



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	Mokpo Landfill Gas Recovery Project for Electricity Generation	
UNFCCC reference number of the project activity	2834	
Version number of the PDD applicable to this monitoring report	Version 6.0	
Version number of this monitoring report	Version 1.0	
Completion date of this monitoring report	17/04/2020	
Monitoring period number	10 th monitoring period	
Duration of this monitoring period	01/01/2019 ~ 17/02/2020	
Monitoring report number for this monitoring period	1	
Project participants	Hanwha Corporation(Republic of Korea) Hanwha Corporation(Switzerland)	
Host Party	Republic of Korea	
Applied methodologies and standardized baselines	Applied methodologies: - AMS I.D: Grid connected renewable electricity generation_V13 -AMS III. G: Landfill methane recovery_V06 No standardized baseline applicable.	
Sectoral scopes	Scope 1. Energy industry Scope 13. Waste handling and disposal	
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 ₂ e	48,218 tCO ₂ e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	12,688 tCO ₂ e (413 days)	

SECTION A. Description of project activity

A.1. General description of project activity

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Mokpo Landfill Gas Recovery Project for Electricity Generation is developed by Hanwha Corporation (hereinafter referred to as HWC) in the Republic of Korea. Mokpo Landfill which is located in Daeyang-dong Mokpo-city Jeollanam-do was constructed at the end of 1995 as a municipal solid waste (MSW) landfill. The total land area is 290,490 m² and waste disposal area is 180,000 m².

The purpose of the project and the measures taken to reduce greenhouse gas emission:

The purpose of this project is to collect and utilize CH₄ (as a renewable energy) for electricity generation at the landfill site.

Prior to this proposed project, Mokpo Landfill was emitting landfill gas (hereinafter referred to as the LFG) into the atmosphere directly without recovery and utilization of LFG. The Project captures the LFG that would have been released to the atmosphere without the project activity and generates electricity with the LFG. The generated electricity will be transmitted to the grid of Korea Electric Power Corporation (hereinafter referred to as the KEPCO grid) which is a company in charge of exclusively managing the grid of Republic of Korea.

The installed technology and equipment:

The proposed project involves the installation of a highly efficient collecting, transmitting and pre-treatment system and two electricity generators. The two generators installed with total capacity of 2.123 MW (1.065 MW and 1.058 MW).

Total emission reduction achieved in this monitoring period:

In terms of CO₂ emission reductions, the reductions were 48,218tons CO₂ over the 14 months (413 days, 01/01/2019~17/02/2020) of crediting period.

The relevant dates for the project activity:

The relevant dates of the project activity are given below:

<Table A-1> Project Schedule

Date	Project Schedule
March 2008	HWC decides to invest in proposed project (2.123 MW)
April 2008	Starting date of the project activity (the date of the start of construction work: gas collecting system)
September 2008	Date of completion for the installation of the 1.065 MW generator
	Starting date of commercial operation (electricity sales to KEPCO)
June 2009	Date of additional 1.058 MW generator installation
	Starting date of commercial operation (electricity sales to KEPCO)
18, February 2010	Registered as a CDM project

A.2. Location of project activity

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Host Party(ies)	Republic of Korea
Region/State/Province, etc.;	Jeollanam-do
City/Town/Community, etc.;	Mokpo city

The site of the “Mokpo Landfill Gas Recovery Project for Electricity Generation” is located in Daeyang-dong, Mokpo City, Jeollanam-do, Republic of Korea. The facilities and equipment were installed inside the Mokpo landfill. The coordinates are latitude of 34.8328 and longitude of 126.4096. The coordinates are based on the power plant.

**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)	Hanwha Corporation	No
Switzerland	Hanwha Corporation	No

A.4. References to applied methodologies and standardized baselines

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The approved small-scale CDM baseline methodologies;

- AMS I. D: Grid connected renewable electricity generation_V13
- AMS III. G: Landfill methane recovery_V06

The referred tools on the approved methodology;

- Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site_V04 (It was changed to “Emissions from solid waste disposal sites_V8.0)
- Tool to calculate the emission factor for an electricity system_V07.0

No standardized baselines are used according to the applied methodology.

A.5. Crediting period type and duration

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Start date: 18/02/2010

Length of crediting period: 10years

Crediting period: 18/02/2010 ~ 17/02/2020

SECTION B. Implementation of project activity**B.1. Description of implemented project activity**

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The Implementation status of the project activity

HWC decided to invest in the proposed 2.123MW LFG generation project in March, 2008. Gas collecting system construction started in April, 2008.

Installation of 1.065MW generator was completed and started commercial operation in September, 2008. A generator with capacity of 1.058MW was added in Mokpo landfill site in June, 2009. Therefore, the total installed generator capacity is 2.123MW. The CDM project monitoring activity has been started since 18/02/2010. It is registered date for CDM project.

The LFG collecting equipment installed on site is described in the registered PDD. The main component is the gas collecting system.

The actual implementation of the flaring system was initiated in September, 2008 and has continued through this monitoring period.

Gas analyzer's specification was corrected as below.

- Linearity is +/- 1% of F.S
- Zero drift is +/- 2% of F.S



<Figure B-1> The gas flow meter



<Figure B-2> The gas analyzer



<Figure B-3> The monitoring system



<Figure B-2> The watt-hour meter

There was no significant event affecting on the amount of reduction during the monitoring period. In addition, any regulation or policy has not changed that could affect the normal operation of the project or the applicability of the methodology.

There were several monitoring equipment maintenances but no significant malfunction was carried out in accordance with the registered PDD. And the monitoring is compliant with the monitoring plan as described in “Operating Manual-Mokpo LFG Power Plant”.

Based on “Operating Manual-Mokpo LFG Power Plant”, if there is system error or any difficulties due to natural disasters, a daily work log or the lowest CH₄ concentration data of the day has been temporarily applied during the error period.

