Monitoring report form for CDM project activity
(Version 06.0)

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

MONITORING REPORT		
Title of the project activity	Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas at Gangnam branch Korea District Heating Corporation Project	
UNFCCC reference number of the project activity	0835	
Version number of the PDD applicable to this monitoring report	1.04	
Version number of this monitoring report	1.1	
Completion date of this monitoring report	30/11/2018	
Monitoring period number	7th	
Duration of this monitoring period	01/01/2017 ~ 31/3/2018	
Monitoring report number for this monitoring report	-	
Project participants	Korea District Heating Corporation	
Host Party	Republic of Korea	
Sectoral scopes	1. Energy industries	
Applied methodologies and standardized baselines	ACM0009 Version 03, N/A	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 tCO_2e	9,703 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	63,988 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

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

This project activity is switching the fuel of the boilers for generating heat from Low Sulphur Waxy Residue fuel oil(LSWR) to natural gas(NG) at Korea District Heating Corporation(KDHC) Gangnam Branch, which operates and manages district heating system. The produced heat is supplied to the local district heating system. This project is developed, financed and implemented solely by KDHC

Brief description of the installed technology and equipment;

The facilities of the project activity consist of three NG HOBs(Heat Only Boilers) to generate hot water for district heating and other supplementary installations. The specifications of the new NG HOBs are shown in the table below

Table 1. Specifications of the project LNG HOB

Type	Novita type hot water heat only boiler
Capacity	103.2 Gcal/hour
Pressure	16 kg/cm^{2}g
Fuel	Natural gas
Efficiency	More than 95.0%
Draft type	Forced draft
Life expectancy	30 to 35 years

Relevant dates for the project activity

Table 2. History of the project activity promotion

Description	Date
Date of completion of NG boiler test run	#1 NG HOB(#3 Boiler) : 30/11/2006 #2 NG HOB(#4 Boiler) : 01/12/2006 #3 NG HOB(#5 Boiler) : 24/04/2007
Start date of commercial operation	#1 NG HOB(#3 Boiler) : 16/12/2006 #2 NG HOB(#4 Boiler) : 16/12/2006 #3 NG HOB(#5 Boiler) : 01/11/2007
Date of crediting period start	01/04/2008

A.2. Location of project activity

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The project site is located in the KDHC Gangnam branch, which is located in the residential area at 732 Suseo-dong, Gangnam-gu, Seoul, Republic of Korea (GPS : Latitude-37.490006˚,Longitude-127.094667˚)

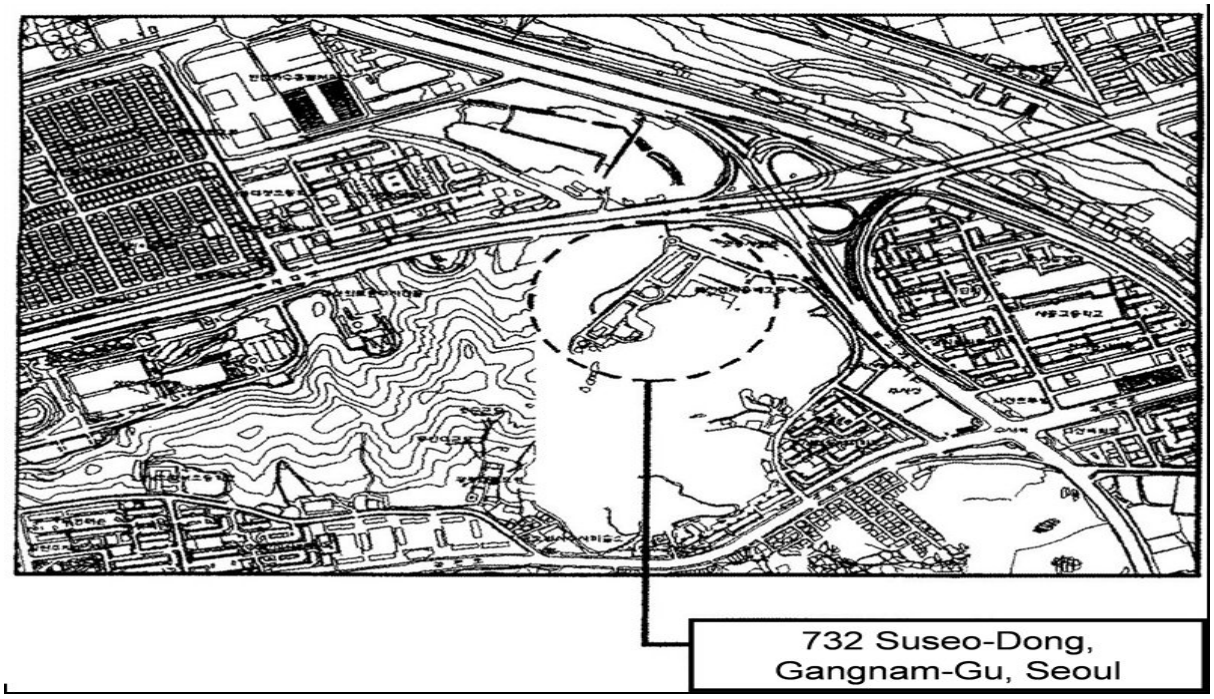

Figure 1. Location of the project facility

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (host Party)	Private entity Korea District Heating Corporation	No

