants in the Operating Margin(2005)

Plant name		Coal (t)	Heavy oil(kl)	Diesel oil(kl)	LNG(t)
Honam	#1	870,214	961	278	-
	#2	912,497	338	185	-
Samchonpo	#1	1,534,223	-	1,220	-
	#2	1,731,265	-	626	-
	#3	1,723,152	-	377	-
	#4	1,632,334	-	1,029	-
	#5	1,516,654	-	1,415	-
	#6	1,546,663	-	1,001	-
Yonghung	#1	2,081,972	-	4,541	-
	#2	1,761,395	-	2,903	-
Boryeong	#1	1,440,343	-	761	-
	#2	1,388,532	-	551	-
	#3	1,589,150	-	90	-
	#4	1,421,343	-	603	-
	#5	1,587,999	-	156	-
	#6	1,260,305	-	627	-
Taean	#1	1,508,570	-	621	-
	#2	1,323,078	-	395	-
	#3	1,494,175	-	650	-
	#4	1,383,297	-	365	-
	#5	1,411,398	-	742	-
	#5	1,504,962	-	417	-
Hadong	#1	1,513,930	-	284	-
	#2	1,410,099	-	792	-
	#3	1,422,196	-	472	-
	#4	1,511,054	-	567	-
	#5	1,345,648	-	614	-

	#6	1,520,774	-	331	-
Dangjin	#1	1,438,702	-	637	-
	#2	1,437,473	-	632	-
	#3	1,549,041	-	141	-
	#4	1,544,010	-	134	-
	#5	499,714	-	5,701	-
	#6	38,671	-	1,779	-
Ulsan	#1	-	70,183	750	-
	#2	-	67,296	585	-
	#3	-	53,085	662	-
	#4	-	375,417	1,971	-
	#5	-	363,992	1,676	-
	#6	-	352,776	1,708	-
Youngnam	#1	-	359,910	844	-
	#2	-	190,085	584	-
Yosu	#1	-	106,919	434	-
	#2	-	218,356	346	-
Pyongtaek	#1	-	293,214	118	3,553
	#2	-	321,188	140	2,641
	#3	-	308,042	132	1,784
	#4	-	311,245	138	2,047
Namjeju	#1	-	14,628	15	-
	#2	-	15,031	12	-
Jeju	#1	-	12,564	12	-
	#2	-	129,516	-	-
	#3	-	122,866	48	-
Seoul	#4	-	-	-	49,143
	#5	-	-	1	108,761

Incheon	#2	-	-	-	8,505
Pyongtaek	C/C	-	-	1	110,953
Ilsan	C/C	-	-	-	533,188
Bundang	C/C	-	-	-	671,944
Ulsan	C/C	-	-	-	470,131
Seoincheon	C/C	-	-	335	989,645
Shinincheon	C/C	-	-	-	1,458,763
Boryeong	C/C	-	-	-	1,161,510
Incheon	C/C	-	-	-	281,813
Busan	C/C	-	-	-	1,211,144
Hallim	C/C	-	-	29,686	-
Anyang	C/C	-	-	-	261,202
Bucheon	C/C	-	-	-	261,705
POSCO POWER	C/C	-	-	-	445,253
G S Bugog	C/C	-	-	-	297,976
Yulchon	C/C	-	-	159	194,534
Namjeju	D/P	-	56,727	37	-
Jeju	D/P	-	31,808	72	-

Source : Statistics of Electric Power in KOREA (2006) (KEPCO)

<Table Annex 4-6> Caloric value(2003)

Plant name		Coal (kcal/kg)	Heavy oil(kcal/l)	Diesel oil(kcal/l)	LNG(kcal/kg)
Honam	#1	5,693	9,859	8,844	-
	#2	5,655	9,901	8,847	-
Samchonpo	#1	5,846	-	9,009	-
	#2	5,844	-	9,011	-
	#3	5,862	-	8,948	-
	#4	5,855	-	8,992	-
	#5	5,766	-	9,000	-
	#6	5,765	-	9,000	-
Boryeong	#1	6,066	-	8,942	-
	#2	6,075	-	8,944	-
	#3	6,254	-	8,749	-
	#4	6,254	-	8,777	-
	#5	6,254	-	8,749	-
	#6	6,239	-	8,749	-
Taean	#1	6,181	-	9,013	-
	#2	6,192	-	9,013	-
	#3	6,188	-	9,013	-
	#4	6,198	-	9,013	-
	#5	6,155	-	9,013	-
	#6	6,167	-	9,013	-
Hadong	#1	6,149	-	8,941	-
	#2	6,144	-	8,984	-
	#3	6,146	-	8,912	-
	#4	6,145	-	8,957	-
	#5	6,148	-	8,871	-
	#6	6,142	-	8,839	-
Dangjin	#1	6,102	-	8,892	-

	#2	6,121	-	8,904	-
	#3	6,129	-	8,889	-
	#4	6,118	-	8,893	-
Ulsan	#1	-	9,861	9,018	-
	#2	-	9,856	9,047	-
	#3	-	9,862	9,035	-
	#4	-	9,921	9,120	-
	#5	-	9,912	9,120	-
	#6	-	9,921	9,120	-
Youngnam	#1	-	9,196	8,997	-
	#2	-	9,043	8,993	-
Yosu	#1	-	9,979	8,975	-
	#2	-	9,983	8,970	-
Pyongtaek	#1	-	9,838	8,974	-
	#2	-	9,844	8,972	12,955
	#3	-	9,845	8,977	12,929
	#4	-	9,842	8,976	12,950
Namjeju	#1	-	9,852	8,900	-
	#2	-	9,853	8,958	-
Jeju	#1	-	10,009	9,238	-
	#2	-	9,945	8,928	-
	#3	-	9,943	8,928	-
Seoul	#4	-	-	9,070	13,013
	#5	-	-	7,515	13,003
Incheon	#1	-	9,828	7,526	13,018
	#2	-	9,833	8,986	13,018
	#3	-	9,822	8,993	13,017
	#4	-	9,830	8,988	13,015
Pyongtaek	C/C	-	-	8,926	13,026
Ilsan	C/C	-	-	8,966	13,021
Bundang	C/C	-	-	-	13,030
Ulsan	C/C	-	-	9,053	13,007
Seoincheon	C/C	-	-	9,151	12,999
Shinincheon	C/C	-	-	9,150	13,005
Boryeong	C/C	-	-	9,131	13,016
Busan	C/C	-	-	9,242	12,997
Hallim	C/C	-	-	8,964	-
Anyang	C/C	-	-	-	13,033
Bucheon	C/C	-	-	-	13,022
K I E Co.	C/C	-	-	9,092	13,014
L G Bugog	C/C	-	-	9,033	13,018
Namjeju	D/P	-	9,852	8,881	-

Source : Statistics of Electric Power in KOREA (2004) (KEPCO)

<Table Annex 4-7> Caloric value(2004)

Plant name		Coal (kcal/kg)	Heavy oil(kcal/l)	Diesel oil(kcal/l)	LNG(kcal/kg)
Honam	#1	5,493	9,814	8,848	-
	#2	5,430	9,817	8,850	-
Samchonpo	#1	5,527	-	9,012	-
	#2	6,275	-	9,010	-
	#3	6,530	-	9,006	-
	#4	6,507	-	9,004	-
	#5	4,829	-	9,000	-
	#6	4,773	-	9,000	-
Yonghung	#1	5,892	-	8,927	-
	#2	5,852	-	8,720	-
Boryeong	#1	5,924	-	8,770	-
	#2	5,922	-	8,910	-
	#3	5,943	-	8,749	-
	#4	5,945	-	8,749	-
	#5	5,931	-	8,749	-
	#6	5,937	-	8,749	-
Taean	#1	5,980	-	8,765	-
	#2	5,977	-	8,699	-
	#3	5,975	-	9,004	-
	#4	5,967	-	8,721	-
	#5	5,996	-	8,912	-
	#6	5,996	-	8,804	-
Hadong	#1	6,032	-	9,002	-
	#2	6,025	-	8,975	-
	#3	6,046	-	8,983	-
	#4	6,097	-	8,993	-
	#5	5,982	-	8,983	-
	#6	5,935	-	8,983	-
Dangjin	#1	6,011	-	8,880	-
	#2	6,000	-	8,889	-
	#3	5,976	-	8,897	-
	#4	5,966	-	8,898	-