The details of operation events during this monitoring period are as follows:

Date	Duration		Operation events	Note
17/01/2019	9:0-13:41	280 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	13:41-14:25	44 min	Error of equipment - Error of magnetic switch contact	
	5.40 hours			
31/01/2019	10:37-14:59	262 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	15:13-15:22	9 min	Error of equipment - Error of gas mix	
	4.52 hours			
01/02/2019	7:58-8:30	31 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	8:30-11:19	169 min		
	3.33 hours			
21/02/2019	7:55-13:37	341 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	13:51-14:5	14 min	Error of equipment - Error of gas mix	

	14:13-15:0	47 min	Error of equipment - Error of spark plug	
	6.70 hours			
22/02/2019	7:59-10:58	179 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	10:58-12:33	95 min		
	4.57 hours			
17/03/2019	8:48-11:4	135 min	Generator shift from 1st generator to 2nd generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	11:15-11:25	10 min	Error of equipment - Error of spark plug	
	11:37-13:3	86 min		
	13:14-13:47	32 min		
	13:56-14:13	17 min		
	14:26-17:57	211 min		
	8.18 hours			
22/03/2019	7:54-12:23	269 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	4.48 hours			
01/04/2019	7:47-12:33	285 min	Maintenance of facilities - Replace oil cooler o-ring	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	4.75 hours			
06/04/2019	12:9-15:10	180 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	3.00 hours			
16/04/2019	7:5-15:23	497 min	Maintenance of facilities	CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration date of the day is applied.
	8.28 hours			
25/04/2019	10:16-12:52	155 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	2.58 hours			
30/05/2019	10:39-16:24	345 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction..
	16:24-23:59	455 min	Maintenance of facilities - Repair oil line	
	13.33 hours			
03/06/2019	8:58-9:22	23 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.38 hours			
18/06/2019	14:19-14:41	22 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.37 hours			
20/06/2019	8:7-8:36	28 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	9:30-11:39	128 min	Error of equipment - 1st generator's trip occurred	
	0.47 hours			
21/06/2019	7:59-8:20	21 min	Error of equipment - 1st generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.35 hours			
22/06/2019	8:43-12:30	226 min	Maintenance of facilities - Replace turbocharger gasket	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	3.77 hours			
08/07/2019	10:40-12:37	116 min	Maintenance of facilities	Flow rate and CH ₄ concentration data is not

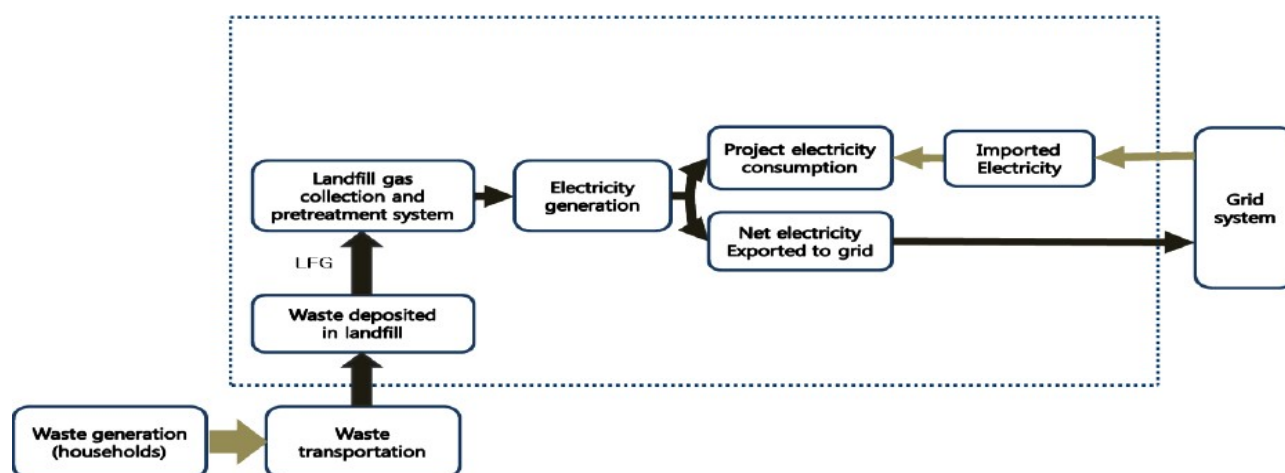
	1.93 hours		- Replace engine oil	available due to measurement error. → Excluded for estimation of emission reduction.
17/07/2019	9:57-10:59	62 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.03 hours			
17/07/2019	9:57-10:20	23 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	10:59-23:59	780 min	Monitoring system error	Flow rate and CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the flow rate and CH ₄ concentration
	13.38 hours			
18/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate and CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the flow rate and CH ₄ concentration
	23.98 hours			
19/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate and CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the flow rate and CH ₄ concentration
	23.98 hours			
20/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate
	23.98 hours			
21/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate
	23.98 hours			
22/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate
	23.98 hours			
23/07/2019	0:0-23:59	1439 min	Monitoring system error	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate
	23.98 hours			
24/07/2019	0:0-13:12	792 min	Monitoring system error	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate
	13.20 hours			
03/08/2019	11:57-12:31	34 min	Maintenance of facilities - Replace actuator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	16:38-16:44	5 min	Error of equipment - 2nd generator's trip occurred	
	0.65 hours			
04/08/2019	1:59-8:47	408 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	6.80 hours			

13/08/2019	7:26-10:18	172 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	22:1-23:26	84 min	Error of equipment - 2nd generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	4.27 hours			
14/08/2019	15:17-15:52	35 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	0.58 hours			
22/08/2019	8:40-8:47	6 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	0.10 hours			
01/09/2019	9:44-15:40	355 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	5.92 hours			
07/09/2019	5:44-10:13	269 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	4.48 hours			
18/09/2019	8:46-10:52	125 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	2.08 hours			
02/10/2019	17:47-23:59	372 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	6.20 hours			
03/10/2019	0:0-8:48	528 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	8.80 hours			
21/10/2019	9:8-9:21	13 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	9:52-10:10	18 min	Error of equipment - 2nd generator's trip occurred	
	0.52 hours			
22/10/2019	11:24-11:29	4 min	Generator shift from 2nd generator to 1st generator	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	11:46-11:49	2 min		
	0.10 hours			
25/11/2019	8:52-10:44	112 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	10:58-14:7	189 min	Generator shift from 1st generator to 2nd generator	
	14:38-17:43	185 min	Generator shift from 2nd generator to 1st generator	
	8.10 hours			
06/12/2019	15:22-16:25	62 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	16:33-16:57	23 min		
	1.42 hours			
19/12/2019	1:16-20:52	1175 min	Error of equipment - 1st generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	19.58 hours			
26/12/2019	18:45-19:33	48 min	Error of equipment - 1st generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	20:21-23:59	218 min		
	4.43 hours			
27/12/2019	0:0-17:8	1028 min	Maintenance of facilities	Flow rate and CH ₄ concentration data is not