A.4. Reference to applied methodologies and standardized baselines

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The approved methodology ACM0009 “Consolidated baseline and monitoring methodology for fuel switching from coal or petroleum fuel to natural gas” (Version 03) is applied for the project. For more information regarding the methodology, please refer to http://cdm.unfccc.int/methodologies/PAmethodologies/approved

A.5. Crediting period type and duration

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- ✓ Type : fixed
- ✓ Start date : 01/04/2008
- ✓ Length of the crediting period : 01/04/2008 ~ 31/03/2018
- ✓ 7th monitoring period : 01/01/2017 ~ 31/03/2018

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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During this monitoring period, there has been no event or situation that may affect the methodology took place. However, the monitoring equipment that impact its operation data and monitoring data has been shut down. For this reason, the monitoring system had to be reset.

Only the project NG boilers were not operated for a certain period of time in the summer because of hot weather.

The information of the actual operation of the project activity is as follows

In the CER calculation, these items have been excluded

Table 3. Information of the actual operation

Item	#3 Boiler	#4 Boiler	#5 Boiler
Inactivity	02/02/2017 11:00 - 08/12/2017 20:00	02/02/2017 21:00 - 22/01/2018 09:00	09/03/2017 10:00 - 22/01/2018 13:00
Reset of Monitoring system	23/02/2018 14:00–15:00	23/02/2018 14:00–15:00	-

B.2. Post-registration changes

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

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N/A

B.2.2. Corrections

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(1) According to the Annex 66 and 67, EB48, the notification of PDD change has been sought EB's decision for the correct application of calorific value from Gross to Net and it was accepted on 20/05/2011. The changes were caused by the wrong baseline energy efficiency coming form wrong calculation using the gross calorific value (GCV) instead of the net calorific value (NCV) of Low Sulphur Waxy Residue fuel oil (LSWR). In addition the changes were also caused by the wrong application of project fuel efficiency, which was presented with GCV basis by the natural gas boiler manufacturer.
Thus, the PDD was revised to apply the NCV for the energy efficiency on 18/02/2010 (ver.1.03), please refer to http://cdm.unfccc.int/Projects/DB/DNV-CUK1167217026.24/history

(2) According to the Annex 4 and Annex 5, EB65, the correction of PDD title has been implemented and then it was approved on 29/11/2012(PRC ref : PRC-0835-001). The correction of PDD title also dose not affect project design.

Table 4. Timeline and changing history of the PDD title

Completion date of PDD	PDD title	Remarks
08/11/2006 (ver.1.02)	Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas at Gangnam branch Korea District Heating Corporation Project	Original PDD title at that time of CDM registration
18/02/2010 (ver.1.03)	Switching of fuel from Low Sulphur Waxy Residue fuel oil (LSWR) to natural gas at heat-only boiler in district heating system	Wrong PDD title at that time of notification of PDD changes approved on 20/05/2011

Completion date of PDD	PDD title	Remarks
15/06/2012 (ver.1.04)	Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas at Gangnam branch Korea District Heating Corporation Project	Corrected PDD title in accordance with the original PDD approved on 29/11/2012

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

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There has been change of the start date of the crediting period in September of 2008. For checking the change record, please refer to http://cdm.unfccc.int/Projects/DB/DNV-CUK1167217026.24/view

- Previous crediting period at the CDM registration stage: 01/01/2008-31/12/2017
- Revised crediting period: 01/04/2008-31/03/2018 (approved on 10/11/2008)

B.2.4. Inclusion of monitoring plan

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N/A

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

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N/A

B.2.6. Changes to project design

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N/A

SECTION C. Description of monitoring system

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Data collection procedure

All measurable parameters related to the project activity in KDHC Gangnam branch are collected in real time by the DCS (Distributed Control System) located in central control room (CCR). Apart from this, the facility operator records the same parameters at central control room for the QA/QC purpose

1. Monitoring data ($FF_{project,i,y}$, $HG_{project,i,y}$) are measured by the monitoring equipments identified in the table D.1

▼

2. Measured parameters are collected by DCS in CCR considering the temperature and pressure measured by the monitoring equipments