Ulsan	#1	-	9,893	9,010	-
	#2	-	9,901	9,010	-
	#3	-	9,896	9,010	-
	#4	-	9,972	9,120	-
	#5	-	9,963	9,120	-
	#6	-	9,959	9,120	-
Youngnam	#1	-	7,432	8,865	-
	#2	-	7,679	8,876	-
Yosu	#1	-	10,011	8,924	-
	#2	-	10,009	8,956	-
Pyongtaek	#1	-	9,877	8,917	12,920
	#2	-	9,879	8,941	12,907
	#3	-	9,902	8,907	12,910
	#4	-	9,903	8,915	12,956
Namjeju	#1	-	9,900	9,333	-
	#2	-	9,901	8,846	-
Jeju	#1	-	9,897	8,961	-
	#2	-	9,912	8,936	-
	#3	-	9,919	8,928	-
Seoul	#4	-	-	9,070	13,011
	#5	-	-	9,070	13,014
Incheon	#1	-	-	-	13,038
	#2	-	-	-	13,039
	#3	-	-	8,951	13,038
Pyongtaek	C/C	-	-	8,758	13,033
Ilsan	C/C	-	-	-	13,017
Bundang	C/C	-	-	-	13,026
Ulsan	C/C	-	-	-	12,920
Seoincheon	C/C	-	-	9,211	13,010
Shinincheon	C/C	-	-	-	13,017
Boryeong	C/C	-	-	-	13,025
Busan	C/C	-	-	-	13,004
Hallim	C/C	-	-	8,972	-
Anyang	C/C	-	-	-	13,025
Bucheon	C/C	-	-	-	13,013
K I E Co.	C/C	-	-	-	13,023
L G Bugog	C/C	-	-	-	13,028
Yulchon	C/C	-	-	11,731	13,014
Namjeju	D/P	-	9,901	8,867	-

Source : Statistics of Electric Power in KOREA (2005) (KEPCO)

<Table Annex 4-8> Caloric value(2005)

Plant name		Coal (kcal/kg)	Heavy oil (kcal/l)	Diesel oil (kcal/l)	LNG(kcal/kg)
Honam	#1	5,392	9,835	8,809	-
	#2	5,376	9,854	8,804	-
Samchonpo	#1	5,913	-	8,841	-
	#2	5,924	-	8,883	-
	#3	5,897	-	9,000	-
	#4	5,898	-	8,943	-
	#5	5,347	-	8,614	-
	#6	5,376	-	9,000	-
Yonghung	#1	6,131	-	8,935	-
	#2	6,053	-	8,947	-
Boryeong	#1	5,830	-	8,943	-
	#2	5,816	-	8,943	-
	#3	5,882	-	8,740	-
	#4	5,890	-	8,748	-
	#5	5,882	-	8,749	-
	#6	5,901	-	8,749	-
Taean	#1	6,000	-	8,692	-
	#2	6,009	-	8,684	-
	#3	6,007	-	8,676	-
	#4	5,999	-	8,705	-
	#5	6,032	-	8,676	-
	#5	6,017	-	8,691	-
Hadong	#1	6,003	-	8,940	-
	#2	5,997	-	8,928	-
	#3	5,998	-	8,982	-
	#4	5,999	-	8,938	-
	#5		-		-

		5,995		8,975	
	#6	5,995	-	8,928	-
Dangjin	#1	5,962	-	8,834	-
	#2	5,962	-	8,915	-
	#3	5,935	-	8,844	-
	#4	5,941	-	8,828	-
	#5	6,115	-	8,904	-
	#6	6,221	-	11,095	-
Ulsan	#1	-	9,900	9,116	-
	#2	-	9,903	9,113	-
	#3	-	9,908	9,119	-
	#4	-	10,001	9,122	-
	#5	-	9,993	9,122	-
	#6	-	9,979	9,118	-
Youngnam	#1	-	7,482	8,942	-
	#2	-	7,729	8,943	-
Yosu	#1	-	9,960	8,887	-
	#2	-	9,944	8,886	-
Pyongtaek	#1	-	9,903	8,943	12,898
	#2	-	9,905	8,961	12,872
	#3	-	9,907	8,949	12,942
	#4	-	9,909	8,949	12,893
Namjeju	#1	-	9,878	9,318	-
	#2	-	9,879	9,307	-
Jeju	#1	-	9,932	8,885	-
	#2	-	9,929	-	-
	#3	-	9,925	8,938	-
Seoul	#4	-	-	-	13,002
	#5	-	-	9,070	13,008

Incheon	#2	-	-	-	13,025
Pyongtaek	C/C	-	-	8,950	13,030
Ilsan	C/C	-	-	-	13,011
Bundang	C/C	-	-	-	13,025
Ulsan	C/C	-	-	-	12,750
Seoincheon	C/C	-	-	9,200	13,009
Shinincheon	C/C	-	-	-	13,013
Boryeong	C/C	-	-	-	13,030
Incheon	C/C	-	-	-	13,012
Busan	C/C	-	-	-	13,000
Hallim	C/C	-	-	8,973	-
Anyang	C/C	-	-	-	13,025
Bucheon	C/C	-	-	-	13,003
POSCO POWER	C/C	-	-	-	13,024
G S Bugog	C/C	-	-	-	13,756
Yulchon	C/C	-	-	10,930	13,023
Namjeju	D/P	-	9,877	8,975	-
Jeju	D/P	-	9,932	8,954	-

Source : Statistics of Electric Power in KOREA (2006) (KEPCO)

<Table Annex 4-9> Electricity generation and COEF(2003)

Plant name		Electricity generation (MWh)	COEF (tonCO2/MWh)
Honam	#1	1,372,873	0.9771
	#2	1,784,483	0.9736
Samchonpo	#1	3,745,916	0.8845
	#2	4,110,134	0.8813
	#3	4,051,427	0.8723
	#4	4,250,404	0.8687
	#5	3,606,167	0.8446
	#6	3,609,696	0.8469
Boryeong	#1	3,237,526	0.8732
	#2	3,380,013	0.8697
	#3	4,090,927	0.8332
	#4	3,754,883	0.8327
	#5	4,063,865	0.8331
	#6	3,709,092	0.8333
Taean	#1	3,995,111	0.8368
	#2	3,651,716	0.8342
	#3	3,994,351	0.8334
	#4	3,708,360	0.8376
	#5	3,370,362	0.8379
	#6	3,637,652	0.8357
Hadong	#1	3,995,331	0.8378
	#2	3,739,800	0.8347
	#3	3,694,945	0.8358
	#4	4,029,035	0.8341
	#5	3,733,243	0.8353
	#6	4,013,010	0.8316
Dangjin	#1	3,677,169	0.8384
	#2	3,685,913	0.8337
	#3	4,034,969	0.8339
	#4	4,096,642	0.8270
Ulsan	#1	430,067	0.7929
	#2	404,834	0.7836
	#3	414,630	0.7931
	#4	1,507,363	0.7272
	#5	2,025,171	0.7251
	#6	1,363,879	0.7275
Youngnam	#1	890,011	0.7907
	#2	753,536	0.8171
Yosu	#1	703,557	0.7524
	#2	328,981	0.7947
Pyongtaek	#1	1,465,460	0.7032
	#2	1,393,188	0.7060
	#3	1,400,056	0.7109
	#4	1,539,552	0.7080
Namjeju	#1	38,080	0.9880
	#2	36,860	0.9963
Jeju	#1	30,288	1.0451
	#2	439,474	0.7438
	#3	513,880	0.7364
Seoul	#4	132,599	0.6743
	#5	503,383	0.6856

