Monitoring report form for CDM project activity
(Version 07.0)

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

MONITORING REPORT		
Title of the project activity	LG Chem Naju plant fuel switching project	
UNFCCC reference number of the project activity	2475	
Version number of the PDD applicable to this monitoring report	10.4	
Version number of this monitoring report	1.0	
Completion date of this monitoring report	21/10/2019	
Monitoring period number	3rd Monitoring Period	
Duration of this monitoring period	01/11/2016 - 03/06/2019	
Monitoring report number for this monitoring period	1	
Project participants	LG Chem, Ltd.	
Host Party	Republic of Korea	
Applied methodologies and standardized baselines	Sectoral Scope 1 – Energy industries (renewable - / non-renewable sources)	
Sectoral scopes	AMS-III.B. ver. 12 - Switching fossil fuels	
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	36,188
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	50,836 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

>>

(a) LG Chem produces octanol, plasticizers and acrylic acid at its Naju plant. In the baseline scenario, steam, which is used in the production process of petrochemical products, is mainly produced in a boiler using bunker fuel oil C (Sulphur 0.5%). The Project activity involves retrofitting the boilers to allow fuel switching from bunker fuel oil C to natural gas. Natural gas is less carbon intensive than bunker fuel oil C. Therefore switching fuel from bunker fuel oil C to natural gas reduces GHG emissions.

(b) The existing boiler has been retrofitted by installing special purpose burners for natural gas combustion as well as other necessary minor modifications. For fuel switching from bunker fuel oil C to natural gas, four natural gas burners have been installed for the main boiler. The total capacity of the four natural gas burners installed is 5,353 Nm_3/hr, which is of sufficient capacity for the expected amount of natural gas consumption at Naju plant. The natural gas burners are provided by Hamworthy Combustion.

(c) The start date of the project activity (the purchase date of the natural gas burners) was 21/06/2006. The project boiler retrofit was started on 30/09/2006 and a test-run of the project activity undertaken in November 2006. Project operation began on 20/11/2006. The project was registered on 04/06/2009.

(d) The total emission reductions achieved in this monitoring period(01/11/2016 - 03/06/2019) are 36,188 tCO_2e

A.2. Location of project activity

>>

(a) Country(Host): Republic of Korea

(b) Province: Jeollanam-do

(c) City: Naju, 1, Songwal-dong (520-130)
It is located in Naju city about 20 km southwest of Gwangju International Airport.

(d) The coordinates for the plant site are: 35.023013 N, 126.717460 E.

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)	LG Chem, Ltd.	No

A.4. References to applied methodologies and standardized baselines

>>

In accordance with Appendix B of the simplified modalities and procedures for small-scale clean development mechanism project activities ("SSC M&P"), the project falls under the following methodology and tools.

(a) Applied methodology: AMS-III.B. Switching fossil fuels (Version12)[1]

[1] https://cdm.unfccc.int/methodologies/DB/1T8IU3YG99FQOYHN12FM3T0QZFFPBX

(b) Applied methodological tool: No methodological tools are used.

(C) Applied standardized baseline: No standardized baselines are used.

A.5. Crediting period type and duration

>>
Type of the crediting period: Fixed
Start date of the crediting period: 04/06/2009
End date of the crediting period: 03/06/2019
Length of the crediting period: 10 years

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>
The starting date of the project activity was 21/06/2006 and commercial operation started on 20/11/2006 following retrofit of the boilers.
The first monitoring period is from 04/06/2009 to 23/02/2011.
The second monitoring period is from 24/02/2011 to 31/10/2016.
The third monitoring period is from 01/11/2016 to 03/06/2019.

The project has been implemented and is operated as per the registered PDD with all physical features (technology, project equipment, monitoring and metering equipment) in place. Monitoring is done according to the applied methodology (AMS-III.B. Ver12.0) and revised monitoring plan.

(b) Description of the installed technology, technical processes and equipment

General description

LG Chem currently produces octanol, plasticizers and acrylic acid at Naju plant. Originally, Naju plant was founded as a fertilizer plant, in 1962 and was modified in 1982 to allow production of octanol. Through subsequent modification and expansion of the plant, current production has reached 190,000 MT/year for octanol, 166,000 MT/year for plasticizers and 26,000 MT/year for acrylic acid.

Project specific description

The existing boiler has been retrofitted by installing special purpose burners for natural gas combustion as well as other necessary minor modifications. There are three boilers in Naju plant. Among the three boilers, one boiler, which is the main boiler in Naju plant and of which specification is described in the following table, is retrofitted. As a result of the Project activity, the capacity of the boiler and the remaining lifetime of the boiler are not changed.

The existing boilers have also combusted purge gas and by-product liquid fuel generated from the processes. However, the combustion of such by-products is not be affected by the Project activity, since only bunker fuel oil C is switched to natural gas.

By-product liquid fuel is generated from EPA Vaporiser, Refine Column, n-Slop Column, Batch Still, VPH Vaporiser and Refine Column.