▼

3. Adjusted data are saved automatically by DCS as a spreadsheet

▼

4. QA/QC Process : Data crosschecking implemented by Operation Management Team
   - For $FF_{project,i,y}$: DCS-based data are compared by natural gas purchase record
   - For $HG_{project,i,y}$: DCS-based data are compared by the amount manually recorded by the facility operators

▼

5. If no issue is raised by the QA/QC process, the spread sheet data are reported to Climate & Environment Team of Head Office. The person in charge of Head Office calculates emission reductions and prepare the CDM monitoring report based on the data

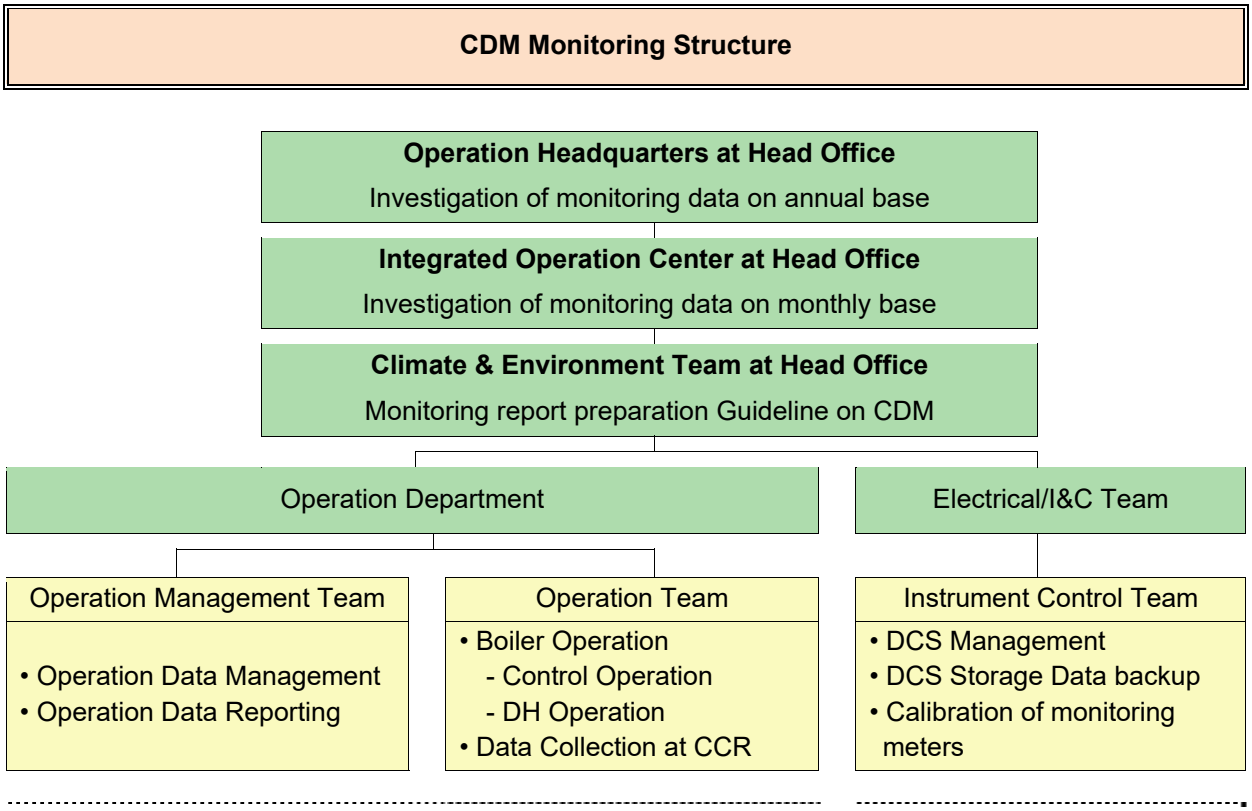
Figure 2. Data management procedure

1. The consumption of natural gas is continuously measured by the gas flow meters installed as each NG boiler. The monitored data is managed at CCR of KDHC Gangnam branch
2. The heat production are calculated automatically by the DCS on the basis of DH (District Heating) water's flow rate continuously measured in front of boilers and temperature difference between DH water supplied to the users and DH water returned to KDHC that are also continuously measured at the back of and in front of NG boilers

CDM monitoring structure

As showed in the figure below, direct monitoring and its management (Boiler operation & management, monitoring data collection & management) are practiced by Operation Department and the Electrical/I&C Team of Gangnam branch. Climate & Environment Team of Headquarters takes charge of the calculation of emission reductions and monitoring report.

The monitoring data and calculations out of it are reported in accordance with the hierarchical structure below. If there is any change to this structure for the monitoring activity in the future, the changes will be described in the corresponding monitoring report.