Incheon	#1	225,023	0.6134
	#2	242,806	0.6021
	#3	267,999	0.6291
	#4	214,153	0.6424
Pyongtaek	C/C	863,292	0.5307
Ilsan	C/C	3,097,425	0.5031
Bundang	C/C	3,344,852	0.4902
Ulsan	C/C	1,557,954	0.4408
Seoincheon	C/C	7,012,289	0.4118
Shinincheon	C/C	10,459,986	0.3796
Boryeong	C/C	4,436,234	0.4111
Busan	C/C	1,574,883	0.4091
Hallim	C/C	55,044	0.7734
Anyang	C/C	1,793,725	0.4969
Bucheon	C/C	1,454,854	0.5018
K I E Co.	C/C	2,683,591	0.4910
L G Bugog	C/C	1,221,992	0.4162
Namjeju	D/P	265,063	0.6393

Source : Statistics of Electric Power in KOREA (2004) (KEPCO)

<Table Annex 4-10> Electricity generation and COEF(2004)

Plant name		Electricity generation (MWh)	COEF (tonCO2/MWh)
Honam	#1	1,855,554	0.9682
	#2	1,625,399	0.9683
Samchonpo	#1	3,974,202	0.8340
	#2	3,839,080	0.9436
	#3	3,652,769	0.9675
	#4	3,811,371	0.9691
	#5	4,147,957	0.7331
	#6	4,185,213	0.7299
Yonghung	#1	2,986,382	0.8348
	#2	1,172,450	0.8847
Boryeong	#1	4,014,109	0.8705
	#2	3,915,285	0.8676
	#3	3,746,265	0.8352
	#4	4,097,489	0.8346
	#5	3,660,240	0.8351
	#6	4,093,207	0.8344
Taean	#1	3,780,097	0.8394
	#2	3,975,123	0.8368
	#3	3,732,363	0.8357
	#4	4,048,258	0.8368
	#5	4,091,406	0.8362
	#6	4,056,835	0.8348
Hadong	#1	3,688,313	0.8383
	#2	4,028,529	0.8357
	#3	3,997,064	0.8375
	#4	3,724,757	0.8438
	#5	4,013,845	0.8252
	#6	3,685,698	0.8194
Dangjin	#1	3,986,406	0.8357
	#2	4,038,457	0.8347
	#3	3,711,787	0.8340
	#4	3,801,495	0.8305
Ulsan	#1	271,544	0.8157
	#2	244,246	0.8073
	#3	268,231	0.8067
	#4	1,759,376	0.7283
	#5	2,141,162	0.7289
	#6	2,196,344	0.7299
Youngnam	#1	973,872	0.8090
	#2	665,973	0.8723
Yosu	#1	723,968	0.7674
	#2	1,304,109	0.7408
Pyongtaek	#1	850,533	0.7314
	#2	880,646	0.7248
	#3	751,633	0.7365
	#4	800,854	0.7359
Namjeju	#1	50,294	0.9902
	#2	48,714	0.9937
Jeju	#1	44,659	1.0336
	#2	486,401	0.7358
	#3	509,330	0.7367
Seoul	#4	90,322	0.6789
	#5	480,919	0.6710

Incheon	#1	47,491	0.6075
	#2	49,144	0.6190
	#3	19,018	0.6310
Pyongtaek	C/C	596,001	0.4546
Ilsan	C/C	3,281,407	0.4951
Bundang	C/C	3,650,122	0.4907
Ulsan	C/C	2,329,524	0.4048
Seoincheon	C/C	8,353,619	0.3963
Shinincheon	C/C	11,596,955	0.3748
Boryeong	C/C	6,979,928	0.3879
Busan	C/C	9,884,075	0.3592
Hallim	C/C	96,435	0.7812
Anyang	C/C	1,506,070	0.4921
Bucheon	C/C	1,425,073	0.4966
K I E Co.	C/C	2,809,983	0.4557
L G Bugog	C/C	1,894,996	0.3768
Yulchon	C/C	36,366	0.6120
Namjeju	D/P	274,089	0.6368

Source : Statistics of Electric Power in KOREA (2005) (KEPCO)

<Table Annex 4-11> Electricity generation and COEF(2005)

Plant name		Electricity generation (MWh)	COEF (tonCO2/MWh)
Honam	#1	1,787,715	0.969775
	#2	1,875,790	0.965165
Samchonpo	#1	3,810,079	0.878838
	#2	4,323,618	0.875081
	#3	4,343,666	0.862831
	#4	4,112,297	0.863929
	#5	3,542,728	0.845002
	#6	3,643,969	0.842121
Yonghung	#1	5,623,299	0.839107
	#2	4,658,862	0.845492
Boryeong	#1	3,547,140	0.873489
	#2	3,433,608	0.867685
	#3	4,124,745	0.835689
	#4	3,698,705	0.835034
	#5	4,121,314	0.83582
	#6	3,283,477	0.835687
Taean	#1	3,992,112	0.836401
	#2	3,484,251	0.841676
	#3	3,957,054	0.836831
	#4	3,653,534	0.837804
	#5	3,744,413	0.838885
	#5	3,999,847	0.835105
Hadong	#1	3,997,914	0.838439
	#2	3,732,583	0.835946
	#3	3,769,077	0.834854
	#4	3,989,315	0.838238
	#5	3,553,901	0.837489
	#6	4,037,763	0.832791
Dangjin	#1	3,797,307	0.833337
	#2	3,798,078	0.832519
	#3	4,081,017	0.83078
	#4	4,079,557	0.829236
	#5	1,318,670	0.865703
	#6	96,365	0.980255
Ulsan	#1	262,393	0.814259
	#2	255,812	0.799711
	#3	200,518	0.807912
	#4	1,549,091	0.741722
	#5	1,500,935	0.741278
	#6	1,454,644	0.740409
Youngnam	#1	1,022,470	0.804523
	#2	531,006	0.845724
Yosu	#1	430,310	0.756566
	#2	904,597	0.732255
Pyongtaek	#1	1,258,662	0.710687
	#2	1,376,342	0.709618
	#3	1,321,167	0.707667
	#4	1,338,204	0.706521

Namjeju	#1	44,602	0.987901
	#2	44,654	1.013819
Jeju	#1	36,266	1.049095
	#2	532,700	0.73543
	#3	502,189	0.740008
Seoul	#4	207,498	0.647692
	#5	444,324	0.669728
Incheon	#2	37,727	0.617604
Pyongtaek	C/C	659,932	0.460786
Ilsan	C/C	2,873,958	0.507729
Bundang	C/C	3,742,073	0.491941
Ulsan	C/C	3,131,075	0.402668
Seoincheon	C/C	7,001,031	0.386929
Shinincheon	C/C	10,543,280	0.378715
Boryeong	C/C	8,221,926	0.387172
Incheon	C/C	2,055,016	0.375319
Busan	C/C	9,076,327	0.364863
Hallim	C/C	100,346	0.774174
Anyang	C/C	1,433,978	0.499029
Bucheon	C/C	1,404,160	0.509728
POSCO POWER	C/C	2,571,095	0.474389
G S Bugog	C/C	2,189,808	0.393716
Yulchon	C/C	1,300,627	0.410083
Namjeju	D/P	268,073	0.637104
Jeju	D/P	151,759	0.635426

