MONITORING REPORT FORM (CDM-MR) *
Version 01 - in effect as of: 28/09/2010

CONTENTS

MONITORING REPORT
Version 1(31/01/2012)

Title:Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas atGangnam branch Korea District Heating Corporation Project
Reference number: 0835

Crediting Period: 01/04/2008 – 31/03/2018
2nd Monitoring Period: 01/04/2009 – 31/10/2011

SECTION A. General description of the project activity

A.1. Brief description of the project activity: >>

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This monitoring report is based on the CDM project "Switching of fuel from Low Sulphur Waxy Residue fuel oil (LSWR) to natural gas at heat-only boiler in district heating system" and is to calculate the actual GHG emission reduction using monitored data during 01/04/2009 – 31/10/2011. The CER amount to be claimed for the monitoring period in question is 94,137tCO_2e. The project activity has been registered on 2 Apr 2007 in UNFCCC, with the CDM registration number of 0835.

The purpose of the project activity is to switch 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.

The project activity primarily aims to reduce greenhouse gas emissions by using NG which generates GHGs less than using LSWR in producing a unit of heat energy. In the project activity, the existing four LSWR-based heat only boilers (HOBs)were replaced by three NG-based heat only boilers.

Table A.1. History of the project activity promotion

Description	Date
Date of completion of NG boiler test run	NG HOB #1(Boiler #3): 29 Nov 2006 NG HOB #2(Boiler #4): 30 Nov 2006 NG HOB #3(Boiler #5): 23 Apr 2007
Date of commercial operation start	NG HOB #1(Boiler #3): 15 Dec 2006 NG HOB #2(Boiler #4): 15 Dec 2006 NG HOB #3(Boiler #5): 31 Oct 2007
Date of crediting period start:	1 Apr 2008

A.2. Project Participants

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Table A.2. Information of project participants

Name of Party involved ('host' indicates a host Party)	Private and/or public entity(ies) project participants	Kindly indicates if the Party i nvolved wish to be considered a project participant (yes/no)
The Republic of Korea (host)	Korea District Heating Corporation	No

A.3. Location of the 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. (GPS: Latitude - 37.490006°/ Longitude-127.094667°)

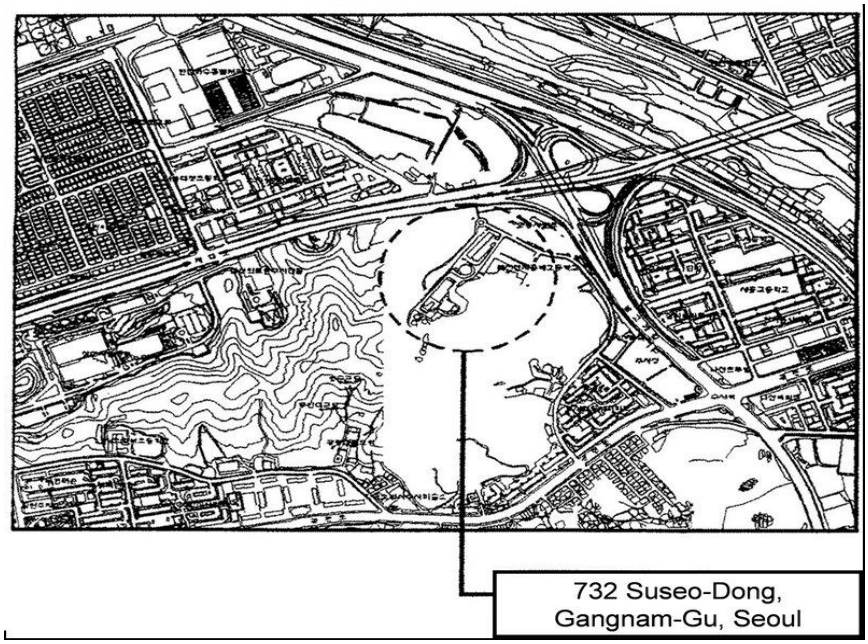

Figure A.1. Location of the project facility

A.4. Technical description of the project

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The facilities of the project activity consist of installing three NG HOBs to generate hot water for district heating purpose and other supplementary installations — stack, burner, gas static pressurer, pipeline and heat care facility. The whole construction of the proposed project activity has been completed in 31st of October, 2007, when the commercial operation of NG HOB #3(Boiler #5) started. The specific information of the LSWR-based boilers of the baseline scenario is included in the registered PDD.

Korea does not possess enough technology for designing large scale natural gas hot water boiler. Therefore it was designed jointly with Finland's Novitor Oy. During this process, design technology was transferred to Korea. The specifications of the new NG HOBs are shown in the table below.

Table A.3. Technical data of the project NG HOBs

Type	Novita type hot water heat-only boiler
Capacity	103.2 Gcal/hour
Designed Pressure	16 kg/㎠ g
Fuel used	Natural gas
Efficiency	More than 95.0%
Draft type	Forced Draft
Life expectancy	30 to 35 years

The natural gas to NG HOBs is supplied from Daehan city gas Co., Ltd. In Korea, Korea Gas Corporation (KOGAS) has imported liquefied natural gas (LNG) from Indonesia, Malaysia, Qatar etc. KOGAS-imported LNG is vaporized and supplied to retailers such as Deahan City Gas.

The following flowchart shows where the monitoring meters installed within the project boundary.