	17.13 hours		- Replace inter cooler	available due to measurement error. → Excluded for estimation of emission reduction
28/12/2019	5:15-6:44	89 min	Error of equipment - 1st generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	6:53-11:50	297 min		
	6.43 hours			
15/01/2020	9:4-9:20	15 min	Error of equipment - 1st generator's trip occurred	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	0.25 hours			
30/01/2020	8:27-13:42	315 min	Maintenance of facilities - Replace engine oil	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	5.25 hours			
04/02/2020	9:37-9:52	15 min	Black-out	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction
	11:0-23:59	779 min		CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the CH ₄ concentration
	13.23 hours			
05/02/2020	0:0-23:59	1439 min	Black-out	CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the CH ₄ concentration
	23.98 hours			
06/02/2020	0:0-23:59	1439 min	Black-out	CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the CH ₄ concentration
	23.98 hours			
07/02/2020	0:0-16:0	960 min	Black-out	CH ₄ concentration data is not available due to maintenance of the monitoring system → Keep an hourly work log on the CH ₄ concentration
	16.00 hours			

The description of the technology

The main process of the project is comprised of a LFG collecting system, a LFG pre-treatment system and an electricity generation system. The best available technology for each process and recycling LFG is effectively adopted into the proposed project.



<Figure B-5> The main process of the proposed project

LFG Collecting System

Mokpo Landfill, located in Daeyang-dong, Mokpo City, Jeollanam-do and constructed at the end of 1995 as a municipal solid waste (MSW) landfill. The total land area is 290,490 m², the amount of available landfill capacity is 2,897,000 m³. The LFG collecting system is a gas transportation network which is consisted of gas collecting wells, lateral gas collecting sub-pipes and a main pipe to cover all the landfill. The LFG which is collected from the gas collecting system is delivered into the CSV (Condensate Separation Vessel). High-density polyethylene (HDPE) collecting system is installed to convey the LFG from the wells to the blower.

The total number of wellhead was 9. Each wellhead consisted of the 12 vertical well. 108 vertical well were being operated in the initial installation in January 2009.

The total number of wellhead has been 11 since April 2009. Thus, 132 vertical well can be operated.

121 vertical well were being operated in the CDM-PDD. During monitoring period, 156 vertical well were being operated. Existing wellhead were relocated and new wellhead was trapped to activate methane gas capture in February 2011.

For the efficient management of landfill, repair work has been conducted in October, 2012. In this time, the least efficient LFG collecting system has been removed to maintain optimum operating condition for methane capture.

The number of vertical well that can be operated will be varied depending on LFG status and other factors. J-trap and wellhead have same situation. To increase efficiency of LFG collection and control, on-going maintenance has been in progress.

The same repair work has been conducted in May 2014. As a result, 150 vertical well were being operated.

As landfill progresses, the management of LFG collecting system has been going on. The total amount of available landfill capacity was 2,897,000 m³. In addition, about 90% of the landfill is in progress. in December 2018.

Detail history of wellhead is shown below <Table B-2>. Each of drawings has been submitted to the DOE.

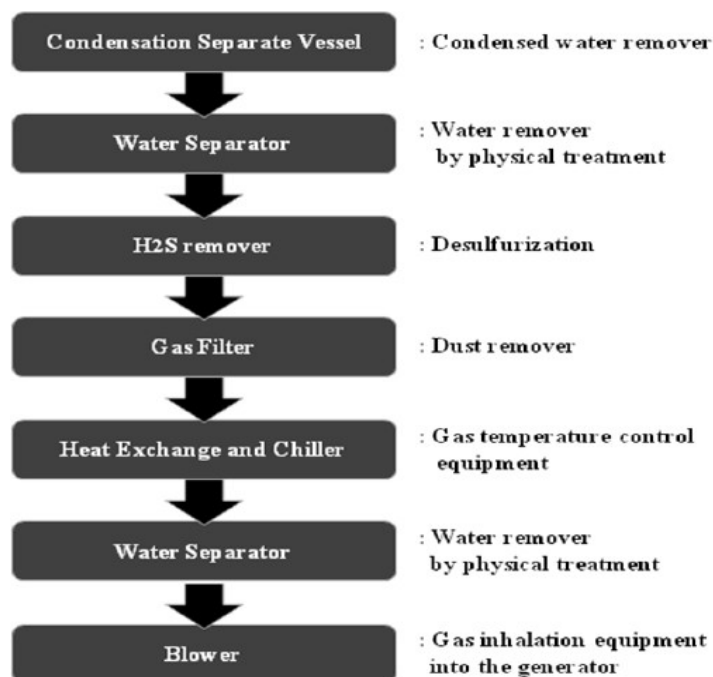
<Table B-2> History of the LFG collecting system

Date	Well			J-Trap
	Wellhead	Well	Usewell	
January 2009	9	108	97	97
April 2009	11	132	121	117
September 2009	11	132	126	117
February 2011	13	156	156	125
October 2012	13	149	149	120
May 2014	13	150	150	120
November 2016	13	150	150	120
October 2017	13	150	150	120

LFG Pre-treatment System

Prior to electricity generation, the LFG must be pre-treated to remove its impurities and moisture to prevent corrosion which could cause generator shutdown. Two water separators are installed to

remove H₂S and to protect the generators for this project. The pre-treatment consists of 1) CSV (Condensate Separation Vessel), 2) water separator, 3) H₂S remover, 4) gas filter, 5) heat exchange and chiller, 6) water separator and 7) blower.



<Figure B-6> Pre-treatment system

Electricity Generation System

Two generators with capacity of 2.123 MW (1.065 MW and 1.058 MW) were installed inside the Mokpo landfill. One generator was installed in the landfill site with capacity of 1.065 MW in September, 2008 and one additional generator with capacity of 1.058 MW was added in June, 2009. The collected LFGs are sent to the generators and the electricity thereby generated is exported to the grid-connected system of the KEPCO supply system.

<Table B-3> The technical data of engine and power generator based on full load

Engine	Capacity of 1.065 MW	Manufacturer	GE Jenbacher
		Engine type	JGS 320 GS-L.L
		Gas volume	522 N m ³ /h
	Capacity of 1.058 MW	Manufacturer	GE Jenbacher
		Engine type	J 320 GS B81
		Gas volume	450 N m ³ /h
Generator	Capacity of 1.065 MW	Manufacturer	STAMFORD
		Type	PE 734 B2
		Electrical output	1065 kW el.
		Frequency	60 Hz
		Voltage	380 V
		Speed	1800 rpm
		Efficiency	97.3%
	Capacity of 1.058 MW	Manufacturer	STAMFORD
		Type	HCI 734 E2
		Electrical output	1058 kW el.
		Frequency	60 Hz
		Voltage	380 V
		Speed	1800 rpm
		Efficiency	96.6%

B.2. Post-registration changes**B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents**

>> N/A

B.2.2. Corrections

>>Approval date and ref. No : 07 Sep 17(ref. No. PRC-2834-002)

The typographical errors of engine type were found during verification period for 7th monitoring.