Purge gas is non-reaction gas from OXO reactor, OXO recycle loop and VPH loop. Since these

processes are not be affected by the fuel type used for the steam generation, the amount of purge gas and by-product liquid fuel is independent from the fuel switching project activity. Moreover, there is no change in the process/equipment for the deliver/combustion of purge gas and by-product liquid fuel before and after the project implementation. Therefore, purge gas and by-product liquid fuel will continue to be combusted in the existing boiler without any change, i.e. the amount of purge gas and by-product liquid fuel to be combusted under the baseline scenario and project scenario would be same and only bunker fuel oil C is switched to natural gas.

For fuel switching from bunker fuel oil C to natural gas, four natural gas burners have been installed for the main boiler. Total capacity of four natural gas burners installed is 5,353 Nm^3/hr, which is of sufficient capacity for the expected amount of natural gas consumption at Naju plant. The natural gas burners are provided by HAMWORTHY COMBUSTION, which is one of the world's largest combustion equipment manufacturers, with the experiences of equipment installation in over 100 countries. The specifications of the current boiler, the Project boiler (after modification) and natural gas burner are as follows:

Table 1. Boiler specification

Description	Baseline scenario	Project scenario
Capacity	70 T/H	70 T/H
Operating pressure	35 kg/cm^2G	35 kg/cm^2G
Steam Temperature	400 ℃	400 ℃
Mail fuel used	Bunker fuel oil C	Natural gas
Efficiency	91 %	91 %

Source: LG Chem, Ltd & Manufacturer

Table 2. Burner specification

Description	Specification	
Maker	HAMWORTHY	
Model	DF 505	
Type	Manifold & Spud	
Burning Capacity	Max	1,405 (Nm^3/hr)
	MCR	1,338 (Nm^3/hr)
	Min	267 (Nm^3/hr)

Source: HAMWORTHY COMBUSTION

The natural gas is supplied by Hae Yang City Gas in Gwangju Metropolitan City. The composition of the natural gas sample is described in the following table.

Table 3. Composition of natural gas (sample)

Component		Value
Methane (CH_4)		89.78 %
Ethane (C_2H_6)		7.48 %
Propane (C_3H_3)		2.02 %
Propylene (C_3H_6)		-
Butane	i-C_4H_{10}	0.36 %
	n-C_4H_{10}	0.34 %
Nitrogen (N_2)		0.02 %
Oxygen (O_2)		-

Source: Hae Yang City Gas

(c) Actual operation of the project activity during the covered monitoring period

The plant was offline for 116 days during the third monitoring period. The outages were due to boiler cleaning or turn around (annual plant shutdown for maintenance). The offline outages are described as below:

Table 4. Description of the offline outages

No.	Start	End	Days	Affected Parameter	Reason
1	16-11-11	16-11-17	6	Steam, LNG, Purge gas, Liquid fuel	- Boiler Cleaning
2	17-2-17	17-2-23	6		
3	17-3-7	17-3-13	6		- Maintenance of Economizer Tube
4	17-3-26	17-3-28	2		
5	17-4-17	17-4-27	10		
6	17-5-4	17-5-5	1		
7	17-6-1	17-6-9	8		- Boiler Cleaning
8	17-7-24	17-7-27	3		- Maintenance of Economizer and Air Preheater element
9	17-10-16	17-11-8	23		- Boiler Cleaning - Replacement of Economizer - Installation of Distributed control system
10	08-3-23	08-3-30	7		- Boiler Cleaning - Replacement of FD Fan Motor - Audit of Boiler Tube
11	08-6-21	08-6-27	6		- Boiler Cleaning
12	08-9-13	08-9-21	8		- Maintenance of Air preheater
13	08-10-15	08-10-21	6		- Boiler Cleaning - Inspection of boiler
14	19-1-21	19-1-25	4		- Boiler Cleaning
15	19-4-5	19-4-25	20		- Boiler Cleaning - Maintenance of fire brick - Inspection of boiler
Total			**116**		

There was no event during the monitoring period that had an impact on the applicability of the methodology.

(d) Situations with impact on the applicability of the methodology

No such situations occurred during the covered monitoring period.

B.2. Post-registration changes

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

>>
No deviation has been applied to the monitoring period.

B.2.2. Corrections

>>
No such corrections have been applied during this monitoring period, neither to any previous monitoring period.

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

>>
No such changes have applied to this monitoring period neither to previous monitoring period in the crediting period.

B.2.4. Inclusion of monitoring plan

>>
No such inclusion has applied to this monitoring period.

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

>>
No permanent changes from the registered monitoring plan, applied standardized baseline have been approved during this monitoring period or submitted with this monitoring report.

B.2.6. Changes to project design

>>
No such changes have applied to this monitoring period neither to any previous monitoring period.