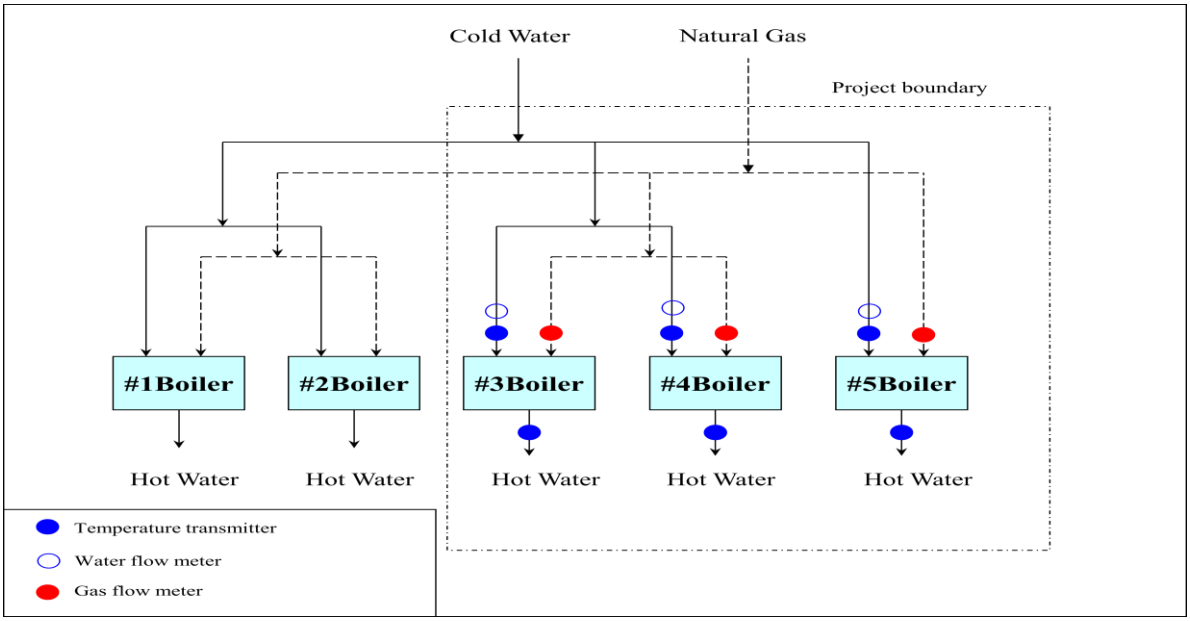

Figure A.2. Diagram of the project activity

A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

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Version 03 of ACM0009 "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas"
Version 03 of ACM0009 "Consolidated monitoring methodology for fuel switching from coal or petroleum fuel to natural gas"

A.6. Registration date of the project activity:

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2 Apr 2007

A.7. Crediting period of the project activity and related information (start date and choice of crediting period):

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Crediting period: 1 Apr 2008 – 31 Mar 2018 (Fixed)

There has been change of the start date of the crediting period in Sep 2008

- Previous crediting period at the CDM registration stage: 1 Jan 2008 – 31 Dec 2017
- Revised crediting period: 1 Apr 2008 – 31 Mar 2018

For checking the change record, refer to this web page (http://cdm.unfccc.int/Projects/DB/DNV-CUK1167217026.24/view).

A.8. Name of responsible person(s)/entity(ies):

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Information of the responsible person/entity for the overall monitoring activity and the second monitoring period (01/04/2009 – 31/10/2011) is as follows;

Assistant Manager, MiYeon, Kim (Ms)
Korea District Heating Corporation, 186 Bundang-dong, Bundang-gu, Songnam-city, Gyeonggi-do, Republic of Korea
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CDM consultant information for the preparation of this monitoring report is as follows

Consultant, Ji Hyeon, Kim (Ms)
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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

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The whole construction of the proposed project activity has been completed in 2007, when the test-run of NG HOB #3(Boiler #5) was completed. After the start of commercial operation of the project NG boilers, it has operated without major problem such as replacing boiler or shut down of the project activity and their operation continues as of 31 Oct 2011.

The relevant dates for the project activity are as follow.

Table B.1. Relevant dated for the project activity

Description	Date
Date of completion of NG boiler test run	NG HOB #1(Boiler #3): 29 Nov 2006 NG HOB #2(Boiler #4): 30 Nov 2006 NG HOB #3(Boiler #5): 23 Apr 2007
Date of commercial operation start	NG HOB #1(Boiler #3): 15 Dec 2006 NG HOB #2(Boiler #4): 15 Dec 2006 NG HOB #3(Boiler #5): 31 Oct 2007
Registration Date	2 Apr 2007
Starting Date of Project Activity	1 Nov 2007
Start date of crediting period	1 Apr 2008

The information of the actual operation of the project activity is as follow.

Table B.2.Information of the actual operation

Item	Boiler #3	Boiler #4	Boiler #5
Overhaul	3 times (01/06/09 – 30/06/09, 05/07/10 – 04/08/10, 11/05/11 – 10/06/11)	3 times (01/06/09 – 30/06/09, 05/07/10 – 04/08/10, 11/05/11 – 10/06/11)	3 times (01/06/09 – 30/06/09, 05/07/10 – 04/08/10, 11/05/11 – 10/06/11)
Downtimes of equipment	N/A	N/A	N/A
Exchange of equipment	N/A	N/A	N/A

There has been no event or situation that occurred during the monitoring period, which may have any impact the applicability of the methodology or the boiler operation.

However, there have been some annual overhauls of the boilers and other equipments during the monitoring period. Overhauls occurred in the monitoring period do not affect the monitoring data because monitoring is not necessary when the project boilers do not operate. In the CER calculation, it does not consider these events.

Also KDHC installed the equipment of DCS(Distributed Control System) data management in 3 Jul 2009 in order to perform the implementation of the project in good conditions.

B.2. Revision of the monitoring plan

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N/A

B.3. Request for deviation applied to this monitoring period

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N/A

B.4. Notification or request of approval of changes

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Notification of changes from the project activity as described in the registered project design document has been accepted by UNFCCC 20 May 2011. The corresponding information is available at the UNFCCC Website that is http://cdm.unfccc.int/Projects/DB/DNV-CUK1167217026.24/view.