(a) Modification to maintain consistency of engine type information representation

- 1st generator engine type : JGS 320 GS-L.L

- 2nd generator engine type : J 320 GS B81

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

>> N/A

B.2.4. Inclusion of monitoring plan

>> 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 methodological regulatory documents

>> Approval date and ref. No : 06 Mar 14(ref. No. PRC-2834-001)

The by watt-hour meter (W_a) was measured 'exported electricity' from both 1st generator and 2nd generator. As per national regulation, "Act on the promotion of the development, use and diffusion of new and renewable energy", the electricity generation from 1st generator and 2nd generator should be measured separately because the commercial operation starting date was different. Accordingly, the PP was requested to measure the electricity generation separately and the PP installed new meter (W_c) to measure electricity from 2nd generator in attendance with KPX, the grid company.

W_a measures generated electricity from 1st and 2nd generators; W_c measures generated electricity from 2nd generator.

For more information, refer to PRC-2834-001.

B.2.6. Changes to project design

>>>> Approval date and ref. No : 07 Sep 17(ref. No. PRC-2834-002)

(a) Changes in the number of facilities of collecting system(vertical well, well head and j-trap) due to maintenance

As landfill progresses, the management of LFG collecting system has been going on. The quantity of facility of collecting system changed by maintenance for 7th monitoring period.

The details of changes are as follow :

Facility	Function	Quantity (PDD ver.5)	Quantity (PDD ver.6)
Vertical well	LFG capture (75mm HDPE)	121	150
Wellhead	Collecting LFG from vertical gas wells	11	13
Barrel trap	Trapping the condensate from the main pipeline	15	15
J-Trap	Trapping the condensate from the vertical wells	117	120
Main Pipeline	LFG supply to the gas engine (250mm)	1	1

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

>> N/A

SECTION C. Description of monitoring system

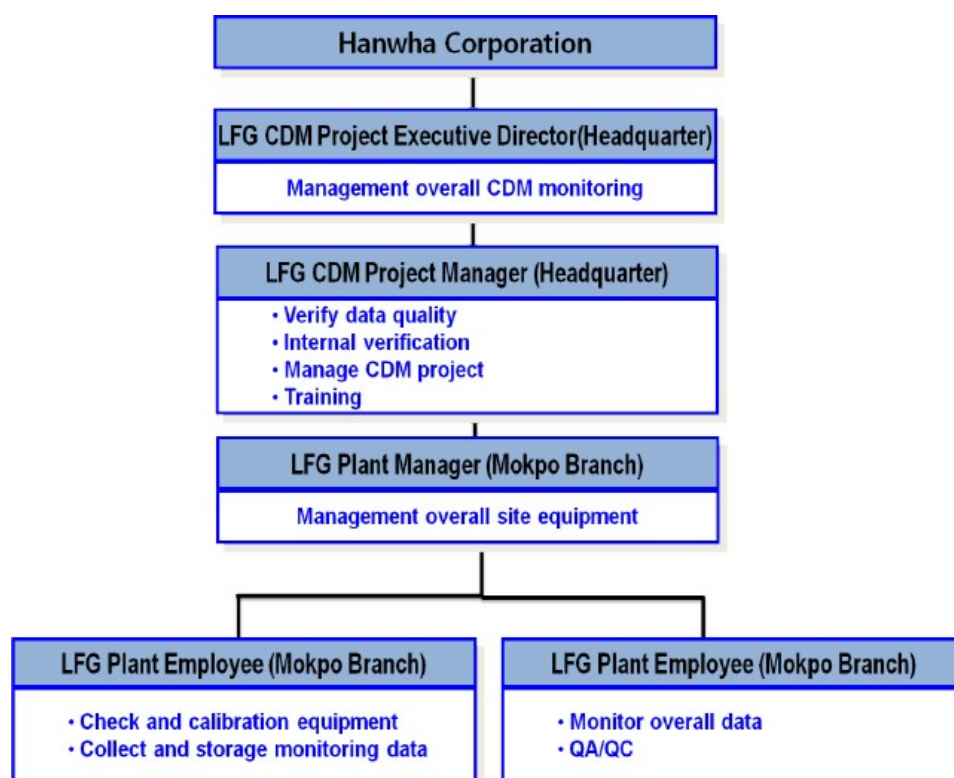
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Monitoring data and parameters will be monitored and their measurement method will be referred to "Operating Manual-Mokpo LFG Power Plant". The relevant document has been submitted to the DOE.

Data and parameters are provided in Section D.

Monitoring organization and the role of each party

The following figure describes the operation and management structure for monitoring of the project activity. Below table shows the responsible party for each task of monitoring.



<Figure C-1> The structure of monitoring system

<Table C-1> The responsible party for each task of monitoring

Item	Sub-item	Responsible person
Measure & Achieve	LFG _{electricity,y}	Responsible person/department for the project : • LFG plant manager / Mokpo operating Team of HWC Mokpo branch
	WCH _{4,y}	
	EL _{EXP,PJT,y}	
	EL _{IMP,PJT,y}	
Measuring instrument check & Calibration	Centralized monitoring system	Responsible person/department for the project : • LFG plant employee / Mokpo operating team of HWC Mokpo branch
	Flow meter	
	Gas analyzer	Responsible person/department for the project : • LFG plant employee / Mokpo operating team of HWC Mokpo branch
	Watt-hour meter Responsible person/department for the project:	Responsible person/department for the project : • Calibration institutions (According to “Act for measurement” and “Regulation for operation of electricity market”)
Establish monitoring plan		Responsible person/department for the project : • LFG CDM project executive director / Green & Renewable energy business team of HWC Headquarter
Task coordination		• LFG plant manager / Mokpo operating team of HWC Mokpo branch • LFG CDM project manager / Green & Renewable energy business team of HWC Headquarter
Monitoring report		Responsible person/department for the project : • LFG plant manager / Mokpo operating team of HWC Mokpo branch • LFG CDM project manager / Environment / Green & Renewable energy business team of HWC Headquarter