Boiler operation & management Take measures in emergency in terms of CDM Monitoring	Meter management

Figure 3. CDM Monitoring Structure

CDM monitoring team is trained for boiler operation and management by Operation Headquarters of Head Office

Emergency procedure

1. Difference between recorded data and monitored data
 - If manually recorded data are different from actually monitored data, the head of Operation Management Team will call a meeting to solve and adjust the difference with the manager of instrument control team, the manager of operation team and the supplier of the monitoring equipment. The minutes of the meeting will be stored.

2. Measuring the amount of natural gas consumption ($FF_{project,i,y}$)
 - If any meter installed on the boiler is not available or operational, the monitoring data from the records of DCG's flow meters (that are originally installed to measure DCG's dealing amount) will be used instead. However, such situation did not happen in the monitoring period.

3. Calculating thermal production amount ($HG_{project,i,y}$)
 - Excluding anthropogenic shut down like periodic maintenance, when the monitoring data of temperature and/or flow meter for calculating thermal production amount is not available, the operating data manually recorded by facility operators will be used instead after the review of verifying DOE.

Diagram of monitoring system

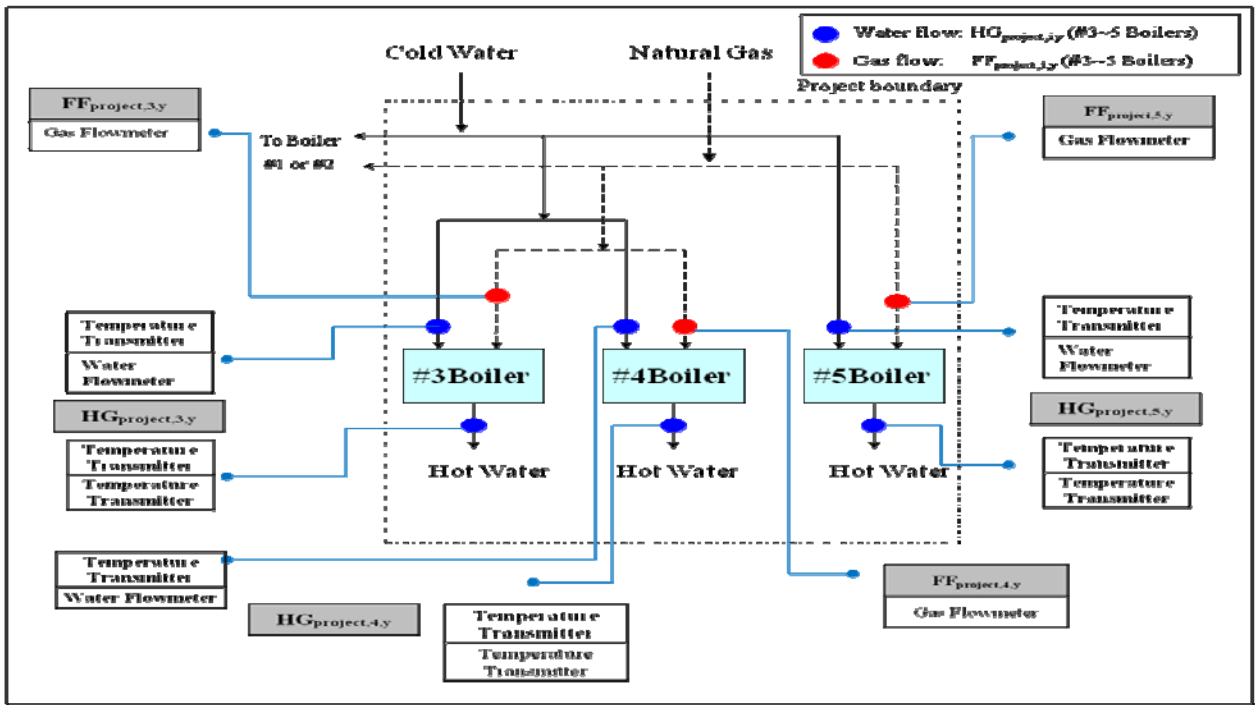


Figure 4. Monitoring point diagram

Main monitoring equipment list and Specification on calibration of monitoring equipment

The calibration frequency of all monitoring equipments is 2 years. Most of equipments have been managed validly according to calibration standard.