SECTION C. Description of the monitoring system

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QA/QC Certification

Korea District Heating Corporation Gangnam branch obtained ISO14001 certification in December, 1996 and is operating continuous and systematic Environment management system.

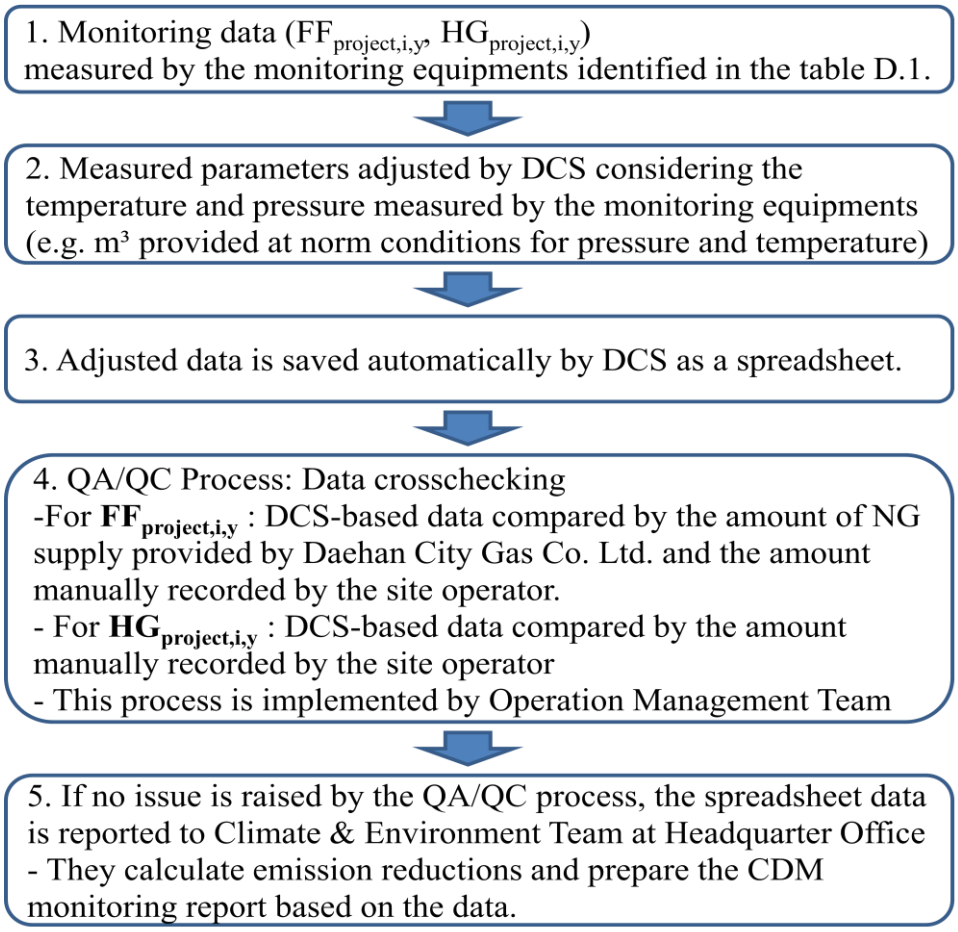
Korea District Heating Corporation Gangnam branch Suseo source established monitoring and QA/QC process for all parameters related to proposed project activity monitoring through ISO14001 certification. Monitoring plan of the proposed project activity will be managed in integration and continuation with Environment management system through ISO14001.

In accordance with the QA/QC process, Climate & Environment Team at Headquarter Office assigns two examiners to organize a team for the annual internal examination on monitoring system. It takes place once a year in principle but more times if necessary.

Data Management Procedure

All measurable parameters related to operating the facilities and the project activity in KDHC Gangnam branch are managed real-time by the DCS(Distributed Control System)located in center control room facility. Apart from this, the facility operator records the same parameters through on-the-spot survey for the QA/QC purpose.

Figure C.1. Data management procedure (Information flow)



1. The consumption of natural gas is continuously measured by the gas flow meters installed at each burner of NG boilers. The monitored data is managed at Center Control Room of KDHC Gangnam branch. The Volume measured is adjusted automatically through DCS by an adjustment factor considering the temperature and pressure.
2. The heat production is calculated automatically by the DCS on the basis of DH(District Heating) water's flow rate continuously measured in front of a boiler 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 respectively.

3. On daily, monthly and yearly base, the collected data is electronically archived as a computer file. Separately, manual check of the monitored parameters is also done by the site operators and it is recorded in paper. Once archived, the monitoring activity reported periodically according to the monitoring plan.

Measures to be taken in emergency situations

1. Difference between recorded data and monitored data
If manually recorded data are different from actually monitored data, the head of Operational 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 ($\mathbf{FF_{project,i,y}}$)
If any meter installed on the boiler is not available or operational, the monitoring data from the records of DCG[1]'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.

[1]Daehan City Gas Co.,Ltd, which is the company that suppliesnatural gas to KDHC