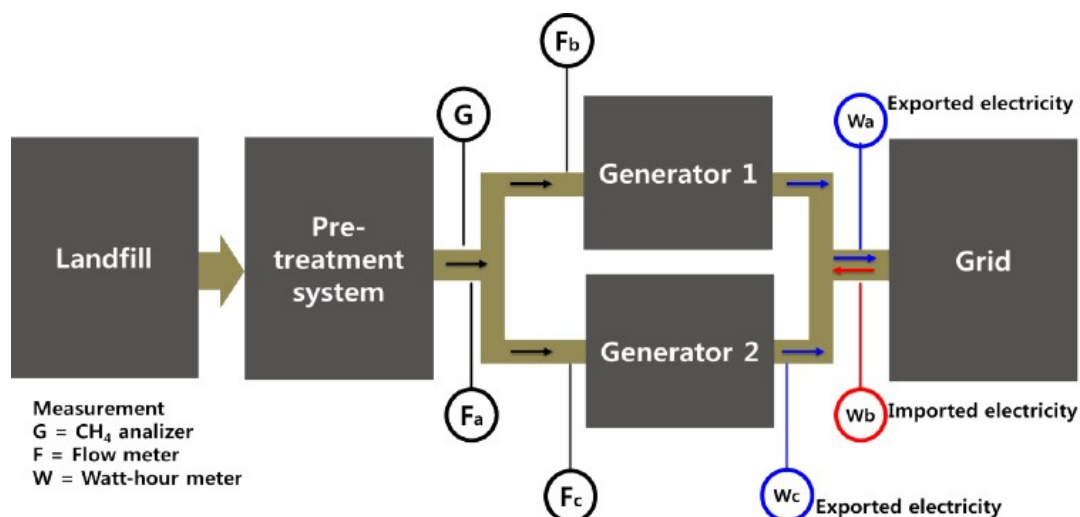
The monitoring equipment to measure the amount of methane and electricity

- Gas flow meters are installed between the blower and generating facility to measure LFG flow rate. LFG volumes are expressed in normalized cubic meters.
- A methane analyzer is located in front of the flow meter to measure the concentration of methane in LFG, which flows into the gas engine.
- The Watt-hour meters are to be set-up transparently in accordance with “Law regarding measurement” and “Act on operation of electricity market”. Thereafter, the electricity measuring meter will be calibrated when it is installed behind the generator and sealed up after affirmation of Korea Power Exchange (hereinafter referred to as KPX). The certified sheet of measurement registration has been submitted to the DOE.
- A watt-hour meter for 2nd generator was installed on January 27th, 2013. HWC added the watt-hour meter for 2nd generator, which requested it under the “Act on the promotion of the development, use and diffusion of new and renewable energy”. In previous installation, total amount of exported electricity out of project had been monitored by W_a watt-hour meter, W_a as shown in <Figure C-2> below.

W_a watt-hour meter had been installed as measure of the amount of exported electricity in Mokpo LFG plant.

After installation watt-hour meter for 2nd generator (W_c) in this monitoring period, the amount of exported electricity is expressed as follows:

- Case 1 (only 1st generator operating): The amount of exported electricity = W_a
- Case 2 (only 2nd generator operating): The amount of exported electricity = W_c
- Case 3 (Both 1st generator and 2nd generator operating): The amount of exported electricity = W_a



<Figure C-2> The layout of monitoring equipment

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

LFG plant manager is the responsible person for quality management, which ensures the quality and accuracy of the measured data. For quality management, the following items are included: data records and storage, equipment calibration and maintenance, corrective action and emergency procedures for unintended emissions.

- Three gas flow meters were installed to ensure that if one of the meters has a problem to measure LFG flow rate, the two remaining meters are measured to calculate the amount of LFG. The manufacturer provides the official document for the unique error between two flow meters and it says the maximum error range is 1,728 Nm³/day from theoretical calculation with each flow meter's accuracy. To be conservative, if the measured value between two flow meters is out of the range, the smaller value was applied. In this monitoring period, there was no event to be conservatively calibrated.

When the flow rate data was transferred to the server, data lag was occurred occasionally. In this case there is no record spot for the data but it is possible to measure total flow rate during the time because measuring figure is accumulated data. When data lag is occurred, data correction applied as a conservative manner.

- Gas analyzer records the density of methane gas in the LFG. Regular maintenance and testing for gas analyzer was done once a month in two ways, zero calibration and span calibration. Zero calibration is to set zero for analyzer and N₂ gas is used. Span calibration is for span point adjustment. For this calibration, the standard gas (CH₄, CO₂, and O₂) was used with a concentration of each specification in accordance with manufacturer's specification.
- When data lag is occurred, the lower CH₄ concentration value was selected between before and after of this lagging time and the CH₄ quantity was calculated with this CH₄ concentration as a conservative manner.
- Two watt-hour meters were installed to measure the amount of exported electricity. The amount of exported electricity was recorded electronically by watt-hour meters which are connected to KPX and collected data shall be compared with those of sales receipt of KPX (<http://epsis.kpx.or.kr>).

- Before installation of the watt-hour meter for 2nd generator (W_c), total amount of exported electricity out of project had been monitored by W_a . After installation of W_c , W_c is used to measure only if 2nd generator was operated. When 1st generator or both 1st and 2nd generator operates, W_a is used to measure the amount of exported electricity.
- A watt-hour meter was installed to measure the amount of imported electricity. Imported electricity for Mokpo LFG power plant was monitored by watt-hour meter (W_b) which managed and monthly invoiced by KEPCO.

<Table C-3> Related watt-hour meters

Tag	Serial No	Accuracy level	Description	Remarks
W_a	95246742	0.5s	Exported electricity (1 st generator)	
W_c	50339836	0.5s	Exported electricity (2 nd generator)	A watt-hour meter for 2 nd generator (W_c) was installed on January 27 th , 2013. W_c added requested it under the "Act on the promotion of the development, use and diffusion of new and renewable energy".
W_b	0190662	1s	Imported electricity	According to the "Measures Act", Watthour meter for imported electricity is replaced on April 14, 2015.
	24142000332	0.5s	Imported electricity	

Data records and storage:

The measured data is monitored by a computer and Mokpo operation team should check it continuously.

Equipment calibration and maintenance:

- LFG plant Manager should check monitoring plan and/or schedules, and also calibrate generators periodically in line with procedure calibration manual from related manufacturer. If necessary, LFG plant manager could calibrate the CDM project related equipment.
- The Watt-hour meters are subject to a regular maintenance and testing regime to ensure accuracy. This is in compliance with the "Act for measurement" and "Regulation for operation in the electricity market" of the Republic of Korea. Under this regulation, the calibration period is every two years. The calibration of watt-hour meter for imported electricity will be certified by authorized organization.