Table 5. Information of monitoring equipment

Element process	Parameter	Type	Serial No.	Accuracy class	Calibration		Validity
					Previous	Last	
#3 Boiler	$FF_{project,i,y}$	Gas flow meter	10512539/4308390	±0.5%	16/09/2015	25/09/2017	24/09/2019
	$HG_{project,i,y}$	Temperature meter	B322662337	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B215675137	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B323684437	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Water flow Meter	A06 68017	±0.5%	15/12/2015	14/12/2016	13/12/2018
#4 Boiler	$FF_{project,i,y}$	Gas flow meter	10512540/4308410	±0.5%	05/10/2013	25/09/2017	24/09/2019
	$HG_{project,i,y}$	Temperature meter	B322662037	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B317603437	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B215679937	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Water flow Meter	A06 68015	±0.5%	15/12/2015	15/12/2016	14/12/2018
#5 Boiler	$FF_{project,i,y}$	Gas flow Meter	10512747/4308392	±0.5%	17/09/2015	25/09/2017	24/09/2019
	$HG_{project,i,y}$	Temperature meter	B215674937	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B323679337	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Temperature meter	B324699737	0.00225t + 0.3	08/10/2014	01/10/2016	30/09/2018
		Water flow meter	A06 68016	±0.5%	15/12/2015	14/12/2016	13/12/2018

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/parameter:	***$NCV_{NG,y}$***
Unit	kcal/N ㎥
Description	Average net calorific value of the natural gas combusted during the year y
Source of data	The Korean Ministry of Knowledge Economy
Value(s) applied)	9,550
Choice of data or measurement methods and procedures	We used the net calorific value defined in “Energy policy law” or “Annual Energy Statistic Report” published by Korean Ministry of Commerce, Industry and Energy.
Purpose of data	Baseline, project and leakage emission calculations
Additional comments	

Data/parameter:	***$EF_{NG,CO2,y}$***
Unit	tCO_2/TJ
Description	CO_2 emission factor of the natural gas combusted in all element processes in the year y
Source of data	The Revised 2006 IPCC Guidelines

Value(s) applied)	56.1
Choice of data or measurement methods and procedures	$EF_{NG, CO2, y}$ is obtained from the "Revised 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2. Energy, Section 1.4.2.1, Table 1-4, Natural gas" $EF_{NG, CO2, y}$ = 15.3 tC/TJ * 3.6667tCO_2/tC = 56.1 tCO_2/TJ
Purpose of data	Project emission calculation
Additional comments	

Data/parameter:	***NCV*** $_{FF,y}$
Unit	kcal/ℓ
Description	Average net caloric value of LSWR that would be combusted in the absence of the project activity in the element process *i* during the year y
Source of data	The Korean Ministry of Knowledge Economy
Value(s) applied)	9,350
Choice of data or measurement methods and procedures	We used the net calorific value defined in "Energy policy law" or "Annual Energy Statistic Report" published by Korean Ministry of Commerce, Industry and Energy.
Purpose of data	Baseline emission calculation
Additional comments	

Data/parameter:	***EF*** $_{FF,CO2,y}$
Unit	tCO_2/TJ
Description	CO_2 emission factor of the LSWR that would be combusted in the absence of the project activity in the all element processes in tCO_2e/TJ
Source of data	The Revised 2006 IPCC Guidelines
Value(s) applied)	77.3667
Choice of data or measurement methods and procedures	$EF_{FF,CO2,y}$ is obtained from the "Revised 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2. Energy, Section 1.4.2.1, Table 1-4, Residual Fuel Oil" $EF_{FF,CO2,y}$ = 21.1 tC/TJ * 3.6667tCO_2/tC = 77.3667 tCO_2/TJ
Purpose of data	Baseline emission calculation
Additional comments	

Data/parameter:	$\varepsilon_{baseline,i,y}$
Unit	%
Description	Energy efficiency of the element process *i* if fired with LSWR
Source of data	KDHC
Value(s) applied)	(process *i* corresponds to #3~#5 boilers) #3 Boilers : 88% #4 Boilers : 88% #5 Boilers : 88%

Choice of data or measurement methods and procedures	Fuel efficiency in element process *i* is calculated by LSWR consumption and heat production. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operation, Shut-down. Fuel efficiency is calculated on the base of Normal operation which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day(24 hours).
Purpose of data	Baseline emission calculation
Additional comments	

Data/parameter:	$EF_{NG,upstream,CH4}$
Unit	tCH_4/PJ
Description	Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in tCH_4 per PJ fuel supplied to final consumers
Source of data	ACM0009 Version 03
Value(s) applied)	296
Choice of data or measurement methods and procedures	IPCC value will be used since there is on reference for CO_2 emission factor in Korea.
Purpose of data	Leakage emission calculation
Additional comments	

Data/parameter:	$EF_{LSWR,upstream,CH4}$
Unit	tCH_4/PJ
Description	Emission factor for upstream fugitive methane emissions from production of the fuel LSWR in tCH_4 per PJ fuel produced
Source of data	ACM0009 Version 03
Value(s) applied)	4.1
Choice of data or measurement methods and procedures	IPCC value will be used since there is on reference for emission factor in Korea.
Purpose of data	Leakage emission calculation
Additional comments	

Data/parameter:	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global warming potential of methane valid for the relevant commitment period
Source of data	The Revised 2006 IPCC Guidelines
Value(s) applied)	25
Choice of data or measurement methods and procedures	IPCC value will be used since there is on reference for Global Warming Potential factor in Korea.