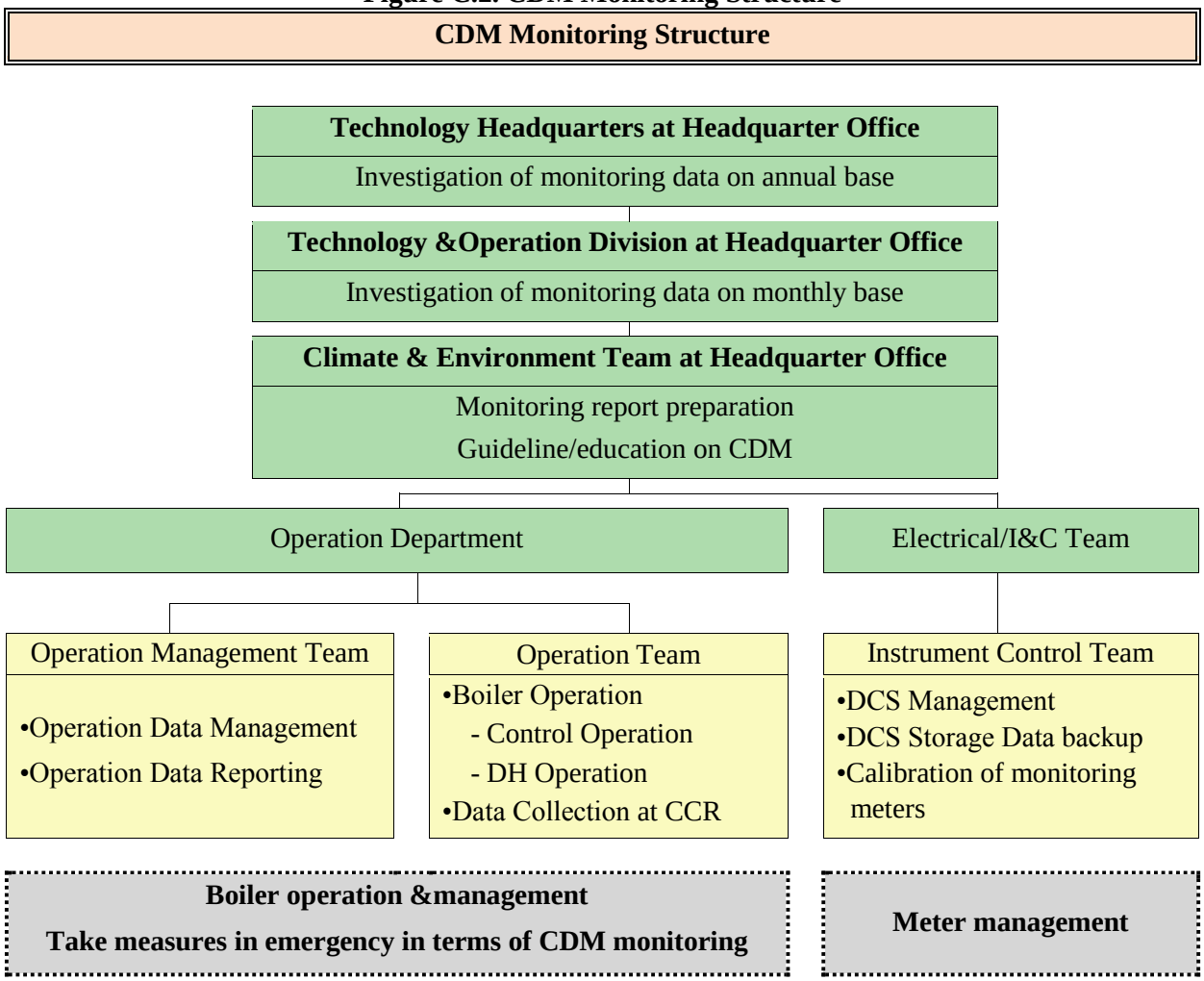
3. Calculating thermal production amount (**$HG_{project,i,y}$**)
Excluding anthropogenic shut down like periodic maintenance, when the monitoring data of temperature and/or flow meter for calculating thermal production amount is not available, the operating data manually recorded by on-site operators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

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.

Figure C.2. CDM Monitoring Structure



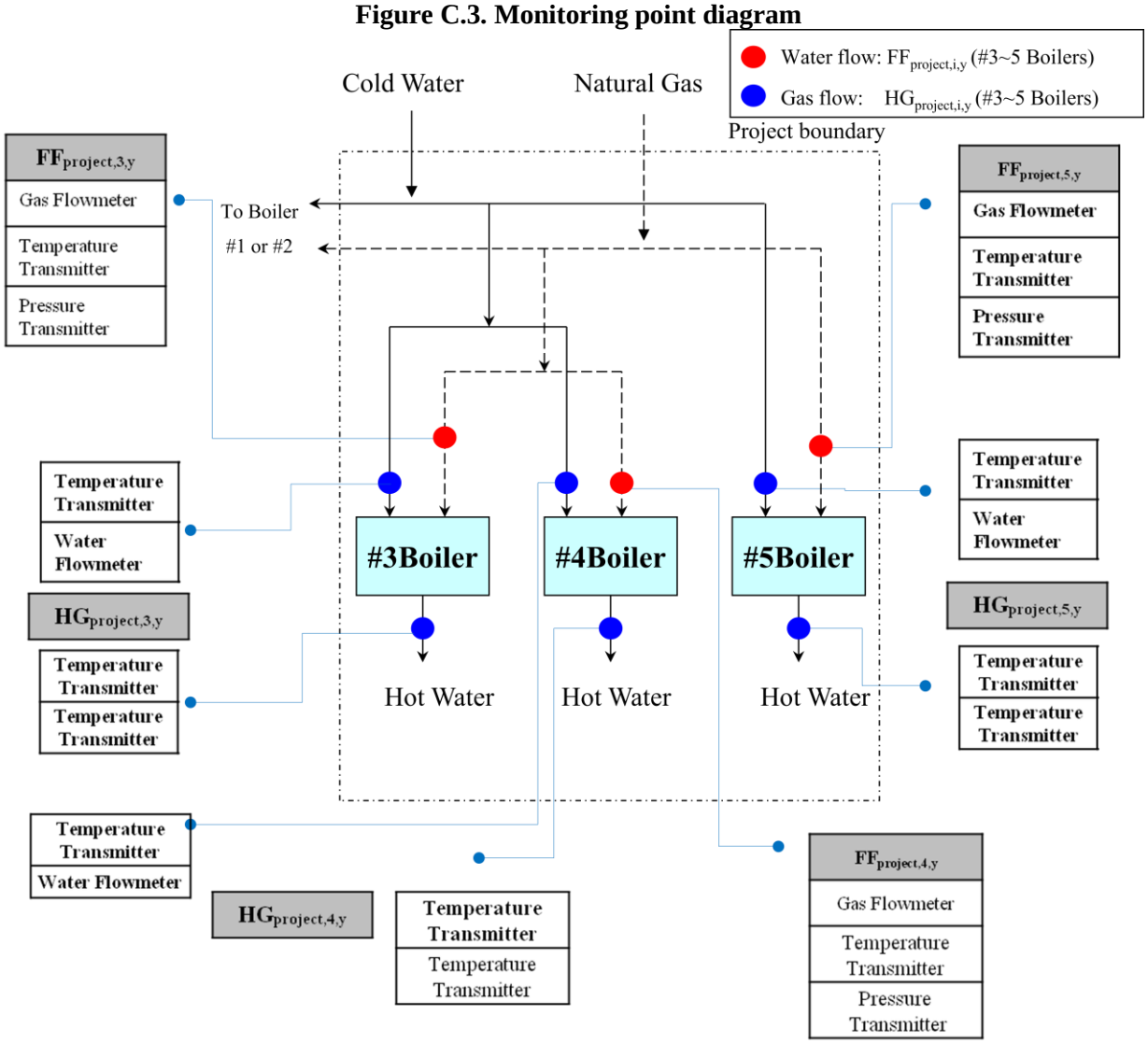
Data storage method
All monitoring data is collected and archived electronically by DCS as a spreadsheet. Separately, the operation records are manually checked by the operators.