Source : Statistics of Electric Power in KOREA (2006) (KEPCO)

<Table Annex 4-12> Fuel Carbon Emission Factor

Fuel	Carbon Emission Factor (tC/TJ)	Fuel	Carbon Emission Factor (tC/TJ)
Liquid Fossil		**Solid Fossil**	
Primary fuels		*Primary Fuels*	
Crude oil	20	Anthracite	26.8
Orimulsion	22	Coking coal	25.8
Natural gas liquids	17.2	Other bituminous coal	25.8
Secondary fuels/products		sub-bituminous coal	26.2
Gasoline	18.9	Lignite	27.6
Jet kerosene	19.5	Oil shale	29.1
Other Kerosene	19.6	Peat	28.9
Shale oil	20	*Secondary fuels/products*	
Gas/Diesel oil	20.2	BKB & Patent Fuel	25.8
Residual fuel oil	21.1	Coke Oven/Gas Coke	29.5
LPG	17.2	Coke gas oven	13
Ethane	16.8	Blast Furnace gas	66
Naphtha	20	**Gaseous Fossil**	
Bitumen	22	Natural gas (dry)	15.3
Lubricants	20	**Biomass**	
Petroleum coke	27.5	Solid Biomass	29.9
Refinery Feedstocks	20	Liquid Biomass	20
Refinery gas	18.2	Gas Biomass	30.6
Other oil	20		

Source: IPCC Guidelines, 1996a

According to the OM calculation equation and variables of above tables, OM is 0.7187 ton CO2 eq./MWh(it is same as 0.7187kgCO2eq./kWh).

Step 2. Calculation of the Build Margin (BM)

According to ACM0002, there are two options to choose in order to calculate the BM.

Option 1. Calculate the Build Margin emission factor $EF_{BM,y}$ *ex ante* based on the most recent information available on plants already built for sample group *m* at the time of PDD submission. The sample group *m* consists of either

- the five power plants that have been built most recently, or
- the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

Option 2. For the first crediting period, the Build Margin emission factor $EF_{BM,y}$ must be updated annually *ex post* for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods, $EF_{BM,y}$ should be calculated *ex-ante*, as described in option 1 above. The sample group *m* consists of either

- the five power plants that have been built most recently, or
- the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

For this project, Option 1 was selected. To select the sample group *m*, “the five power plants that have been built most recently” and “the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) which have been built most recently” were compared and the results are as follows.

<Table Annex 4-13> Sample Plant group (m) for determining Build margin Emission factor

Sample group(m) Classification	“The five power plants that have been built most recently”	“The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.”	Comments
Electricity quantity	1,319 GWh	70,513 GWh	Total generation is 348,187 GWh in Korea (based on KEPCO’s data of the year 2005)
Proportion (ratio to total generation in Korea)	0.38%	20.25%	
Selected Group		**O**	

The annual generation of “the five power plants that have been built most recently” was 1,319 GWh (0.38% of total generation of the grid system), and the annual generation of “the power plants capacity additions in the electricity system that comprise 20.25 % of the system generation and that have been built most recently” was 70,513 GWh. Therefore, the latter was chosen as a lager figure than the other one.

The calculation of BM_y is as follows;

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_{m} GEN_{m,y}}$$

<Table Annex 4-14> Sample group plants used in the Build Margin calculation and Carbon Emission Factor of the Build Margin

Plant name		Technology	year operation	Fuel	MWh in 2005	% of total output	CEF	Result
Suncheon Solar		solar	2005.12	solar	215	0.00%	0	0
Samcheonpo solar energy		solar	2005.10	Solar	37	0.00%	0	0
Dangjin	#5	steam	2005.10	Anthracite	1,318,670	1.88%	0.9113	0.0171
Yangyang		small hydro power	2005.08	hydro	2,141	0.00%	0	0
Taean solar energy		Solar	2005.08	Solar	43	0.00%	0	0
Wunjeong LFG		Steam by LFG	2005.07	LFG	13,166	0.02%	0	0
Yulchon		Combined cycle power	2005.07	LNG	1,300,627	1.85%	0.4556	0.0084
Incheon		Combined cycle power	2005.06	LNG	2,055,016	2.92%	0.4170	0.0122
Daegok		small hydro power	2005.06	Hydro	522	0.00%	0	0
Donghwa		small hydro power	2005.05	Hydro	2,399	0.00%	0	0
Ulchin	#6	Nuclear	2005.04	nuclear	7,085,820	10.08%	0	0
Hanryo LFG		LFG	2005.04	LFG	4,774	0.01%	0	0
Busan Bio-gas		Steam	2005.01	LFG	120	0.00%	0	0
Maebongsan-wind power		Wind	2004.12	Wind	5,543	0.01%	0	0
Yongheng	#2	Steam	2004.11	bituminous	4,658,862	6.63%	0.8900	0.0590
new solar energy		Solar power	2004.09	solar	209	0.00%	0	0
Daegwanryung-wind power		Wind power	2003.11/2004.08	Wind	4,137	0.01%	0	0
Yongheng	#1	Steam	2004.07	bituminous	5,623,299	8.00%	0.8833	0.0707
Ulchin	#5	Nuclear	2004.07	nuclear	7,313,595	10.41%	0	0
Busan	C/C	Combined cycle	2003.05/2004	LNG	9,076,327	12.92%	0.4054	0.0524

		power	.03					
Hankyung-wind power		Wind	2004.02	Wind	18,265	0.03%	0	0
Chunsang		small hydro power	2004.01	Hydro	40	0.00%	0	0
Cheongju LFG		Internal	2004.01	LFG	6,168	0.01%	0	0
Daejon Geumgodong		Internal	2003.06	LFG	12,794	0.02%	0	0
Hoicheon ENC		Internal	2003.05	LFG	3,650	0.01%	0	0
Gunsan-wind power		Internal	2002.11/2003.09	Wind	6,582	0.01%	0	0
Sangwon ENC		Internal	2001.12/2003.03/2003.06	LFG	39,309	0.06%	0	0
Muju		small hydro power	2003.04	Hydro	569	0.00%	0	0
Seohee- ENC		Internal	2003.04	LFG	31,360	0.04%	0	0
Yonggwang	#6	nuclear	2002.12	nuclear	7,776,138	11.06%	0	0
Taean	#6	Steam	2002.05	bituminous	3,999,847	5.69%	0.8791	0.0500
Yonggwang	#5	nuclear	2002.05	nuclear	7,748,431	11.03%	0	0
Sanchong pumping #2		Pumping	2001.11	Hydro	138,862	0.20%	0	0
Milyang		small hydro power	2001.10	Hydro	6,147	0.01%	0	0
Sanchong pumping #1		Pumping	2001.09	Hydro	224,274	0.32%	0	0
Yongdam		small hydro power	2001.09	Hydro	172,266	0.25%	0	0
Yeongcheon		small hydro power	2001.08	Hydro	1,708	0.00%	0	0
Hadong	#6	Steam	2001.07	bituminous	4,037,763	5.75%	0.8766	0.0504
Dangjin	#4	Steam	2001.03	bituminous	4,079,557	5.80%	0.8729	0.0507
Pohang-wind power		wind	2001.02	Wind	-	0.00%	0	0.0000

Taean	#5	Steam	2001.01	bituminous	3,744,413	5.15%	0.8830	0.0455
Total					70,513,665	100%	BM Factor	0.3920

Source: Statistics of Electric Power in KOREA (2006) (KEPCO), Current status of power generating facility(2006, Korea power exchange)

According to the BM calculation formula and variables of above tables, BM is 0.3920tCO2/MWh(it is same as 0.3920 kgCO_2 equ/kWh).