Purpose of data	Leakage emission calculation
Additional comments	

Data/parameter:	$EF_{CO2,upstream,LNG}$
Unit	tCO_2/TJ
Description	Emission factor for upstream CO_2 emission due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system
Source of data	ACM0009 Version 03
Value(s) applied)	6
Choice of data or measurement methods and procedures	Where reliable and accurate data on upsteam CO_2 emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission fator. Since there is no such data that is available, we assumed a default value of 6 tCO_2/TJ as a rough approximation.
Purpose of data	Leakage emission calculation
Additional comments	

D.2. Data and parameters monitored

Data/parameter:	$FF_{baseline,i,y}$
Unit	ℓ
Description	Quantity of LSWR that would be combusted in the absence of the project activity in element process *i* during the year *y*
Measured/calculated/default	Calculated
Source of data	Calculated based on monitoring data by DCS
Value(s) of monitored parameter	(*i* corresponds to #3~#5 boilers) #3 Boiler : 11,259,796 #4 Boiler : 8,648,221 #5 Boiler : 10,119,914
Monitoring equipment	Refer to $FF_{proejct,i,y}$ and $HG_{project,i,y}$ of Table 5
Measuring/reading/recording frequency:	Monthly
Calculation method (if applicable):	Refer to **E.1.**
QA/QC procedures:	DCS-based data are compared by natural gas purchase record
Purpose of data:	Baseline and leakage emission calculations
Additional comments:	

Data/parameter:	$FF_{project,i,y}$
Unit	Nm^3
Description	Quantity of natural gas consumed at the element process *i* in year y
Measured/calculated/default	Measured
Source of data	Monitoring data by DCS
Value(s) of monitored parameter	(*i* corresponds to #3~#5 boilers) #3 Boiler : 11,132,749, #4 Boiler : 8,404,250, #5 Boiler : 9,739,240
Monitoring equipment	Refer to $FF_{proejct,i,y}$ of Table 5
Measuring/reading/recording frequency:	Continuously

Calculation method (if applicable):	N/A
QA/QC procedures:	DCS-based data are compared by natural gas purchase record
Purpose of data:	Baseline, project and leakage emission calculations
Additional comments:	

Data/parameter:	$HG_{project,i,y}$
Unit	Gcal
Description	Quantity of heat generated at the element process *i* in year y
Measured/calculated/default	Measured
Source of data	Monitoring data by DCS
Value(s) of monitored parameter	(*i* corresponds to #3~#5 boilers) #3 Boiler : 92,646, #4 Boiler : 71,158, #5 Boiler : 83,267
Monitoring equipment	Refer to $HG_{project,i,y}$ of Table 5
Measuring/reading/recording frequency:	Continuously
Calculation method (if applicable):	N/A
QA/QC procedures:	DCS-based data are compared by the amount manually recorded by the facility operators
Purpose of data:	Baseline and leakage emission calculations
Additional comments:	

Data/parameter:	$\varepsilon_{project,i,y}$
Unit	%
Description	Fuel efficiency of natural gas used at the element process *i* in year y
Measured/calculated/default	Calculated
Source of data	Calculated based on monitoring data by DCS
Value(s) of monitored parameter	(*i* corresponding to #3~#5 boilers) #3 Boiler : 87.1, #4 Boiler : 88.7, #5 Boiler : 89.5
Monitoring equipment	Refer to $FF_{project,i,y}$ and $HG_{heat,i,y}$ of table 5
Measuring/reading/recording frequency:	Monthly
Calculation method (if applicable):	[Heat production(Gcal) / (NG consumption(Nm^3) x NCV_{NG}(kcal/Nm^3))]x 10^6kcal/Gcal
QA/QC procedures:	DCS-based data are compared by the amount manually recorded by the facility operators
Purpose of data:	Baseline and leakage emission calculations
Additional comments:	

D.3. Implementation of sampling plan

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N/A

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

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Baseline emissions (BEy) include CO_2 emissions from the combustion of the quantity of the baseline fuel (LSWR) that would be used in all element processes *i* (#3~#5 boilers) in the absence of the project activity.