Training
CDM monitoring team is trained for boiler operation and management by Technology & Operation Division.

Responsibilities and institutional arrangements for data collection and archiving
KDHC Gangnam branch is in charge of data collection and the Head office is in charge of its storage.

Diagram of monitoring points

Figure C.3. Monitoring point diagram



SECTION D. Data and parameters

D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

Data / Parameter:	**$NCV_{NG,y}$**
Data unit:	Kcal/N㎥
Description:	Average net calorific value of the natural gas combusted during the yea r y
Source of data used:	Korean Ministry of Commerce, Industry and Energy
Value(s) :	9,550
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline, project and leakage emission calculations
Additional comment:	

Data / Parameter:	***$EF_{NG,CO2,y}$***
Data unit:	tCO_2/TJ

Description:	CO_2 emission factor of the natural gas combusted in all element proces ses in the year y
Source of data used:	IPCC
Value(s) :	56.1
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations
Additional comment:	

Data / Parameter:	$NCV_{FF,y}$ and $NCV_{LSWR,y}$
Data unit:	Kcal/ℓ
Description:	Average net caloric value of LSWR that would be combusted in the ab sence of the project activity in the element process *i* during the year y
Source of data used:	Korean Ministry of Commerce, Industry and Energy
Value(s) :	9,350
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	

Data / Parameter:	$EF_{FF,CO2,y}$
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor of the LSWR that would be combusted in the abse nce of the project activity in the all element processes in tCO_2e/TJ
Source of data used:	IPCC
Value(s) :	77.3667
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	

Data / Parameter:	$\varepsilon_{baseline,i,y}$
Data unit:	%
Description:	Energy efficiency of the element process *i* if fired with LSWR
Source of data used:	KDHC
Value(s) :	(process *i* corresponds to #3~5 boilers) Boiler #3: 88% Boiler #4:88% Boiler #5:88%
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	

Data / Parameter:	$EF_{NG,upstream,CH4}$
Data unit:	tCH_4/PJ
Description:	Emission factor for upstream fugitive methane emissions from producti on, transportation and distribution of natural gas in tCH_4 per MWh fuel supplied to final consumers
Source of data used:	ACM0009
Value(s) :	296
Indicate what the data are	Leakage emission calculations

used for (Baseline/ Project/ Leakage emission calculations)	
Additional comment:	

Data / Parameter:	$EF_{LSWR, upstream, CH4}$
Data unit:	t CH4 / PJ
Description:	Emission factor for upstream fugitive methane emissions from producti on of the fuel LSWR in tCH4 per MWh fuel produced
Source of data used:	ACM0009
Value(s) :	4.1
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Leakage emission calculations
Additional comment:	

Data / Parameter:	GWP_{CH4}
Data unit:	t CO2e / t CH4
Description:	Global warming potential of methane valid for the relevant commitmen t period
Source of data used:	the Revised 1996 IPCC Guideline
Value(s) :	21
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Leakage emission calculations
Additional comment:	

D.2. Data and parameters monitored

Data / Parameter:	$\mathbf{FF_{baseline,i,y}}$
Data unit:	ℓ
Description:	Quantity of LSWR that would be combusted in the absence of the project activity in all element processes during the year *y*
Measured /Calculated /Default:	Calculated
Source of data:	Calculated based on monitoring records by KDHC
Value(s) of monitored parameter:	In total for the corresponding monitoring period, (*i* corresponds to #3~5 boilers) Boiler #3: 67,646,203 Boiler #4: 65,611,790 Boiler #5: 46,655,845
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Refer to $\mathbf{FF_{project,i,y}}$and $\mathbf{HG_{heat,i,y}}$of Table D-1
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Expressed in normalized cubic meters considering temperature and pressure
QA/QC procedures applied:	DCS-based data compared by the amount of NG supply provided by Daehan City Gas Co. Ltd. and the amount manually recorded by the site operator.