Corrective action

LFG plant manager will report all issues and data related to plant operation to LFG CDM project manager (Green & Renewable energy business team).

Operation review, internal audit and corrective action are carried out by Green & Renewable energy business team according to the "Mokpo LFG Power Plant Operation Manual".

Emergency procedure:

In case of emergency situation, proper action is carried out to minimize damage in accordance with "Mokpo LFG Power Plant Operation Manual".

Training

All employees involved in this project should be trained for the knowledge of operating equipment and monitoring by skilled technician from the generator manufacturer. The employees should attain a comprehensive knowledge with regard to the general and technical aspects of the CDM project.

Employees involved in the monitoring were trained internally on the overall CDM project activity.

External training for emissions trading scheme was done by experts (from consulting company) on November 26, 2019.

Internal training for the monitoring was done by LFG CDM project manager of headquarter on November 26, 2019.

SECTION D. Data and parameters**D.1. Data and parameters fixed ex ante**

Data/Parameter	Operation Margin Emission Factor (EF _{OM})
Unit	tCO ₂ e/MWh
Description	The generation-weighted average of CO ₂ emission per electricity unit generated by the existing grid-connected power plants
Source of data	"Statistics of Electric Power in Korea"
Value(s) applied	0.6817
Choice of data or measurement methods and procedures	The simple OM method is used to calculate EF _{OM} in accordance with the guidance of AMS-I.D. which allows the above method where low-cost/must-run resources constitute less than 50% of total grid generation. The generating sources do not include low-cost and must-run plant in conformity with the direction of AMS-I.D. EF _{OM} is calculated using the data for the most recent 3 years (2005-2007) for which data are available at time of the PDD submission, and fixed for the crediting period.
Purpose of data/parameter	Calculation of Baseline/Project emission
Additional comments	This data is available at time of the PDD submission, and fixed for the crediting period

Data/Parameter	Build Margin Emission Factor (EF _{BM})
Unit	tCO ₂ e/MWh
Description	The generation-weighted average of CO ₂ emission per electricity unit generated additionally constructed power plants.
Source of data	"Statistics of Electric Power in Korea"
Value(s) applied	0.3933
Choice of data or measurement methods and procedures	EF _{BM} is calculated ex-ante based on the most recent information available on plants already built for sample group at this PDD submission. According to AMS-I.D., the sample group consists of either the five power plants that have been built most recently or the power plant capacity additions in the electricity system that comprise 20% of the system generation and that have been built most recently. In this project, the latter is selected because project participant has to select the sample group that comprise the larger annual generation in guidance with the direction of AMS-I.D. the value EF _{BM} is fixed for the crediting period.
Purpose of data/parameter	Calculation of Baseline/Project emission
Additional comments	This data is available at time of the PDD submission, and fixed for the crediting period

Data/Parameter	CO ₂ Emission Intensity of the Electricity displaced (CEF _{electricity})
Unit	tCO ₂ e/MWh
Description	The weighted average of EF _{OM} and EF _{BM}
Source of data	"Statistics of Electric Power in Korea"
Value(s) applied	0.5375
Choice of data or measurement methods and procedures	CO ₂ Emission Intensity has to be calculated by combining EF _{OM} and EF _{BM} with an appropriate weight, because the quantities of electricity displaced are come from both existing power plant and new plant. The weight is suggested by default in AMS-I.D. 0.5 for both EF _{OM} and EF _{BM} . In this project, the default weight is used.

Purpose of data/parameter	Calculation of Baseline/Project emission
Additional comments	This data is available at time of the PDD submission, and fixed for the crediting period

D.2. Data and parameters monitored

Data/Parameter	F
Unit	Not applied.
Description	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Measured/calculated/default	Not applied.
Source of data	Written information from the operator of the solid waste disposal site and/or site visits at the solid waste disposal site
Value(s) of monitored parameter	0
Monitoring equipment	Not applied.
Measuring/reading/recording frequency	Monitored annually.
Calculation method (if applicable)	Not applied.
QA/QC procedures	Not applied.
Purpose of data/parameter	Calculation of Baseline emission
Additional comments	Not applied.

Data/Parameter	GWP_{CH₄}
Unit	tCO ₂ e/tCH ₄
Description	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
Measured/calculated/default	Not applied.
Source of data	Decisions under UNFCCC and the Kyoto Protocol
Value(s) of monitored parameter	21(to be applied for the first commitment period of the Kyoto Protocol) 25(to be applied for the secondary commitment period of the Kyoto Protocol)
Monitoring equipment	Not applied.
Measuring/reading/recording frequency	Monitored annually.
Calculation method (if applicable)	Not applied.
QA/QC procedures	Not applied.
Purpose of data/parameter	Calculation of Baseline emission
Additional comments	Not applied.

Data/Parameter	LFG_{electricity,y}
Unit	N m ³ / y
Description	Amount of LFG combusted in power plant
Measured/calculated/default	Measured
Source of data	Gas flow meters

Value(s) of monitored parameter	Data	Measured LFG _{electricity,y} (N m ³)			Applied value	
		F _b	F _c	F _a	F _b + F _c	F _a
	01/01/2019 ~ 18/01/2019	126,271.200	10,117.400	138,735.300	136,388.600	0
	19/01/2019 ~ 18/02/2019	246,485.000	4,935.500	265,245.500	251,420.500	0
	19/02/2019 ~ 18/03/2019	211,628.100	16,585.500	231,532.000	228,213.600	0
	19/03/2019 ~ 18/04/2019	238,536.300	28,819.800	265,381.500	267,356.100	0
	19/04/2019 ~ 18/05/2019	370,574.800	0.000	370,300.900	370,574.800	0
	19/05/2019 ~ 18/06/2019	321,860.400	45,308.000	363,622.700	367,168.400	0
	19/06/2019 ~ 18/07/2019	355,086.000	14,329.000	369,297.400	369,415.000	0
	19/07/2019 ~ 18/08/2019	352,759.300	31,771.800	384,383.900	384,531.100	0
	19/08/2019 ~ 18/09/2019	387,979.300	0.000	382,905.800	387,979.300	0
	19/09/2019 ~ 18/10/2019	372,225.100	0.000	372,742.100	372,225.100	0
	19/10/2019 ~ 18/11/2019	393,773.800	10,909.600	396,359.600	404,683.400	0
	19/11/2019 ~ 18/12/2019	389,586.300	167.900	390,742.700	389,754.200	0
	19/12/2019 ~ 18/01/2020	370,312.700	0.000	370,652.300	370,312.700	0
	19/01/2020 ~ 17/02/2020	395,316.200	0.000	389,648.900	395,316.200	
	01/01/2019 ~ 17/02/2020	4,532,394.500	162,944.500	4,691,550.600	4,695,339.000	
	<p>Measured LFG data by the flow meter is accumulated data showing integrating meter. Measured real time data have calculated from automatically recorded data by continuous integrating flow meters. 'Measured LFG_{electricity, y}' in above table is calculated by difference between current measuring data and previous measuring data in every recording time.</p> <p>The manufacturer provides the official document for the unique error between two flow meters and it says the maximum error range is 1,728 N m³/day from theoretical calculation with each flow meter's accuracy. In this monitoring period, there wasn't the error between them.</p> <p>All measured data for the crediting period has been submitted to the DOE as a spreadsheet named "Mokpo_10th MR_2834_Emission Reduction".</p>					