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

>>
N.A

SECTION C. Description of monitoring system

>>
LG Chem has organized an Operating and Monitoring Team, as per the PDD, which composes a manager and operators. The manager is responsible for monitoring and archiving all data associated with items depicted in the PDD monitoring plan. Operators working under the manager are assigned to the task of monitoring the different parameters on a timely basis as well as recording and archiving data in an orderly manner. All data collected as part of the monitoring plan will be archived electronically and be kept at least two (2) years after the end of the crediting period. Monitoring reports are reviewed by the manager on a monthly basis in order to ensure that the Project activity meets all requirements.

1. Allocation of Project management responsibilities

The management and operation of the Project is the responsibility of LG Chem, the Project operator. Ensuring the environmental credibility of the Project through accurate and systematic monitoring of the Project's implementation and operation for the purpose of achieving trustworthy CERs is the key responsibility and accountability of the operator.

2. Management and operational systems

The project developers have implemented a management and operational system that meets the requirements of the Project. This includes:

2.1 Data handling

– The establishment of a transparent system for the collection, computation and storage of data, including adequate record keeping and data monitoring systems.

2.2 Quality assurance

– LG Chem has designated a manager to be accountable for the generation of CERs including monitoring, record keeping, computation of CERs, audits and verification. The manager officially sign-offs on all GHG Emission worksheets.
– The manager follows well-defined protocols and routine procedures, with good, professional data entry, extraction and reporting are undertaken to maximize transparency of data archiving.
– Proper management processes and recording of all official data is undertaken.

2.3 Training

– Internal training is made available to operational staff to enable them to undertake the tasks required by the MP.

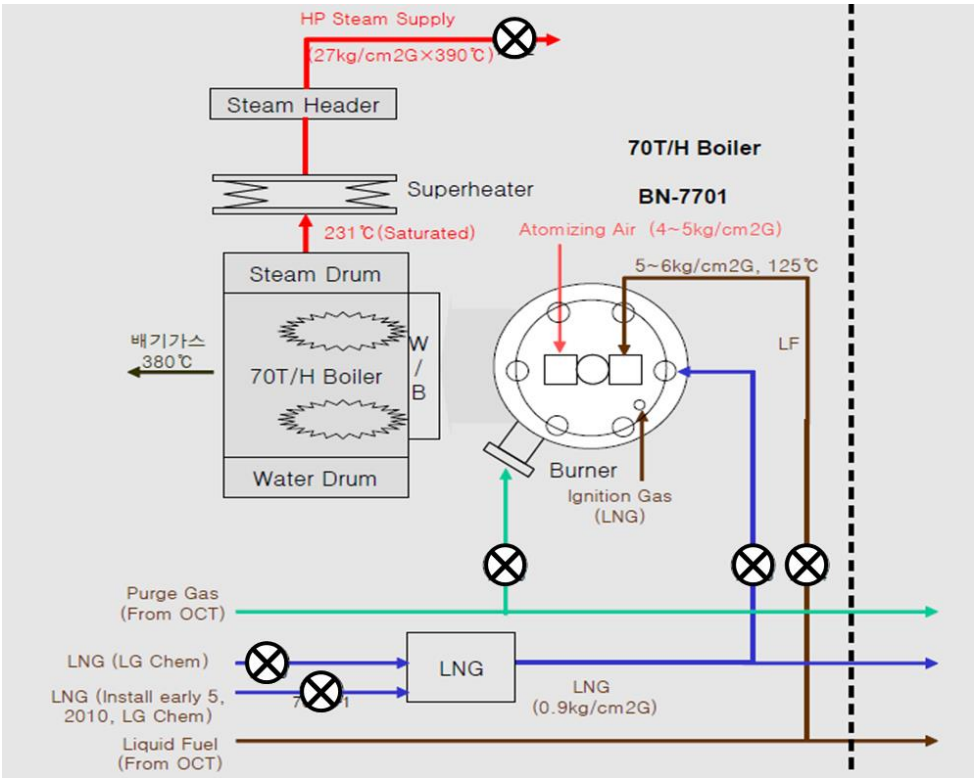

Figure 1. All relevant project monitoring points

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/parameter:	**$EF_{NG,CO2}$**
Unit	tCO_2/TJ
Description	CO_2 emission factor of the natural gas combusted
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	56.1
Choice of data or measurement methods and procedures	N/A
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante

Data/parameter:	**$FF_{baseline}$**
Unit	Liter
Description	Quantity of bunker fuel oil C combusted in the baseline situation
Source of data	LG Chem.
Value(s) applied	70,730,291
Choice of data or measurement methods and procedures	N/A
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante. 3 years data prior to the project implementation (from 1st, November 2003 to 31st, October 2006) is used.