Data / Parameter:	**$FF_{project,i,y}$**
Data unit:	Nm^3
Description:	Natural gas consumed in element process *i* in year y
Measured /Calculated /Default:	Measured
Source of data:	Monitoring records by KDHC
Value(s) of monitored parameter:	In total for the corresponding monitoring period, (*i* corresponds to #3~5 boilers) Boiler #3: 61,654,258 Boiler #4: 59,648,374 Boiler #5: 43,938,593
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline and project emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Refer to Table D-1
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	Expressed in normalized cubic meters considering temperature and pressure
QA/QC procedures applied:	DCS-based data compared by the amount of NG supply provided by Daehan City Gas Co. Ltd. and the amount manually recorded by the site operator.

Data / Parameter:	**$HG_{project,i,y}$**
Data unit:	Gcal
Description:	Heat produced by the element process *i* in the year *y*
Measured /Calculated /Default:	Measured
Source of data:	Monitoring records by KDHC
Value(s) of monitored parameter:	In total for the corresponding monitoring period, (*i* corresponds to #3~5 boilers) Boiler #3: 556,767 Boiler #4: 539,177 Boiler #5: 386,350
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Refer to Table D-1
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	N/A
QA/QC procedures applied:	DCS-based data compared by the amount manually recorded by the site operator

Data / Parameter:	**$\varepsilon_{project,\ i,\ y}$**
Data unit:	%
Description:	Fuel efficiency of natural gas used at the element process *i*
Measured /Calculated /Default:	Calculated
Source of data:	Calculated based on monitoring records by KDHC

Value(s) of monitored parameter:	Fuel efficiency of natural gas is applied to the calculation of baseline emission per 12 months. Therefore there are three values each boiler because this monitoring period is 2 years and 7months. In average for the 1st period (Apr 2009 – Mar 2010), (*i* corresponds to #3~5 boilers) Boiler #3: 94.2% Boiler #4: 94.2% Boiler #5: 90.9% In average for the 2nd period (Apr 2010 – Mar 2011), (*i* corresponds to #3~5 boilers) Boiler #3: 94.8% Boiler #4: 95.3% Boiler #5: 92.0% In average for the 2nd period (Apr 2011 – Oct 2011), (*i* corresponds to #3~5 boilers) Boiler #3: 94.1% Boiler #4: 95.5% Boiler #5: 94.5%
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Refer to $\mathbf{FF_{project,i,y}}$ and $\mathbf{HG_{heat,i,y}}$ of Table D-1
Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Calculated based on $FF_{project,i,y}$ and $HG_{project,i,y}$ parameters measured by the monitoring equipments and adjusted by DCS.
QA/QC procedures applied:	-

Specification on Calibration of Monitoring Equipment

All the calibrations below are valid in accordance with its calibration standard. The calibration frequency for flow meters and temperature and pressure meters is 2 years. Certificates of calibration for these monitoring equipments are submitted to DOE in verification process. Though most of meters are calibrated at actual date later than date scheduled, the data monitored between Jun 2010 and Sep 2010 is still valid because there is no operation during the period (Jun 2010 – Sep 2010).

However, monitoring data of $HG_{project,i,y}$ between Oct 2010 and Dec 2010 shall be corrected in accordance with the relevant accuracy, namely ± 0.5%, because calibration of the water flow meters installed in the each boiler (FIT-2601, FIT-2602, FIT-2603) are performed in Dec 2010. Therefore monitoring data of $HG_{project,i,y}$ used to calculate baseline emissions in the period (Oct 2010 – Dec 2010) were deducted at 0.5% and this calculation is appropriately reflected to the ER calculation sheet and this monitoring report.

Table D.1. Information of monitoring equipment

Categorization		Monitoring Equipment	Serial No.	Original Location Ref.	Manufacturer	Model	Accuracy Class	Initial Calibration	Previous Calibration	Last Calibration	Validity
Boiler #3	**$FF_{project,i,y}$**	Gas Flow meter	C15-S0539HN	FIT-5301A (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	17/06/2006	10/06/2008	03/08/2010	02/08/2012
		Gas Flow meter	C15-S0561HN	FIT-5301B (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	17/06/2006	10/06/2008	03/08/2010	02/08/2012
		Gas Flow meter	C15-S0554HN	FIT-5301C (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	18/06/2006	09/06/2008	03/08/2010	02/08/2012
		Temperature Transmitter	B318623437	TIT-5301 (Front of Burner)	Honeywell	STT25M	±0.19%	16/06/2006	07/07/2008	27/07/2010	26/07/2012
		Pressure Transmitter	06060206001	PIT-5301 (Front of Burner)	Honeywell	STG944	± 0.25%	22/06/2006	07/07/2008	28/07/2010	27/07/2012
	$HG_{project,i,y}$	Temperature Transmitter	B322662337	TIT-5601 (Front of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/072010	24/072012
		Temperature Transmitter	B215675137	TIT-5603 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Temperature Transmitter	B323684437	TIT-5604 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Water Flow meter	A06 68017	FIT-2601 (Front of Boiler)	Krohne	VXF1150	± 0.5%	17/08/2006	17/06/2008	14/12/2010	13/12/2012
Boiler #4	**$FF_{project,i,y}$**	Gas Flow meter	C15-S0637HN	FIT-6301A (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	18/06/2006	09/06//2008	04/08/2010	03/08/2012