Monitoring equipment	Tag	F_a (main)	F_b (1st generator)	F_c (2nd generator)
	Serial No	GR-1906043	GR-19060434	GR-170320
	Accuracy level	0.5% of F.S	0.5% of F.S	0.5%
	Type	Thermal Mass Flow Meter		
	Calibration Frequency	1 years		3 years
	Date of installation	08/07/2019	08/07/2019	20/03/2017
	Date of last calibration	03/07/2019	03/07/2019	20/03/2017
	Validity	02/07/2020	02/07/2020	19/03/2020
	Calibration Entity	Golden Rules Co., Ltd.	Golden Rules Co., Ltd.	Golden Rules Co., Ltd.
	<ul style="list-style-type: none"> Measured automatically and continuously by integrating flow meters. The measured data is monitored by a computer and Mokpo operation team should check it continuously. To ensure accuracy, the flow meters are subject to regular maintenance and testing. The flow meter (GR-170320) is calibrated every three years. The achieved data is kept during the crediting period as well as two years after that. Daily data is documented in paper and achieved in electronic file. To measure accurately, reinstalled the flow meters (GR-160994-5) to new flow meters (GR-1906043-4) in 08/07/2019 . <p>The temperature and pressure in LFG are not monitored separately.</p> <p>This project involves the installation of two electricity generator. One of the generators is operating normally, and the other one is used as a standby unit.</p> <p>During the normal operation period, either one or the other generator has been operated.</p>			
Measuring/reading/recording frequency	Measured automatically.			
Calculation method (if applicable)	Not applied.			
QA/QC procedures	To ensure accuracy, the flow meters are subject to regular maintenance and testing. The flow meter is calibrated every three years.			
Purpose of data/parameter	Calculation of Baseline emission			
Additional comments	Not applied.			

Data/Parameter	W_{CH₄},y																
Unit	%																
Description	Methane fraction in LFG																
Measured/calculated/default	Measured																
Source of data	Methane analyzer																
Value(s) of monitored parameter	<p>- Weighted average CH₄ concentration during the monitoring period. The Measured methane fraction data is monitored automatically and continuously by gas analyzer.</p> <table border="1"> <thead> <tr> <th>Date</th><th>Measured CH₄ (%) (Weighted average CH₄ concentration)</th></tr> </thead> <tbody> <tr> <td>01/01/2019 ~ 17/02/2020</td><td>53.618</td></tr> </tbody> </table> <p>All measured data for the crediting period has been submitted to the DOE as a spreadsheet.</p>	Date	Measured CH ₄ (%) (Weighted average CH ₄ concentration)	01/01/2019 ~ 17/02/2020	53.618												
Date	Measured CH ₄ (%) (Weighted average CH ₄ concentration)																
01/01/2019 ~ 17/02/2020	53.618																
Monitoring equipment	<table border="1"> <thead> <tr> <th>Tag</th><th>G</th></tr> </thead> <tbody> <tr> <td>Serial No</td><td>A8M7282T</td></tr> <tr> <td>Accuracy level</td><td>Linearity 1%, Repeatability 0.5%</td></tr> <tr> <td>Type</td><td>Infrared gas analyzer</td></tr> <tr> <td>Calibration frequency</td><td>3 years</td></tr> <tr> <td>Date of last calibration</td><td>26/03/2018</td></tr> <tr> <td>Validity</td><td>25/03/2021</td></tr> <tr> <td>Calibration Entity</td><td>National Metrology Institute</td></tr> </tbody> </table> <ul style="list-style-type: none"> Methane fraction is measured with continuous gas analyzer. The measured data is monitored by a computer and Mokpo operation team should check it continuously. To ensure accuracy, the gas analyzer is subject to regular maintenance and testing regime in accordance with the manufacturer's specification. The methane analyzer is calibrated every three years. The achieved data is kept during the crediting period as well as two years after that. Daily data is documented in paper and achieved in electronic file. 	Tag	G	Serial No	A8M7282T	Accuracy level	Linearity 1%, Repeatability 0.5%	Type	Infrared gas analyzer	Calibration frequency	3 years	Date of last calibration	26/03/2018	Validity	25/03/2021	Calibration Entity	National Metrology Institute
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Validity	25/03/2021																
Calibration Entity	National Metrology Institute																
Measuring/reading/recording frequency	Measured automatically.																
Calculation method (if applicable)	Not applied.																
QA/QC procedures	To ensure accuracy, the gas analyzer is subject to regular maintenance and testing regime in accordance with the manufacturer's specification. The methane analyzer is calibrated every three years.																
Purpose of data/parameter	Calculation of Baseline emission																
Additional comments	Not applied.																