Step 3. Calculation of the baseline emission factor (*EF_y*)

Baseline emission factor is the weighted average of the Operating Margin emission factor ($EF_{OM,y}$) and the Build Margin emission factor ($EF_{BM,y}$).

$$EF_y = w_{OM} * EF_{OM\,y} + w_{BM} * EF_{BM,\,y}$$

The weights w_{OM} and w_{BM}, by defult, are 50% (i.e. = = 0.5) and $EF_{OM,y}$ and $EF_{BM,y}$ are calculated as described in Steps 1 and 2 and expressed in tCO2/MWh.

For wind and solar projects, the default weights are as follows : w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature).

Therefore,

$$EF_y = 0.5 * 0.7187 tCO2/MWh + 0.5 * 0.3920 tCO2/MWh$$
$$= 0.5554 tCO2/MWh$$

EF(Emission factor) is 0.5554 CO_2 ton/MWh (it is same as 0.5554kgCO2e/kWh).

Appendix 5. Further background information on monitoring plan

For normal situation, refer to section D.

1. LNG supply

This section (1. LNG supply in Annex 4) is about abnormal situation when LNG is supplied and mixed with LFG.

Data / Parameter	LNG
Unit	Nm3
Description	Amount of LNG supplied
Source of data	Read from flow-meter
Value(s) applied	N/A
Measurement methods and procedures	The data is read from flow meter installed continuously.
Monitoring frequency	Data to be aggregated monthly and yearly
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of project emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Flow-meter installed after the LNG supplier for monitoring this data is ‘Vortex Flow meter’. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	LNG supply time
Unit	N/A
Description	The time LNG is supplied.
Source of data	Automatically recored
Value(s) applied	N/A
Measurement methods and procedures	When amount of LNG supplied is measured and recorded, LNG supply time is recorded together.
Monitoring frequency	Data to be aggregated monthly and yearly
QA/QC procedures	If necessary, the equipment for monitoring LNG supply time should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	-

Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	Mixed $gas_{electricity,y}$
Unit	Nm3
Description	The volume of mixed gas (LFG+LNG) fed into the electricity generator
Source of data	Read from flow meter
Value(s) applied	N/A
Measurement methods and procedures	If LNG is supplied, the gas fed into the electricity generator is mixed gas of LFG and LNG. The volume of mixed gas fed into the electricity generator will be monitored by flow meter installed in front of the generator.
Monitoring frequency	Data to be aggregated monthly and yearly
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of project emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	Mixed $gas_{thermal,y}$
Unit	Nm3
Description	The volume of mixed gas (LFG+LNG) fed into the boiler
Source of data	Read from flow meter
Value(s) applied	N/A
Measurement methods and procedures	If LNG is supplied, the gas fed into the boiler is mixed gas of LFG and LNG. The volume of mixed gas fed into the boiler will be monitored by flow meter installed in front of the generator.
Monitoring frequency	Data to be aggregated monthly and yearly
QA/QC procedures	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of project emissions
Additional comment	- Archived data are to be kept during the crediting period and two years after. - Data to be aggregated monthly and yearly. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2.

Data / Parameter	$w_{CH4, y, Mixed gas}$
Unit	m3 CH4/m3 Mixed gas
Description	Methane fraction in the mixed gas
Source of data	Read from gas analyzer installed behind the gas storage tank.
Value(s) applied	50%
Measurement methods and procedures	The data is read from gas analyzer installed continuously.
Monitoring frequency	Hourly
QA/QC procedures	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Purpose of data	Calculation of project emissions
Additional comment	- In abnormal situation that LNG is supplied, $w_{CH4, y, Mixed gas}$ will be measured by the gas analyzer installed behind the gas storage tank. - Archived data are to be kept during the crediting period and two years after. - Gas Analyzer installed for monitoring this data is ‘Infrared Gas Analyzer’. - Uncertainty level of data is low. Therefore, it means that the accuracy of the measurement method is high. - For responsible person/entity that should undertake the measurement method, refer to B.7.2. - The measured data will be used to calculate $MD_{thermal,y, mixed gas}$ and $MD_{electricity,y, mixed gas}$

Data / Parameter	PE_{LNG}
Unit	tonCO2eq.
Description	CO2 emissions caused by combustion of LNG
Source of data	Calculated
Value(s) applied	N/A

Measurement methods and procedures	Using the amount of LNG supply and content of LNG, this value will be calculated. The calculation method is explained below, the equation number (1) to (5).
Monitoring frequency	Hourly
QA/QC procedures	N/A
Purpose of data	Calculation of project emissions
Additional comment	- This value will be calculated just in case LNG is supplied for conservativeness of the project activity.

Data / Parameter	Content of supplied LNG
Unit	Monthly average value of content of supplied LNG
Description	When LNG is supplied, monthly average value of content of supplied LNG can be provided by the LNG supplier.
Source of data	N/A
Value(s) applied	N/A
Measurement methods and procedures	N/A
Monitoring frequency	Monthly
QA/QC procedures	N/A
Purpose of data	Calculation of project emissions
Additional comment	N/A

All other data and parameters required to calculate to emission reductions are to be monitored as stated in section B.7.1 such as LFG_{total}, $LFG_{flare,y}$, FE, Operation time of gas engine generator, Operation time of boiler, P, T, EL_{imp}, etc.

Captured LFG is supplied to user for producing thermal energy and caloric value of supplied LFG maintains a certain level for the operation condition of the boiler and according to the contract between supplier and user, supply range of caloric value of supplied LFG is 4,625 kcal/Nm3(LHV) (5,127kcal/Nm3(HHV))±250 kcal/Nm3. Therefore, when caloric value of captured LFG is less than 4,625 kcal/Nm3(LHV)(5,127kcal/Nm3(HHV))±250 kcal/Nm3, LNG (city gas) may abnormally be supplied to the landfill site and mixed with LFG which is supplied to the boiler as fuel to satisfy the operation condition of the boiler which is in Korea District Heating Corp. In that situation, the volume of the gas supplied from the landfill site to the boiler is the volume of mixed gas (LNG and LFG). Therefore, the volume of LNG is to be monitored so that CO2 emission caused by combustion of LNG can be considered as project emission and methane destroyed by combustion of LNG in the boiler can be excluded from methane destroyed by combustion of mixed gas in the boiler. The volume of mixed gas (LNG and LFG) supplied from the landfill site to the boiler can be monitored with flow meters. Furthermore, the amount of LNG supplied can be monitored with flow meter anytime.

In that abnormal situation, emission reductions can be monitored through additional way as follows:

To monitor emission reduction in that abnormal situation, $LFG_{flared,y}$, $LFG_{electricity,y}$ and $LFG_{thermal,y}$ are monitored and $MD_{project,y}$ will be calculated using monitored data. However, supplied LFG to Korea District Heating Corp. will be mixed with LNG to adjust the caloric value for boiler operating condition and monitored $LFG_{electricity,y}$ and $LFG_{thermal,y}$ are amount of LFG including LNG. Therefore, when $MD_{project,,y}$ is calculated, supplied LNG should be considered.
According to the methodology ACM0001, the formula to calculate $MD_{project,y}$ is:

$$MD_{project,,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y}$$

and each MD is calculated using amount of LFG, methane fraction of the LFG and methane density. Additionally, $LFG_{electricity,y}$ and $LFG_{thermal,y}$ include LNG. Therefore, to calculate real $MD_{project,y}$, quantity of methane destroyed by using LNG should be eliminated from calculated $MD_{project,y}$ using monitored $LFG_{electricity,y}$ and $LFG_{thermal,y}$ in monitoring procedure.