		Gas Flow meter	C15-S0635HN	FIT-6301B (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	19/06/2006	10/06//2008	03/08/2010	02/08/2012
		Gas Flow meter	C15-S0537HN	FIT-6301C (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	19/06/2006	09/06//2008	04/08/2010	03/08/2012
		Temperature Transmitter	B317603637	TIT-6301 (Front of Burner)	Honeywell	STG944	±0.19%	16/06/2006	07/07/2008	27/07/2010	26/07/2012
		Pressure Transmitter	06060206009	PIT-6301 (Front of Burner)	Honeywell	STT25M	± 0.25%	22/06/2006	07/07/2008	28/07/2010	27/07/2012
	$HG_{project,i,y}$	Temperature Transmitter	B322662037	TIT-6601 (Front of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Temperature Transmitter	B317603437	TIT-6603 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Temperature Transmitter	B215679937	TIT-6604 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Water Flow meter	A06 68015	FIT-2602 (Front of Boiler)	Krohne	VXF1150	± 0.5%	17/08/2006	17/06/2008	13/12/2010	12/12/2012
Boiler #5	$FF_{project,i,y}$	Gas Flow meter	C15-S0633HN	FIT-7301A (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	20/06/2006	10/06/2008	04/08/2010	03/08/2012
		Gas Flow meter	C15-S0553HN	FIT-7301B (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	23/08/2006	10/06/2008	04/08/2010	03/08/2012
		Gas Flow meter	C15-S0655HN	FIT-7301C (Front of Burner)	Oval Korea	UFM3030F	± 0.5 %	22/08/2006	09/06/2008	04/08/2010	03/08/2012
		Temperature Transmitter	B322671937	TIT-7301 (Front of Burner)	Honeywell	STG944	±0.19%	16/06/2006	07/07/2008	28/07/2010	27/07/2012
		Pressure Transmitter	06060206017	PIT-7301 (Front of Burner)	Honeywell	STT25M	± 0.25%	22/06/2006	07/07/2008	28/07/2010	27/07/2012
	$HG_{project,i,y}$	Temperature Transmitter	B215674937	TIT-7601 (Front of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	25/07/2010	24/07/2012
		Temperature Transmitter	B323679337	TIT-7603 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	27/07/2010	26/07/2012
		Temperature Transmitter	B324699737	TIT-7604 (Rear of Boiler)	Honeywell	STG944	± 0.2%	16/06/2006	24/06/2008	27/07/2010	26/07/2012
		Water Flow meter	A06 68016	FIT-2603 (Front of Boiler)	Krohne	VXF1150	± 0.5%	17/08/2006	17/06/2008	13/12/2010	11/12/2012

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

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Baseline emissions (BE_y) include CO_2 emissions from the combustion of the quantity of the baseline fuel(LSWR, Low Sulphur Waxy Residue fuel oil) that would be used in all element processes *i*(Boiler#3~5)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.

The equations for the ER calculation are described below. Actual calculations for the project NG boiler #3 applying the specified value are provided just below of each equation as an example. For detailed information on calculations and LNG consumption and heat production by the project activity, refer to the separate calculation sheet.

Calculation of $FF_{baseline,i,y}$

The quantity of LSWR that would be used in an element process *i*($FF_{baseline,i,y}$) in the absence of the project activityis calculated based on the actual monitored quantity of natural gas combusted in this element process ($FF_{project,i,y}$), the energy efficiencies and the net calorific values of both baseline and project fuel (NG and LSWR).

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

$FF_{baseline,i,y}$ is calculated from 12 monthly according to the provision of approved methodology ACM0009 (ver. 03) and BE_y is also calculated from 12 monthly. Therefore $FF_{baseline,i,y}$ and BE_y are each sum of the values in the 1st period (Apr 2009 – Mar 2010), 2nd period (Apr 2010 – Mar 2011) and 3rd period (Apr 2011 – Oct 2011).

For an example of $FF_{baseline,i,y}$ in case of the project NG boiler #3 in the 1st period (Apr 2009 – Mar 2010), the $FF_{baseline,i,y}$ value is calculated as follows;

$$28,347,926 = 25,939,852 \times \frac{9,550 \times 94.2\%}{9,350 \times 88.0\%}$$

Where,

Table E.1. Parameters for calculating $FF_{baseline,i,y}$

Parameter	Data unit	Value applied
$FF_{project,i,y}$	m^3	Calculated
$FF_{baseline,i,y}$	*l*	Calculated
$NCV_{NG,y}$	Kcal/Nm^3	9,550
$NCV_{FF,y}$	Kcal/*l*	9,350
$\varepsilon_{baseline,i,y}$	%	88%
$\varepsilon_{project,i,y}$	%	Calculated

$\varepsilon_{baseline,i,y}$ is fixed as in PDD section B.6.2. The actual value calculated for the baseline LSWR boilers are about 87.8%. However, the boiler efficiency of 88% is applied for the PDD to be conservative on the value.

$\varepsilon_{project,i,y}$ is calculated using the heat production and gas consumption that are monitored during the monitoring period. The separate calculation sheet includes the detailed information of calculation.

Calculation of BE_y

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

For an example of BE_y in case of the project NG boiler #3 in the 1st period (Apr 2009 – Mar 2010),

$$85,856 = 28,347,926 \times \frac{9,550 \times 94.2\%}{9,350 \times 88.0\%} \times 9,350 \times 77.3667 \times 4.1868(\text{Cal to J})/10^9(\text{Kilo to Tera})$$

Where,

Table E.2. Parameters for calculating BE_y

Parameter	Data unit	Value applied
BE_y	tCO_2e	Calculated
$EF_{FF,CO2,y}$	tCO_2/TJ	77.3667

Table E.3. Calculation of BE_y

BE_y	=	$FF_{baseline,i,y}$	×	$NCV_{FF,y}$	×	$EF_{FF,Co2,y}$	×	Kcal to TJ
544,895	=	179,913,837	×	9,350	×	77.3677	×	0.0000000041868

For detailed information on full calculation, refer to the separate calculation sheet.