Data/parameter:	***$EF_{baseline,CO2}$***
Unit	tCO_2/TJ
Description	CO_2 emission factor of bunker fuel oil C
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value(s) applied	77.4
Choice of data or measurement methods and procedures	N/A
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante

Data/parameter:	$Q_{total,baseline}$
Unit	TJ
Description	Total quantity of steam generated by bunker fuel oil C, purge gas and by-product liquid fuel in the baseline situation
Source of data	LG Chem.
Value(s) applied	3,701.09
Choice of data or measurement methods and procedures	3 years data prior to the project implementation (from 1st, November 2003 to 31st, October 2006) is used. LG Chem produces superheated steam at 27 atm, 390°C. The enthalpy of the superheated steam is 767.7kcal/kg of steam according to the steam table (Spirax Sarco: http://www.spiraxsarco.com/Resources/Pages/Steam-Tables/superheated-steam.aspx). The temperature of the feed water is 104℃.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante.

Data/parameter:	$PG_{baseline}$
Unit	Nm^3
Description	Quantity of purge gas combusted in the boiler in the baseline situation
Source of data	LG Chem.
Value(s) applied	13,203,959
Choice of data or measurement methods and procedures	3 years data prior to the project implementation (from 1st, November 2003 to 31st, October 2006) is used.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante.

Data/parameter:	$LF_{baseline}$
Unit	Liter
Description	Quantity of by-product liquid fuel combusted in the boiler in the baseline situation
Source of data	LG Chem.
Value(s) applied	26,297,017
Choice of data or measurement methods and procedures	3 years data prior to the project implementation (from 1st, November 2003 to 31st, October 2006) is used.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante.

Data/parameter:	**$NCV_{PG,baseline}$**
Unit	TJ/Nm^3
Description	Net calorific value of purge gas
Source of data	LG Chem
Value(s) applied	52.15×10^{-6}
Choice of data or measurement methods and procedures	3 years data prior to the project implementation (from 1st, November 2003 to 31st, October 2006) is used.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante.

Data/parameter:	**$NCV_{LF,baseline}$**
Unit	TJ/Nm^3
Description	Net calorific value of by-product liquid fuel
Source of data	LG Chem
Value(s) applied	30.576×10^{-6}
Choice of data or measurement methods and procedures	Due to the absence of the reliable data for the period of 3 year prior to the project implementation (from 1st, November 2003 to 31st, October 2006) does not exist, the data recently measured by the independent laboratory is used.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex-ante.

Data/parameter:	**$NCV_{baseline}$**
Unit	TJ/liter
Description	Net calorific value of bunker fuel oil C
Measured/calculated/default	Default
Source of data	Calorific Value table approved by the Government
Value(s) applied	39.1×10^{-6}
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Yearly
Calculation method (if applicable):	N/A
QA/QC procedures:	The accurate and reliable national data is used. The value is from the Calorific Value Table in “Energy Act” approved by Korean Government.
Purpose of data	Baseline emission calculations
Additional comments	The value is set ex- ante.

D.2. Data and parameters monitored

<table>
<tr><td>Data/parameter:</td><td>$FF_{projcet,y}$</td></tr>
<tr><td>Unit</td><td>Nm^3</td></tr>
<tr><td>Description</td><td>Quantity of natural gas combusted in the project boiler during the year, y</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>On-site measurement</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>41,903,234</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Type</td><td>Vortex(Orifice)</td></tr>
<tr><td>Accuracy Class</td><td>±1.0%</td></tr>
<tr><td>Name</td><td>FQ_7705</td></tr>
<tr><td>Serial Number</td><td>C15-S0728HN</td></tr>
<tr><td>Calibration frequency</td><td>Every 3 years</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>The meter has been calibrated at least every 3 years and calibration certificates have been issued.
The meter was calibrated as follows;
<table>
<tr><td>No.</td><td>Calibration date (validity date)</td></tr>
<tr><td>1</td><td>4-Nov-2013 (4-Nov-2013 to 3-Nov-2016)</td></tr>
<tr><td>2</td><td>30-Oct-2017 (30-Oct-2017 to 29-Oct-2020)</td></tr>
</table>
The maximum error was applied from November 2016 to October 2017 due to the delayed calibration.

According to the revised monitoring plan, the amount measured by this meter was cross-checked with the receipt of purchase and consumption at other points in the plant. The result of cross-checking shows that the average difference between total natural gas consumption and the purchased total amount of natural gas is only 2%, within a reasonable and acceptable range. The meter FQ-7705 was also calibrated periodically as per the revised monitoring plan of the Project.