The formulae to calculate real $MD_{project,y}$ are as follows:

$$MD_{project,y,real} = (MD_{flared,y} + MD_{electricity,y,mixed\ gas} + MD_{thermal,y,\ mixed\ gas}) - MD_{LNG,y}$$
$$MD_{LNG,y} = LNG * w_{CH4,y,LNG} * D_{CH4}$$

$MD_{project,y,real}$: the real amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH4)
$MD_{flared,y}$: the quantity of methane destroyed by flaring
$MD_{electricity,y,\ mixed\ gas}$: the quantity of methane destroyed by generation of electricity and monitored Mixed $gas_{electricity,y}$ which is used to calculate includes LNG
$MD_{thermal,y,\ mixed\ gas}$: the quantity of methane destroyed for the generation of thermal energy and monitored Mixed $gas_{thermal,y}$ which is used to calculate includes LNG
$MD_{LNG,y}$: the quantity of methane destroyed by using LNG
LNG : the quantity of LNG supplied
$w_{CH4,y,LNG}$: methane fraction of LNG
D_{CH4} : the methane density

Among data above, $w_{CH4,y,LNG}$ applied for the project can be known through a monthly average value of LNG (city gas) content which can be provided by LNG (city gas) supplier and the value is generally 89~90%. D_{CH4} is 0.0007168 tCH4/m3CH4 which is suggested in the methodology ACM0001.

Also, in the abnormal situation, CO2 emission caused by combustion of LNG in the boiler is considered as project emission (PE_{LNG}) and in this situation, emission reductions will be calculated as follow:

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} - leakage - PE_{LNG}$$

PE_{LNG} can be calculated using a monthly average value of LNG (city gas) content which can be provided by LNG (city gas) supplier, complete combustion reaction formula and oxidation factor. As oxidation factor for combustion of LNG, the fraction of carbon oxidised of gas which is suggested in Revised 1996 IPCC will be applied and the value is 0.995.

Applied formula for each content is as follows:

(1) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
$CH4_{LNG} = LNG * w_{CH4,y,LNG}$
$CO2_{LNG,CH4} = CH4_{LNG} \div 22.4m3/kmol * 44kg/kmol * 0.995 * 1ton/1000kg$

Where :
$CH4_{LNG}$: methane volume included in LNG (m3)
LNG : the quantity of LNG supplied(m3)
$w_{CH4,y,LNG}$: methane fraction of LNG (vol%)
$CO2_{LNG,CH4}$: CO2 emission caused by complete combustion of CH4 included in LNG (tonCO2)
22.4m3/tonmol : volume of 1 tonmol of gas at standard temperature and pressure
44ton/tonmol : molecular weight of CO2
0.995 : fraction of carbon oxidised of gas (source : Revised 1996 IPCC)

(2) $C_2H_6 + 7/2O_2 \longrightarrow 2CO_2 + 3H_2O$
$C2H6_{LNG} = LNG * w_{C2H6,y,LNG}$
$CO2_{LNG,C2H6} = 2 * C2H6_{LNG} \div 22.4m3/kmol * 44kg/kmol * 0.995 * 1ton/1000kg$

Where :
$C2H6_{LNG}$: Ethane volume included in LNG (m3)
LNG : the quantity of LNG supplied(m3)
$w_{C2H6,y,LNG}$: Ethane fraction of LNG (vol%)
$CO2_{LNG,C2H6}$: CO2 emission caused by complete combustion of C2H6 included in LNG (tonCO2)
22.4m3/tonmol : volume of 1 tonmol of gas at standard temperature and pressure
44ton/tonmol : molecular weight of CO2
0.995 : fraction of carbon oxidised of gas (source : Revised 1996 IPCC)

(3) $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

$C3H8_{LNG} = LNG * w_{C3H8,y,LNG}$

$CO2_{LNG,C3H8} = 3 * C3H8_{LNG} \div 22.4m3/kmol * 44kg/kmol * 0.995 * 1ton/1000kg$

Where :
$C3H8_{LNG}$: Propane volume included in LNG (m3)
LNG : the quantity of LNG supplied(m3)
$w_{C3H8,y,LNG}$: Propane fraction of LNG (vol%)
$CO2_{LNG,C3H8}$: CO2 emission caused by complete combustion of C3H8 included in LNG (tonCO2)
22.4m3/tonmol : volume of 1 tonmol of gas at standard temperature and pressure
44ton/tonmol : molecular weight of CO2
0.995 : fraction of carbon oxidised of gas (source : Revised 1996 IPCC)

(4) $C_4H_{10} + 13/2O_2 \longrightarrow 4CO_2 + 5H_2O$

$C4H10_{NG} = LNG * w_{C4H10,y,LNG}$

$CO2_{LNG,C4H10} = 4 * C4H10_{LNG} \div 22.4m3/kmol * 44kg/kmol * 0.995 * 1ton/1000kg$

Where :
$C4H10_{LNG}$: Butane volume included in LNG (m3)
LNG : the quantity of LNG supplied(m3)
$w_{C4H10,y,LNG}$: Butane fraction of LNG (vol%)
$CO2_{LNG,C4H10}$: CO2 emission caused by complete combustion of C4H10 included in LNG (tonCO2)
22.4m3/tonmol : volume of 1 tonmol of gas at standard temperature and pressure
44ton/tonmol : molecular weight of CO2
0.995 : fraction of carbon oxidised of gas (source : Revised 1996 IPCC)
C4H10(Butane) above includes both I-C4H10 and N-C4H10.

(5) $C_5H_{12} + 8O_2 \longrightarrow 5CO_2 + 6H_2O$

$C5H12_{NG} = LNG * w_{C5H12,y,LNG}$

$CO2_{LNG,C5H12} = 5 * C5H12_{LNG} \div 22.4m3/kmol * 44kg/kmol * 0.995 * 1ton/1000kg$

Where :
$C5H12_{LNG}$: Pentane volume included in LNG (m3)
LNG : the quantity of LNG supplied(m3)
$w_{C5H12,y,LNG}$: Pentane fraction of LNG (vol%)
$CO2_{LNG,C5H12}$: CO2 emission caused by complete combustion of C5H12 included in LNG (tonCO2)
22.4m3/tonmol : volume of 1 tonmol of gas at standard temperature and pressure
44ton/tonmol : molecular weight of CO2
0.995 : fraction of carbon oxidised of gas (source : Revised 1996 IPCC)
C5H12(Pentane) above includes both I-C5H12 and N-C5H12.

$CO2_{LNG} = CO2_{LNG,CH4} + CO2_{LNG,C2H6} + CO2_{LNG,C3H8} + CO2_{LNG,C4H10} + CO2_{LNG,C5H12}$

Where :
$CO2_{LNG}$: CO2 emission caused by combustion of LNG

For reference, table below shows a monthly average value of LNG (city gas) content in December, 2006.

<Table Annex 4-1> a monthly average value of LNG (city gas) content in December, 2006.