Baseline emissions are calculated based on the quantity of the calculated fuel consumption ($FF_{baseline,i,y}$), net calorific value ($NCV_{FF,y}$) and CO_2 emission factor($EF_{FF,CO2,y}$) of LSWR.

$$BE_y = \sum_{i=1}^{3} FF_{baseline,i,y} \times NCV_{FF,y} \times EF_{FF,CO2,y}$$

with

$$FF_{baseline,i,y} = FF_{project,i,y} \times \frac{NCV_{NG,y} \times \varepsilon_{project,i,y}}{NCV_{FF,y} \times \varepsilon_{baseline,i,y}}$$

Where

BE_y	Baseline emissions during the year y in tCO_2e
$FF_{baseline,i,y}$	Quantity of LSWR that would be combusted in the absence of the project activity in the element process *i* during the year y in ℓ
$FF_{project,i,y}$	Quantity of natural gas combusted in the element process *i* during the year *y* in m^3
$NCV_{NG,y}$	Average net calorific value of the natural gas combusted during the year *y* in kcal/Nm^3
$NCV_{FF,y}$	Average net calorific value of the LSWR that would be combusted in the absence of the project activity in the element process *i* during the year *y* in kcal/ℓ
$\varepsilon_{project,i,y}$	Energy efficiency of the element process *i* if fired with natural gas
$\varepsilon_{baseline,i,y}$	Energy efficiency of the element process *i* if fired with LSWR
$EF_{FF,CO2,y}$	CO_2 emission factor of the LSWR that would be combusted in the absence of the project activity in the element process *i* in tCO_2/TJ

Table 6. Measured data of $FF_{project,i,y}$

Year	$FF_{project,i,y}$			$HG_{project,i,y}$		
	#3 boiler	#4 boiler	#5 boiler	#3 boiler	#4 boiler	#5 boiler
2018	11,132,749	8,404,250	9,739,240	92,646	71,158	83,267

$FF_{project,i,y}$ and $HG_{project,i,y}$ of table 6 are the sum of amount estimated when the quantity of natural gas consumed in each boiler is greater than 365Nm^3/ h that is lower limit of the measuring range of the gas flow meter. To sum up, KDHC selected reliable values measured in measuring range of the gas meter with accuracy. The measuring range of the gas flow meter was calculated according to the formula below and relative documents was submitted to DOE

$$Q\max = V \times \frac{Pa + Pg}{Pa} \times \frac{Ta}{Tg + Ta}$$

Where

Qmax	Max.flow rate in Nm^3/h
V	Maximum flow rate under operating conditions, 6500m^3/h
Pa	Atmosphere pressure, 1.01325bar
Pg	Gage pressure under operating conditions, 2.451664 bar
Ta	Absolute temperature at normal state, 273 K

Tg Absolute temperature under operating conditions, 293 K

$$Q\min = \frac{Q\max}{T.D.R} \times \frac{1}{\sqrt{P \times d}}$$

Where

Qmin Min.flow rate in Nm^3/h

T.D.R Turn down ratio, 20:1

P Absolute pressure under operating conditions, 3.464914 bar

d Specific gravity of NG, 0.624

Table 7. Energy efficiency

Item	*#3 boiler*	#4 boiler	#5 boiler
$\varepsilon_{project,i,y}$	87.1%	88.7%	89.5%

According to PDD, energy efficiency of the element process has to be calculated on the base of normal operating mode which has the longest period of operational mode but it is calculated on the base of whole operational mode. Because there is not a distinct criteria to distinguish the normal mode in whole operational mode, KDHC calculated energy efficiency conservatively including start-up and shut-down modes with lower energy efficiency compared with normal mode

For example, $FF_{baseline,1,y}$ of #3 boiler and BE_y are calculated as follows

$$FF_{baseline,1,y} = 11,132,749 \times \frac{9,550 \times 87.1\%}{9,350 \times 88.0\%} = 11,259,796$$

$$BE_y = 11,259,796 \times 9,350 \times 77.3667 \times 4.1868(\text{kcal to kJ})/10^9(\text{Kilo to Tera}) = 53,730$$

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

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Project emissions (*PEy*) include CO_2 emissions from the combustion of natural gas in all element process *i*(#3~#5 Boilers). Project emissions are calculated based on the quantity of natural gas combusted in all element process *i*, net caloric value and CO_2 emission factors of natural gas ($EF_{NG, CO2}$) of natural gas

$$PE_y = \sum_{i=1}^{3} FF_{project,i,y} \times NCV_{NG,y} \times EF_{NG,CO_2,y}$$

Where

PE_y Project emissions during the year in tCO_2e

$FF_{project,i,y}$ Quantity of natural gas combusted in all element process during the year y in m^3

$NCV_{NG,y}$ Average net calorific value of the natural gas combusted during the year y in $kcal/m^3$

$EF_{NG,CO2,y}$ CO2 emission factor of the natural gas combusted in all element processes in the year y in tCO_2/TJ

For example, PE_y of #3 boiler are calculated as follow

$$PE_y = 11,132,749 \times 9,550 \times 56.1 \times 4.1868(\text{kcal to kJ})/10^9(\text{Kilo to Tera}) = 24,972$$

E.3. Calculation of leakage emissions

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Leakage may result from fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of fossil fuels outside of the project boundary. This includes mainly fugitive CH_4 emissions and CO_2emissions from associated fuel combustion and flaring. In this project, the following leakage emission sources shall be considered:

• Fugitive methane emissions

Fugitive CH_4 emissions associated with fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of natural gas used in the project plant and fossil fuels used in the grid in the absence of the project activity.