The quantity of the combusted natural gas has been measured by the meter of orifice type, the pressure is normalized, and the thermometer(Tag No. FT-7705) of the natural gas were periodically calibrated during monitoring period for normalization of the quantity of the natural gas.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments</td><td>The name tags were changed due to the introduction of DCS.</td></tr>
</table>

Data/parameter:	$NCV_{NG,y}$
Unit	TJ/Nm^3
Description	Net calorific value of natural gas in year, y
Measured/calculated/default	Default
Source of data	Calorific Value Table approved by the Government
Value(s) of monitored parameter	Weighted average : 39.12×10^{-6}

Sort	NCV	Quantity of Natural gas
Until 2017	39.4×10^{-6}	18,506,710
After 2017	38.9×10^{-6}	23,396,524
Weighted average	39.12×10^{-6}	41,903,234

Monitoring equipment	N/A
Measuring/reading/recording frequency	Yearly
Calculation method (if applicable)	N/A
QA/QC procedures	The accurate and reliable national data is used. The value is from the Calorific Value Table in “Energy Act” approved on 28 December 2017 and 30 December 2011 by Korean Government.
Purpose of data/parameter	Project emission calculations
Additional comments	The weighted average value is used for the project emission calculations.

Data/parameter:	$Q_{total,y}$
Unit	TJ
Description	Total quantity of steam generated by natural gas, purge gas and by-product liquid fuel in the project boiler during the year, y
Measured/calculated/default	Measured
Source of data	On-site measurement
Value(s) of monitored parameter	2,554.24
Monitoring equipment	

Type	Differential pressure
Accuracy Class	±2.0%
Name	FT-7702
Serial Number	91M642405
Calibration frequency	Every year

Measuring/reading/recording frequency	Continuous
Calculation method (if applicable)	The total quantity of steam generated from the combustion of natural gas, purge gas, and by-product liquid fuel (the difference in the energy of the feedwater going into the system and the steam leaving the system) was calculated via steam tables. The minimum values identified during the monitoring period were used in the calculation. For steam, 26 kgf/cm^2 and 368°C and for feedwater, 129.09°C are used to calculate the enthalpy of steam. The enthalpy of the superheated steam is 755.84kcal/kg according to the steam table. The enthalpy of the feedwater is 129.09kcal/kg. (http://www.spiraxsarco.com/Resources/Pages/Steam-Tables/superheated-steam.aspx).

<table>
<tr><td>QA/QC procedures</td><td>The revised monitoring plan on PDD does not specify a calibration frequency of the meter, but the calibration has conducted yearly with previous monitoring report. The yearly calibration frequency for the steam flow meter is satisfied with “Law of measurement” approved by Korean Government.

The meter was calibrated as follows;
<table>
<tr><th>No.</th><th>Calibration date (validity date)</th></tr>
<tr><td>1</td><td>16-Apr-2016 (16-Apr-2016 to 15-Apr-2017)</td></tr>
<tr><td>2</td><td>30-Oct-2017 (30-Oct-2017 to 29-Oct-2018)</td></tr>
<tr><td>3</td><td>27-Mar-18 (27-Mar-18 to 26-Mar-19)</td></tr>
<tr><td>4</td><td>10-Apr-19 (10-Apr-19 to 10-Apr-20)</td></tr>
</table>
The maximum error was applied from April 2017 to October 2017 and from March 2019 to April 2019 due to the delayed calibration.

The thermometer(Tag No. TT-7712) and pressure gauges(Tag No. PT-7701) were managed through comparative testing according to internal standards by LG Chem. Both have no erroneous measurement or malfunction detected during the monitoring period.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments</td><td>The name tags were changed due to the introduction of DCS.</td></tr>
</table>

<table>
<tr><td>Data/parameter:</td><td>PG_y</td></tr>
<tr><td>Unit</td><td>Nm^3</td></tr>
<tr><td>Description</td><td>Quantity of purge gas combusted in the project boiler during the year, y</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>On-site measurement</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>14,255,290</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Type</td><td>Differential pressure</td></tr>
<tr><td>Accuracy Class</td><td>±2.0%</td></tr>
<tr><td>Name</td><td>FT_7706</td></tr>
<tr><td>Serial Number</td><td>91L751790</td></tr>
<tr><td>Calibration frequency</td><td>Every year</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
</table>

<table>
<tr><td>QA/QC procedures</td><td>The revised monitoring plan on PDD does not specify a calibration frequency of the meter (Tag No. 7106), but the calibration has conducted yearly with previous monitoring report. The yearly calibration frequency for the purge gas meter is satisfied with “Law of measurement” approved by Korean Government.

The meter was calibrated as follows;
<table>
<tr><th>No.</th><th>Calibration date (validity date)</th></tr>
<tr><td>1</td><td>16-Apr-2016 (16-Apr-2016 to 15-Apr-2017)</td></tr>
<tr><td>2</td><td>30-Oct-2017 (30-Oct-2017 to 29-Oct-2018)</td></tr>
<tr><td>3</td><td>27-Mar-18 (27-Mar-18 to 26-Mar-19)</td></tr>
<tr><td>4</td><td>10-Apr-19 (10-Apr-19 to 10-Apr-20)</td></tr>
</table>

The maximum error was applied from April 2017 to October 2017 and from March 2019 to April 2019 due to the delayed calibration.