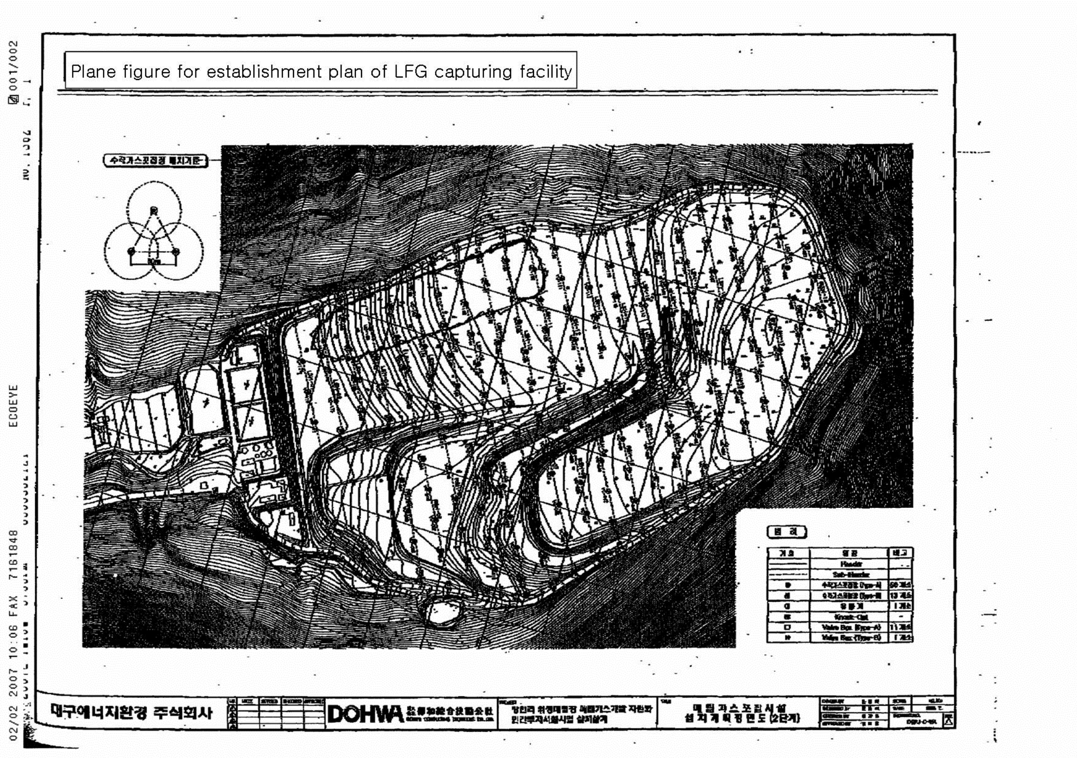
Content	Percentage (vol%)
CH4 (Methane)	90.60
C2H6 (Ethane)	5.71
C3H8 (Propane)	2.46
I-C4H10 (I-Butane)	0.52
N-C4H10 (N-Butane)	0.52
I-C5H12 (I-Pentane)	0.01
N-C5H12 (N-Pentane)	0.00
N2 (Nitrogen)	0.17
CO2 (Carbon dioxide)	0.00
Total	100.00

The amount of LNG is monitored always just in case and if LNG is supplied, the formulae above will be applied during monitoring procedure. Therefore, LNG does not need to be considered to calculate estimated emission reductions in PDD and it means that $MD_{project,y,real}$ in formula above is same as $MD_{project,y}$ in Section B.

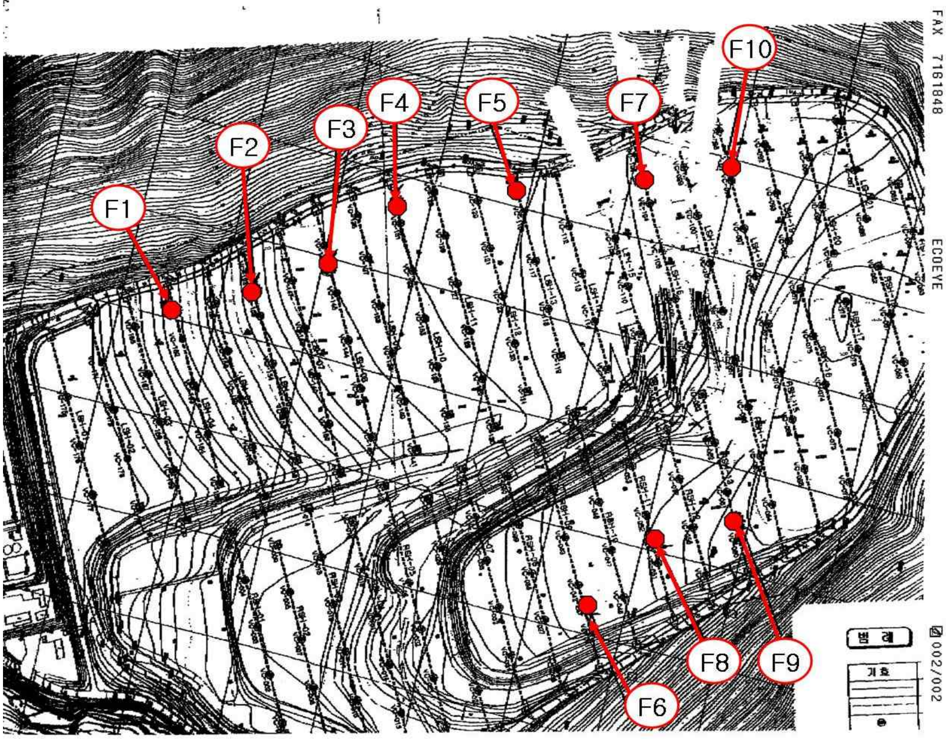
2. AF

AF applied for estimation of emission reductions in the PDD is ex-ante value and AF will be calculated again in the monitoring process and calculated value will be applied for certifying emission reductions. Simple burning system was used before the project activity but it is not used to treat LFG anymore. However, to calculate AF, 10 simple burning facilities will be established for measuring amount of methane captured by simple burning facility and total number of simple burning facilities applied to calculate AF will be assumed as 41 which is number of simple burning facilities before the project activity and applied for calculating ex-ante AF. LFG captured and methane fraction of LFG of 10 simple burning facilities will be measured quarterly for the first crediting period using portable measuring equipment which has similar capability with the equipment applied for measuring the value for calculation of ex-ante AF. 10 simple burning facilities locate evenly in the landfill site which is under filling-up and the landfill site in which filling-up is completed. Also, the point which is rarely influenced by capturing LFG by blower is selected as the location of 10 simple burning facilities and establishment depth of simple burning facility will be averagely 2 to 2.5m under the ground. Additionally, measurement will be performed between 12 o'clock a.m. and 3 o'clock p.m. because the temperature is high and gas emission is quite active at that time during a day. It will be measured over 3 times each a simple burning facility.

The location of 10 simple burning systems is shown in <Figure Annex 4-2>.



<Figure Annex 4-1> Plane figure for establishment plan of LFG capturing facility



<Figure Annex 4-2> The location of 10 simple burning systems

Measurement procedure is summarized below:

1. Measurement of methane fraction (w_{CH4})

(1) Portable gas analyser is to be used to analyse the composition of gas.

(2) Prior to operation of the gas analyser, to tightly close gas collection well and/or sampling hole so as to prevent inflow of air.

(3) To connect the detector part with sampling point and operate the gas analyser.

(4) If the gas collection well is made of pipes with holes, the holes should be blocked and the detector should be placed as deeply as possible to lower oxygen density

(5) To record the measured value after volume of gas is observed stable.

(6) To calculate average methane fraction of 10 simple burning facilities.

2. Measurement of flow rate of landfill gas($F_{n,LFG}$)
   (1) To install portable portable equivalent flow meter in perpendicular angle to the gas flow.
   (2) To measure average flow rate of gas
   (3) To measure the diameter of collection well pipe.
   (4) To calculate the volume of gas ($F_{n,LFG}$)

3. Using measured data and default value, AF can be calculated as follows:

$AF = MD_{reg,y}/MD_{project,y}$
$= (MD_{reg,y}/CH4_{gen})/(MD_{project,y}/ CH4_{gen})$

Where:
$MD_{reg,y}$: methane destroyed in the baseline scenario (tCH4)
$MD_{project,y}$: methane destroyed by the project (tCH4)
$CH4_{gen}$: methane generated in the first crediting period (tCH4) (This value can be calculated using the amount of LFG generated in the first crediting period and methane fraction in landfill gas. Expected amount of LFG generated has already been calculated using EPA model. For this value, refer to Annex 3. Methane fraction in landfill gas will be measured by gas analyzer during monitoring period.)