• CO_2 emissions from LNG

In the case LNG is used in the project plant: CO_2 emissions from fuel combustion or electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system.

$$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$$

Where,

LE_y	Leakage emission during the year y in tCO_2e
$LE_{CH4,y}$	Leakage emission due to fugitive upstream CH4 emissions in the year y in tCO_2e
$LE_{LNG,CO2,y}$	Leakage emission due to fossil combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in tCO_2e

For example, *LEy* of #3 boiler are calculated as follow

$$LE_y = 5,163 + 4,244 = 9,407$$

Calculation of $LE_{CH4,y}$

$$LE_{CH4,y} = (FF_{project,y} \times NCV_{NG,y} \times EF_{NG,upstream,CH4} - FF_{baseline,LSWR,y} \times NCV_{LSWR} \times EF_{LSWR,upstream,CH4}) \times GWP_{CH4}$$

Where,

$FF_{project,i,y}$	Quantity of nautral gas combusted in all element processes during the year y in m^3
$NCV_{NG,y}$	Average net calorific value of the natural gas combusted during the year *y* in $kcal/m^3$
$EF_{NG,upstream,CH4}$	emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in tCH_4 per PJ fuel supplied to final consumers
$FF_{baseline,LSWR,y}$	Quantity of LSWR that would be combusted in the absence of the project activity in the element process during the year y in ℓ

NCV_{LSWR} Average net calorific value of the LSWR that would be combusted in the absence of the project activity in the element process during the year *y* in kcal/ℓ

$EF_{LSWR,upstream,CH4}$ Emission factor for upstream fugitive methane emissions from production of the fuel LSWR in tCH_4 per PJ fuel produced

GWP_{CH4} Global warming potential of methane valid for the relevant commitment period

For example, $LE_{CH4,y}$ of #3 boiler is calculated as follow

$$LE_{CH4,y} = (11.132.749 \times 9,550 \times 296 \times 4.1868(\text{kcal to kJ})/10^{12}(\text{Kilo to Peta}) - 11.259.796 \times 9,350 \times 4.1 \times 4.1868(\text{kca l to kJ})/10^{12}(\text{Kilo to Peta})) \times 21 = 3,249$$

Calculation of $LE_{LNG,CO2,y}$

$$LE_{LNG,CO2,y} = FF_{project,y} \times EF_{CO2,upstream,LNG}$$

Where,

$FF_{project,y}$ Quantity of nautral gas combusted in all element processes during the year y in m^3

$EF_{CO2,upstream,LNG}$ Emission factor for upstream CO_2 emission due to fossil fuel combustion/electricity consumption associated with the liquefaction, tranportation, re-gasfication and compression of LNG into a natural gas transmission or distribution system

For example during this period, $LE_{LNG,CO2,y}$ of #3 boiler is calculated as follow

$$LE_{LNG,CO2,y} = 11,132,749 \times 6 \times 9,550(m^3 \text{ to Kcal}) \times 4.1868(\text{kcal to kJ})/10^{9}(\text{Kilo to Tera}) = 2,671$$

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
#3 boiler	34,101	24,972	5,920	-	3,209	3,209
#4 boiler	26,192	18,852	4,469	-	2,871	2,871
#5 boiler	30,649	21,847	5,179	-	3,623	3,623
Total	90,942	65,671	15,568	-	9,703	9,703

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante (t CO_2e)
9,703	63,988

E.6. Remarks on increase in achieved emission reductions

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In this monitoring period (01/01/17- 31/03/18), the actual emission reduction is 9,703tCO_2e. This amount is about 54,285tCO_2e lower than the expected emission reduction as calculated in the PDD. This is mainly because the amount of heat generated from the project site during this monitoring period was lower than the average heat generation amount in the past.

In short, the overall GHG emission from the heat generation went down as less fuel was consumed than expected. The main reason why less heat is generated compared to the past years is that the new heating pipeline network was linked from Pangyo branch to Gangnam branch during this monitoring period. Decreased fuel consumption and heat generation of Gangnam branch than the past years were due to the heat supply of Pangyo branch.

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Document information

Version	*Date*	*Description*
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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