The thermometer(Tag No. TT-7706) for the purge gas temperature was managed through comparative testing according to internal standards by LG Chem. Both have no erroneous measurement or malfunction detected during the monitoring period.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments</td><td>The name tags were changed due to the introduction of DCS.</td></tr>
</table>

<table>
<tr><td>Data/parameter:</td><td>LF_y</td></tr>
<tr><td>Unit</td><td>Liter</td></tr>
<tr><td>Description</td><td>Quantity of by-product liquid fuel combusted in the project boiler during the year, y</td></tr>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>On-site measurement</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>22,333,888</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><td>Type</td><td>Positive displacement</td></tr>
<tr><td>Accuracy Class</td><td>±0.5%</td></tr>
<tr><td>Name</td><td>FQ_7704</td></tr>
<tr><td>Serial Number</td><td>CN25-8674R</td></tr>
<tr><td>Calibration frequency</td><td>Every 3 years</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Continuous</td></tr>
<tr><td>Calculation method (if applicable)</td><td>N/A</td></tr>
<tr><td>QA/QC procedures</td><td>The meter (Tag No. FQ-7704) has been calibrated at least every 3 years and calibration certificates have been issued. The revised monitoring plan on PDD does not specify a calibration frequency, but the calibration has conducted every 3 years with previous monitoring report. The calibration frequency for the by-product liquid fuel meter is satisfied with “Law of measurement” approved by Korean Government.

The meter was calibrated as follows;
<table>
<tr><th>No.</th><th>Calibration date (validity date)</th></tr>
<tr><td>1</td><td>22-Oct-2014 (22-Oct -2014 to 21-Oct-2017)</td></tr>
<tr><td>2</td><td>30 - Jul- 2017 (30-Jul-2017 to 30-Jul-2020)</td></tr>
</table>
</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculations</td></tr>
</table>

Additional comments	The meter was replaced in July 2017. Serial number was changed from B153-6983 to CN25-8674R. The name tags were changed due to the introduction of DCS.

Data/parameter:	**$NCV_{WG,y}$**
Unit	TJ/Nm^3
Description	Net calorific value of purge gas
Measured/calculated/default	Measured
Source of data	On-site measurement
Value(s) of monitored parameter	See table below
Monitoring equipment	See table below
Measuring/reading/recording frequency	Quarterly
Calculation method (if applicable)	The measured quarterly and weighted average yearly.

Year	month	Net calorific Value(TJ/Nm^3)
2016	11~12	32.98×10^{-6}
2017	1~3	38.94×10^{-6}
	4~6	35.26×10^{-6}
	7~9	40.86×10^{-6}
	10~12	40.06×10^{-6}
2018	1~3	41.18×10^{-6}
	4~6	47.33×10^{-6}
	7~9	49.11×10^{-6}
	10~12	45.26×10^{-6}
2019	1~3	48.39×10^{-6}
	4~6	55.96×10^{-6}
Weighted average		42.68×10^{-6}

Purge gas is consisted of C_3H_6, C_3H_8, H_2 and is generated by product of Octanol. Its composition can be able to change, accordingly, its net calorific value could be changed.

Type	Agilent 7890A Network Gas Chromatograph
Accuracy Class	· Inlet modules: Pressure sensors: Accuracy: <±2% full scale, Repeatability: <±0.05 psi, Temperature coefficient: <±0.01 psi/°C, Drift: <±0.1 psi/6 months Flow sensors: Accuracy <±5% depending on carrier gas, Repeatability: <±0.35% of setpoint, normalized temperature and pressure (NTP, 25°C, 1atm) per °C for He or H_2, <0.05mL/min NTP per °C for N_2 or Ar/CH_4. · Detector modules: Accuracy: <± 3mL/min NTP or 7% of setpoint Repeatability: <±0.35% of setpoint

QA/QC procedures	The NCV of purge gas was analyzed using standard gas (reference material) as per ASTM D 3588 (Standard practice for calculating heat value, compressibility factor and relative density (specific gravity) of gaseous fuels) widely using for NCV of gaseous fuels. GC (Gas chromatograph) maintenance is entrusted to specialized companies and is managed periodically. NCV for Purge gas can be crosschecked with the values are verified by 3rd verification body under K-ETS. can be crosschecked with the values are verified by 3rd verification body under K-ETS. The NCV value calculation method also conforms to the criteria set out in the regulation such as “Guideline for Greenhouse Gas and Energy Target Management Scheme” approved by Korean Government.
Purpose of data/parameter	Project emission calculations
Additional comments	

Data/parameter:	**$NCV_{LF,y}$**
Unit	TJ/Liter
Description	Net calorific value of by-product liquid fuel
Measured/calculated/default	Measured
Source of data	On-site measurement
Value(s) of monitored parameter	See table below
Monitoring equipment	N/A
Measuring/reading/recording frequency	Quarterly
Calculation method (if applicable)	The measured quarterly and weighted average yearly.
QA/QC procedures	For the reliable value from the quarterly measurement, NCV for by-product liquid fuel were measured by the 3rd party under KOLAS quarterly. NCV for by-product liquid fuel can be crosschecked with the values are verified by 3rd verification body under K-ETS. The NCV value calculation method also conforms to the criteria set out in the regulation such as “Guideline for Greenhouse Gas and Energy Target Management Scheme” approved by Korean Government.
Purpose of data/parameter	Project emission calculations
Additional comments	