$\mathbf{MD_{reg,y} = F_{CH4} * N * (60*24*365) * FE_{simple} * D_{CH4}}$

Where:
F_{CH4} : Average captured methane of 10 simple burning facilities (Nm3-CH4/min/EA)
N : number of total simple burning facilities in the baseline scenario (Simple burning system is the way to treat LFG before the project and this way is not applied to treat LFG anymore in the project site. Therefore, the past value is applied. When ex-ante value of AF was calculated, applied value was 41 of simple burning facilities which were established before the project activity. Same value, 41 simple burning facilities, is to be applied to calculate ex-post AF.)
FE_{simple} : Flare efficiency of simple burning system. (The most conservative default value for the baseline scenario is 100% of flare efficiency.)
D_{CH4} : Density of methane. (According to ACM 0001, at standard temperature and pressure, this value is 0.0007168 tCH4/m3CH4) For this value, refer to section B.6.2.

$\mathbf{Fn_{CH4} = Fn_{LFG} * w_{CH4}}$

Where:

Fn_{CH4} : methane captured at each simple burning facility (Nm3-CH4/min/EA)
Fn_{LFG} : LFG captured at each simple burning facility (Nm3-LFG/min/EA)
(Actual captured LFG is measured with Am3 unit. However, temperature and pressure will be measured as well. Therefore, actual captured LFG will be adjusted to Nm3 unit.)
w_{CH4} : methane fraction in landfill gas (%)
n : each simple burning facility number

$\mathbf{F_{CH4} = (F1_{CH4} + F2_{CH4} + ...+F10_{CH4})/10}$
- $F1_{CH4}$ ~ $F10_{CH4}$: captured methane of each simple burning facility (m3/min/EA)

*Data for calculation of AF will be recorded in the recording format below.

Fn	CH4(%)	CO2(%)	O2(%)	Vol.(L/min)		Tem.	Pre.	Normalised Vol. (L/min)	
				LFG	CH4			LFG	CH4
F1									
F2									
F3									

F4									
F5									
F6									
F7									
F8									
F9									
F10									

Data / Parameter	F_{CH4}
Unit	Nm3-CH4/min/EA
Description	Average captured methane of 10 simple burning facilities
Source of data	Calculated
Value(s) applied	N/A
Measurement methods and procedures	This value is the average value of $F1_{CH4}$ ~ $F10_{CH4}$ and the method to calculate this value is explained above.
Monitoring frequency	N/A
QA/QC procedures	N/A
Purpose of data	N/A
Additional comment	- This value will be calculated just during the first year of the crediting period to calculate ex-post AF for the project.

Data / Parameter	N
Unit	Units
Description	number of operating simple burning facilities in the baseline scenario
Source of data	The history data of the landfill site
Value(s) applied	41 (applied for calculating ex-ante AF)
Measurement methods and procedures	The number of simple burning facilities, which were operating in the landfill site before the project activity, will be applied for this value.
Monitoring frequency	N/A
QA/QC procedures	N/A
Purpose of data	N/A
Additional comment	- This value will be used just during the first year of the crediting period to calculate ex-post AF for the project. - This value is same as the value which was applied for calculating ex-ante AF.

Data / Parameter	FE_{simple}
Unit	%
Description	Flare efficiency of simple burning system
Source of data	Conservative value
Value(s) applied	100% (applied for calculating ex-ante AF)
Measurement methods and procedures	The most conservative value, 100% of flare efficiency, will be applied.
Monitoring frequency	N/A
QA/QC procedures	N/A
Purpose of data	N/A

Additional comment	- This value will be used just during the first year of the crediting period to calculate ex-post AF for the project. - This value is same as the value which was applied for calculating ex-ante AF.

3. Conversion to the volume of dry gas($LFG_{total,y}$) as a reference

There is only flow meter for $LFG_{total,y}$ in front of Scrubber, but Measured volume of $LFG_{total,y}$ by a flow meter is the volume of wet gas. Therefore, $LFG_{total,y}$ needs to be converted to the value of dry basis for reference because condition of gas flow is nearly dry state behind cooler.

$LFG_{total,y}$ in dry condition = $LFG_{total,y}$ in wet condition - H2O

The amount of moisture included in gas can be estimated using calculated pressure of saturated water vapor which is called steam pressure. Steam pressure depends on the temperature and it is standardized internationally. Therefore, pressure of saturated water vapor (steam pressure) depends on measured temperature of gas cooler and it can be found in temperature-vapor pressure table (source: Basic Principles and Calculations in Chemical Engineering 6th Edition, David M. Himmelblau) (Source: The Japan Society of Mechanical Engineers (JSME)) which is released internationally.
Applied temperature of gas cooler and outlet pressure of LFG are monthly average value.

$$H_2O(Nm^3/hr) = \frac{22.4(H_2O, Nm3/kmole) \times Wet\,Gas\,Volume\,(Nm^3/hr) \times steam\ pressure(kg/cm^2)}{22.4(Wet\,Gas\,Mole, Nm^3/kmole) \times (Outlet\ pressure(kg/cm^2)}$$

$$H_2O(Nm^3/hr) = \frac{Wet\,Gas\,Volume\,(Nm^3/hr) \times steam\ pressure(kg/cm^2)}{(Outlet\ pressure(kg/cm^2)}$$

$$H_2O(kg/hr) = Wet\,Gas\,Volume\,(kg/hr) - Dry\,Gas\,Volume\,(kg/hr)$$
$$H_2O(Nm^3/hr) = Wet\,Gas\,Volume\,(Nm^3/hr) - Dry\,Gas\,Volume\,(Nm^3/hr)$$

For reference, the volume of dry gas is calculated by using design value of each data which is suggested in the execution design report and design value of $LFG_{total,y}$ is as follows:

The volume of wet gas : 3,900Nm3/hr
Outlet pressure of LFG : 0.896kg/cm2
Temperature of gas cooler : 40℃
According to temperature-vapor pressure table which is released internationally, when the temperature is 40℃, steam pressure is 0.075204kg/cm2

$$H_2O(Nm^3/hr) = \frac{Wet\,Gas\,Volume\,(Nm^3/hr) \times steam\ pressure(kg/cm^2)}{(Outlet\ pressure(kg/cm^2)}$$

$$= \frac{3{,}900(Nm^3/hr) \times 0.075204(kg/cm^2)}{0.896(kg/cm^2)} = 327.34(Nm^3/hr)$$

∴ **Dry Gas Volume = 3,900 – 327= 3,573 Nm^3/hr**

To verify the calculation method, the amount of moisture included the gas is calculated by using design value of the volume dry gas. The volume of dry gas which is suggested in the execution design report is 4,544kg/hr.

$$gas\ flow(Nm3/hr) = \frac{4,544\,(kg/hr)\times 22.4(m3/kmol)}{28.46(kg/kmole)} = 3,576\,Nm3/hr$$

Volume of dry gas which is converted by using the volume of wet gas is 3,573 Nm3/hr and it is almost similar with value which is calculated by design value (3,576.Nm3/hr). The Difference value (3Nm3/hr) also contains confidential level (95%). Therefore, it can be known that suggested calculation method for estimation the volume of dry gas by using measured volume of wet gas is reasonable.

For monitoring data, refer to section B.7.1.

Appendix 6. Summary of post registration changes

※ Corrections

- Correction of main equipment due to different between preparation specification(Preliminary design) and actual specification(Working design) (A.3 Technologies and/or measures)

※ Corrections

- In the section B.7.1 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 in B.7.3 as the company name is changed. And the name of person in charge was omitted because it is often changed.

※ Deviation

- There was the period which is not installed monitoring instrument in place. (FIQ-301)

※ Deviation

- Flame detector for claiming flare efficiency (50%) is not installed for 4th monitoring period.

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