E.2. Project emissions calculation

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For this project activity, Project emissions (PE_y) include CO_2 emissions from the combustion of natural gas in all element process *i* in accordance with ACM0009 Ver.3. 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 ($EF_{NG,CO2}$), as follow:

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

For an example of PE_y in case of the project NG boiler #3,

$$138,297 = 61,654,258 \times 9,550 \times 56.1 \times 4.1868(\text{Cal to J})/10^9(\text{Kilo to Tera})$$

Where,

Table E.4. Parameters for calculating PE_y

Parameter	Data unit	Value applied
PE_y	tCO_2e	Calculated
$EF_{NG,CO2,y}$	tCO_2/TJ	56.1

Table E.5. Calculation of PE_y

PE_y	=	$FF_{project,i,y}$	×	$NCV_{NG,y}$	×	$EF_{NG,CO2,y}$	×	Kcal to TJ

370,653	=	165,241,225	x	9,550	x	56.1	x	0.0000000041868

E.3. Leakage calculation

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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_4emissions and CO_2emissions from associated fuel combustion and flaring. In this methodology, the following leakage emission sources shall be considered:

•Fugitive methane emissions
Fugitive CH_4emissions 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_2emissions from LNG
In the case LNG is used in the project plant: CO_2emissions from fuel combustion or electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system.

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

For an example of LE_y in case of the project NG boiler #3,
$29,887 = 15,096 + 14,791$

Where,

Table E.6. Parameters for calculating LE_y

Parameter	Data unit	Value applied
LE_y	tCO_2e	Calculated
$LE_{CH4,y}$	tCO_2e	Calculated
$LE_{LNG,CO2,y}$	tCO_2e	Calculated

Calculation of $LE_{CH4,y}$

For the purpose of determining fugitive methane emissions associated with the production – and in case of natural gas, the transportation and distribution of the fuels – project participants should multiply the quantity of natural gas consumed in all element processes *i* with a methane emission factor for the upstream emissions ($EF_{NG,upstream,CH4}$), and subtract LSWR quantity multiplied with its methane emission factor($EF_{LSWR,upstream,CH4}$), as follows:

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

For an example of $LE_{CH4,y}$in case of the project NG boiler #3,
$15,096 = (61,654,258 \times 9,550 \times 296 \times 4.1868(\text{Cal to J})/10^{12}(\text{Kilo to Peta}) - 67,646,203 \times 9,350 \times 4.1 \times 4.1868(\text{Cal to J})/10^{12}(\text{Kilo to Peta})) \times 21$

Where,

Table E.7. Parameters for calculating $LE_{CH4,y}$

Parameter	Data unit	Value applied

$EF_{NG,upstream,CH4}$	tCH_4/PJ	296
$EF_{LSWR,upstream,CH4}$	tCH_4/PJ	4.1
GWP_{CH4}	tCO_2e/tCH_4	21

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

CO_2 emissions from fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system ($LE_{LNG,CO2,y}$) should be estimated by multiplying the quantity of natural gas combusted in the project with an appropriate emission factor, as follows:

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

For an example of $LE_{LNG,CO2,y}$ in case of the project NG boiler #3,

$$14{,}791 = 61{,}654{,}258 \times 6 \times 9{,}550(\mathrm{m}^3 \text{ to Kcal}) \times 4.1868(\text{Cal to J})/10^9(\text{Kilo to Tera})$$

Where,

Table E.8. Parameters for calculating $LE_{LNG,CO2,y}$

Parameter	Data unit	Value applied
$EF_{CO2,upstream,LNG}$	tCO_2/TJ	6

Table E.9. Calculation of LE_y

LE_y	=	$LE_{CH4,y}$	+	$LE_{LNG,CO2,y}$
80,105	=	40,463	+	39,642

For detailed information on full calculation, refer to the separate calculation sheet.

E.4. Emission reductions calculation / table

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The GHG emission reduction(ER) by the project activity during the monitoring period in question is calculated by the following equation

$$ER_y = BE_y - PE_y - LE_y$$

General description of the emission reduction is as follow. In the calculation sheet, the detail information on the calculation is included.

Table E.10. Calculation of BEy, PEy and LEy

	Boiler No.	BEy (tCO_2e)	PEy (tCO2e)	LEy (tCO2e)	ERy (tCO2e)
Monitoring Period (01/04/09 – 31/10/11)	**3**	204,876	138,297	29,887	36,693
	4	198,715	133,797	28,914	36,004
	5	141,304	98,559	21,304	21,441
	Total	**544,895**	**370,653**	**80,105**	**94,137**

E.5. Comparison of actual emission reductions with estimates in the CDM-PDD

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Table E.11. Comparison of actual emission reductions with estimates in the CDM-PDD

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO_2e) (Annual : 365 days)	63,988	36,398
Emission reductions (tCO_2e) (Monitored : 944 days)	**165,492**	**94,137**

*Actual value reached for the monitored period (944 days) is adjusted accordingly for comparison with ex-ante annual (365 days) calculation of the registered PDD.

E.6. Remarks on difference from estimated value in the PDD

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In the second monitoring period (01/04/ 09 – 31/10/11), the actual emission reduction is 94,137tCO_2e. This amount is about 71,355tCO_2e lower than the expected emission reduction as calculated in the PDD. This is mainly due to the fact that 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 heat demand was relatively small during the second monitoring period. Fuel consumption and heat generation vary year after year based on the demand of consumer.

Table E.12. Comparison of actual emission reductions with estimates in the CDM-PDD

PDD ER estimation	Actual calculation	Difference	Reason
165,492 tCO_2e	94,137 tCO_2e	**71,355 ↓**	Relatively low heat generation in Apr 2009 – Oct 2011(944 days) compared to the past generation amount
Past Average Heat Generation (2001-2005, Used for estimating the average amount for PDD ER estimation[2])		**Heat Generation (Used for calculating the actual ER estimation)**	
2,406,026Gcal (944 days)		1,482,294Gcal (944 days)	

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History of the document

Version	Date	Nature of revision
01	EB 54, Annex 34 28 May 2010	Initial adoption.
Decision Class: Regulatory Document Type: Guideline, Form Business Function: Issuance		

[2] For the related information, refer to B.6.1 of the PDD.