Year	month	Net calorific Value(TJ/Liter)
2016	11~12	28.53×10^{-6}
2017	1~3	29.30×10^{-6}
	4~6	28.03×10^{-6}
	7~9	30.62×10^{-6}
	10~12	30.56×10^{-6}
2018	1~3	31.20×10^{-6}
	4~6	29.88×10^{-6}
	7~9	29.79×10^{-6}
	10~12	29.52×10^{-6}
2019	1~3	29.65×10^{-6}
	4~6	27.68×10^{-6}
Weighted average		29.64×10^{-6}

Data/parameter:	**$\varepsilon_{projcet,y}$**
Unit	%
Description	Energy efficiency of the boiler during the year, y
Measured/calculated/default	Calculated

<table>
<tr><td>Source of data</td><td>Calculated using measured data</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>
<table>
<tr><th>Year</th><th>month</th><th>Efficiency</th><th>Yearly</th></tr>
<tr><td>2016</td><td>11~12</td><td>86.51</td><td>86.51</td></tr>
<tr><td rowspan="4">2017</td><td>1~3</td><td>85.83</td><td rowspan="4">84.26</td></tr>
<tr><td>4~6</td><td>83.02</td></tr>
<tr><td>7~9</td><td>80.48</td></tr>
<tr><td>10~12</td><td>88.08</td></tr>
<tr><td rowspan="4">2018</td><td>1~3</td><td>93.02</td><td rowspan="4">91.47</td></tr>
<tr><td>4~6</td><td>92.20</td></tr>
<tr><td>7~9</td><td>90.65</td></tr>
<tr><td>10~12</td><td>89.91</td></tr>
<tr><td rowspan="2">2019</td><td>1~3</td><td>86.54</td><td rowspan="2">87.29</td></tr>
<tr><td>4~6</td><td>89.77</td></tr>
<tr><td colspan="3">Weighted average</td><td>87.79</td></tr>
</table>
</td></tr>
<tr><td>Monitoring equipment</td><td>N/A</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Quarterly</td></tr>
<tr><td>Calculation method (if applicable)</td><td>The energy efficiency of the boiler was calculated by the direct method (dividing the net heat generation by the energy content of the fuels fired) at least quarterly.</td></tr>
<tr><td>QA/QC procedures</td><td>The meters used for monitoring of the relevant parameters (steam generation, fuel consumption) will be calibrated periodically. Once the erroneous measurement or malfunction is detected, corrective actions will be taken by LG Chem.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculations</td></tr>
<tr><td>Additional comments</td><td></td></tr>
</table>

D.3. Implementation of sampling plan

>>

A sampling approach was not employed.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>

$$EF_{baseline} = FF_{baseline} \times EF_{baseline,CO2} \times NCV_{baseline} / Q_{baseline}$$

$$= 70{,}730{,}291(liter) \times 77.4(tCO_2/TJ) \times 39.1 \times 10^{-6}(TJ/liter) / 2{,}403.73(TJ)$$

$$= 89.05\ tCO_2e/TJ$$

Where:

$FF_{baseline}$	Quantity of bunker fuel oil C combusted in the baseline situation (liter)
$EF_{baseline,CO2}$	CO_2 emission factor of bunker fuel oil C (tCO_2/TJ)
$NCV_{baseline}$	Net calorific value of bunker fuel oil C (TJ/liter)

$Q_{baseline}$ Quantity of steam generated by bunker fuel oil C in the baseline situation (TJ)

For quantity of bunker fuel oil C combusted, $FF_{baseline}$, and quantity of steam generated by bunker fuel oil C, $Q_{baseline}$, 3 years data prior to project implementation (from 1_{st}, November, 2003 to 31_{st}, October 2006) is used.

$$Q_{baseline}=Q_{total,baseline}\times\frac{FF_{baseline}\times NCV_{baseline}}{(FF_{baseline}\times NCV_{baseline}+PG_{baseline}\times NCV_{PG,baseline}+LF_{baseline}\times NCV_{LF,baseline})}$$

$$Q_{baseline}=Q_{total,baseline}\times(FF_{baseline}\times NCV_{baseline})/(FF_{baseline}\times NCV_{baseline}+PG_{baseline}\times NCV_{PG,baseline}+LF_{baseline}\times NCV_{LF,baseline})$$

$$=3{,}701.09(TJ)\times[70{,}730{,}291(liter)\times 39.1\times 10^{-6}(TJ/liter)]/[70{,}730{,}291(liter)\times 39.1\times 10^{-6}(TJ/liter)\times$$

$$13{,}203{,}959(Nm^3)\times 52.15(TJ/liter)\times 26{,}297{,}017(liter)\times 30.576\times 10^{-6}(TJ/liter)]$$

$$=2{,}403.73\ TJ$$

Where:

$Q_{total,baseline}$ Total quantity of steam generated by bunker fuel oil C, waste gas and by-product liquid fuel in the baseline situation (TJ)

$PG_{baseline}$ Quantity of purge gas combusted in the boiler in the baseline situation (Nm^3)

$NCV_{PG,baseline}$ Net calorific value of purge gas (TJ/Nm^3)

$LF_{baseline}$ Quantity of by-product liquid fuel combusted in the boiler in the baseline situation (liter)

$NCV_{LF,baseline}$ Net calorific value of by-product liquid fuel (TJ/liter)

Quantity of steam generated by natural gas, Q_y

Since purge gas and by-product liquid fuel are also combusted in the boiler, the quantity of steam generated by natural gas, Q_y, is calculated based on the proportion of fuel used as follows:

$$Q_y=Q_{total,y}\times\frac{FF_{project,y}\times NCV_{NG,y}}{(FF_{project,y}\times NCV_{NG,y}+PG_y\times NCV_{WG,y}+LF_y\times NCV_{LF,y})}$$

$$=2554.24(TJ)\times[41{,}903{,}234(Nm^3)\times 39.12\times 10^{-6}(TJ/Nm^3)]/[41{,}903{,}234(Nm^3)\times 39.12\times 10^{-6}(TJ/Nm^3)$$

$$+14{,}255{,}290(Nm^3)\times 42.68\times 10^{-6}(TJ/Nm^3)+22{,}333{,}888(liter)\times 29.64\times 10^{-6}(TJ/liter)]$$

$$=1{,}439.10\ TJ$$

Where:

$Q_{total,y}$	Total quantity of steam generated by natural gas, purge gas and by-product liquid fuel during year, y (TJ)
$FF_{project,y}$	Quantity of natural gas combusted in the project boiler during the year, y (Nm^3)
PG_y	Quantity of purge gas combusted in the boiler during year, y (Nm^3)
$NCV_{PG,y}$	Net calorific value of purge gas (TJ/Nm^3)
LF_y	Quantity of by-product liquid fuel combusted in the boiler during year, y (liter)
$NCV_{LF,y}$	Net calorific value of by-product liquid fuel (TJ/liter)

Baseline emission, BE_y

$$BE_y = EF_{baseline} \times Q_y$$

$$= 89.05(tCO_2e/TJ) \times 1,439.10(TJ)$$

$$= 128,152.62\ tCO_2e$$

Where:

BE_y	Baseline emission during the year y (tCO_2e)
$EF_{baseline}$	Baseline emission factor for the baseline situation (tCO_2/TJ)
Q_y	Quantity of steam generated by natural gas (TJ)

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

>>

Project emissions consist of those emissions related with the use of fossil fuel after the fuel switch. Project emissions are calculated as follows:

$$PE_y = FF_{project,y} \times NCV_{NG,y} \times EF_{NG,CO2}$$

$$=41,903,234(Nm^3) \times 39.12 \times 10^{-6}(TJ/Nm^3) \times 56.10(tCO_2/TJ)$$

$$=91,964.12\ tCO_2e$$

Where:

PE_y	Project emissions during the year, y (tCO_2e)

$FF_{project,y}$ Quantity of natural gas combusted in the project boiler during the year, y (Nm^3)

$NCV_{NG,y}$ Net calorific value of the natural gas combusted in year, y (TJ/Nm^3)

$EF_{NG,CO2}$ CO_2 emission factor of the natural gas combusted in the project boiler (tCO_2/TJ)

E.3. Calculation of leakage emissions

>>

As described in AMS-III.B, no leakage calculation is required.

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
Total	128,152	91,964	0	0	36,188	36,188

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

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
36,188 tCO_2e	50,836 tCO_2e

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

>>

Annual Estimation of emission reductions in the PDD is 19,635 tCO_2e. The annual Estimation of emission reductions is converted to 50,836 tCO_2e[19,635 tCO_2e/365dayX945day] on 945 days basis.

E.6. Remarks on increase in achieved emission reductions

>>

The actual emission reductions achieved during the monitoring period is only 71.2% of the value calculated ex ante in the PDD due to following reasons:

1. Fuel mix of $FF_{project,y}$, PG_y and LF_y was changed. Compared with the ex-ante estimation, the share of PG_y and LF_y have increased, resulting in a change to the baseline as well as the project emission.

2. Steam generation (Q_y) from the system has decreased, due to lower demand of steam at the factory.

3. Increase of down time. Due to various reasons, the boiler was down for 116 days, during the total 945 days monitoring period, as indicated in Section B.1 Table 4

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

>>

The emission reduction in the monitoring period is 36,188 t CO_2e, not exceeding 60 kt CO_2e per year.

Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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