Data/Parameter	EL_{EXP,PJT,y}																																																																
Unit	MWh																																																																
Description	Total amount of exported electricity out of the project																																																																
Measured/calculated/default	Measured																																																																
Source of data	Watt-hour meter																																																																
Value(s) of monitored parameter	<table border="1"> <thead> <tr> <th>Date</th><th>W_a</th><th>W_c</th><th>Total EL_{EXP} (MWh)</th></tr> </thead> <tbody> <tr><td>01/01/2019 ~ 18/01/2019</td><td>141.687</td><td>12.717</td><td>154.404</td></tr> <tr><td>19/01/2019 ~ 18/02/2019</td><td>264.141</td><td>6.080</td><td>270.221</td></tr> <tr><td>19/02/2019 ~ 18/03/2019</td><td>222.156</td><td>17.454</td><td>239.610</td></tr> <tr><td>19/03/2019 ~ 18/04/2019</td><td>240.067</td><td>29.905</td><td>269.972</td></tr> <tr><td>19/04/2019 ~ 18/05/2019</td><td>466.966</td><td>0.000</td><td>466.966</td></tr> <tr><td>19/05/2019 ~ 18/06/2019</td><td>420.629</td><td>54.111</td><td>474.740</td></tr> <tr><td>19/06/2019 ~ 18/07/2019</td><td>459.183</td><td>18.498</td><td>477.681</td></tr> <tr><td>19/07/2019 ~ 18/08/2019</td><td>456.904</td><td>37.293</td><td>494.197</td></tr> <tr><td>19/08/2019 ~ 18/09/2019</td><td>501.212</td><td>0.000</td><td>501.212</td></tr> <tr><td>19/09/2019 ~ 18/10/2019</td><td>483.998</td><td>0.000</td><td>483.998</td></tr> <tr><td>19/10/2019 ~ 18/11/2019</td><td>492.060</td><td>14.452</td><td>506.512</td></tr> <tr><td>19/11/2019 ~ 18/12/2019</td><td>485.637</td><td>0.000</td><td>485.637</td></tr> <tr><td>19/12/2019 ~ 18/01/2020</td><td>475.952</td><td>0.000</td><td>475.952</td></tr> <tr><td>19/01/2020 ~ 17/02/2020</td><td>477.204</td><td>0.000</td><td>477.204</td></tr> <tr><td>01/01/2019 ~ 17/02/2020</td><td>5,587.796</td><td>190.510</td><td>5,778.306</td></tr> </tbody> </table> <p>The exported electricity data is automatically monitored by certified watt-hour meters which are connected to KPX and cross-checked by sales receipts from KPX. All measured data for the crediting period has been submitted to the DOE as a spread sheet.</p>	Date	W _a	W _c	Total EL _{EXP} (MWh)	01/01/2019 ~ 18/01/2019	141.687	12.717	154.404	19/01/2019 ~ 18/02/2019	264.141	6.080	270.221	19/02/2019 ~ 18/03/2019	222.156	17.454	239.610	19/03/2019 ~ 18/04/2019	240.067	29.905	269.972	19/04/2019 ~ 18/05/2019	466.966	0.000	466.966	19/05/2019 ~ 18/06/2019	420.629	54.111	474.740	19/06/2019 ~ 18/07/2019	459.183	18.498	477.681	19/07/2019 ~ 18/08/2019	456.904	37.293	494.197	19/08/2019 ~ 18/09/2019	501.212	0.000	501.212	19/09/2019 ~ 18/10/2019	483.998	0.000	483.998	19/10/2019 ~ 18/11/2019	492.060	14.452	506.512	19/11/2019 ~ 18/12/2019	485.637	0.000	485.637	19/12/2019 ~ 18/01/2020	475.952	0.000	475.952	19/01/2020 ~ 17/02/2020	477.204	0.000	477.204	01/01/2019 ~ 17/02/2020	5,587.796	190.510	5,778.306
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Calculation method (if applicable)	Not applied.
QA/QC procedures	<ul style="list-style-type: none"> To ensure accuracy, the watt-hour meters are subject to regular maintenance and testing regime complying with the "Regulation for operation of electricity market" in Republic of Korea. The calibration of watt-hour meters will be carried out before the installation initially and periodically performed at least once in 2 years.
Purpose of data/parameter	Calculation of Baseline emission
Additional comments	Not applied.

Data/Parameter	EL_{IMP,PJT,y}	
Unit	MWh	
Description	Total amount of imported electricity to meet project requirement	
Measured/calculated/default	Measured	
Source of data	Watt-hour meter	
Value(s) of monitored parameter	Date	Measured EL_{IMP} (MWh)
	01/01/2019 ~ 18/01/2019	0.672
	19/01/2019 ~ 18/02/2019	0.264
	19/02/2019 ~ 18/03/2019	0.480
	19/03/2019 ~ 18/04/2019	0.408
	19/04/2019 ~ 18/05/2019	0.048
	19/05/2019 ~ 18/06/2019	0.264
	19/06/2019 ~ 18/07/2019	0.216
	19/07/2019 ~ 18/08/2019	0.168
	19/08/2019 ~ 18/09/2019	0.120
	19/09/2019 ~ 18/10/2019	0.168
	19/10/2019 ~ 18/11/2019	0.048
	19/11/2019 ~ 18/12/2019	0.288
	19/12/2019 ~ 18/01/2020	1.320
	19/01/2020 ~ 17/02/2020	0.168
	01/01/2019 ~ 17/02/2020	4.632
	<p>The imported electricity data is automatically monitored by a certified meter. All measured data for the crediting period has been submitted to the DOE as a spread sheet.</p> <p>01/01/2019 ~ 17/02/2020, The amount of imported electricity can be checked by the paper bill (from KEPCO) monthly. In the case of Mokpo landfill site, the billing cycle is from 19th of last month to 18th of this month. For conservative estimation, we calculated the total amount of imported electricity including last whole month without divide into a daily basis.</p>	

Monitoring equipment	Tag	W_b
	Serial No	24142000332
	Accuracy level	0.5s
	Type	Watt-hour meter
	Calibration Frequency	Once in 2 years
	Date of installation	14/04/2015
	Date of last calibration	07/08/2018 ~ 09/08/2018
	Validity	06/08/2020
	Calibration Entity	Korea Testing Certification (KTC)
	<ul style="list-style-type: none"> The amount of imported electricity will be measured automatically by certified watt-hour meter. The project participant will check the amount of the imported electricity at the web site (http://cyber.kepco.co.kr) and get the paper bill from KEPCO monthly. The achieved data is kept during the crediting period as well as two years after that. The monthly data is achieved in paper bill from KEPCO. 	
Measuring/reading/recording frequency	Measured automatically.	
Calculation method (if applicable)	Not applied.	
QA/QC procedures	<ul style="list-style-type: none"> To ensure accuracy, the watt-hour meter is subject to regular maintenance and testing regime complying with the "Measures Act" in Republic of Korea. The calibration of watt-hour meter will be carried out before the installation initially and periodically performed at least once in 2 years. 	
Purpose of data/parameter	Calculation of Project emission	
Additional comments	Not applied.	

D.3. Implementation of sampling plan

>> N/A

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>

$$BE_y = (MD_y - MD_{reg,y}) + EL_{EXP,PJT,y} * CEF$$

Parameter	Unit	Description
MD _y	tCO ₂ e	CO ₂ equivalent of the methane captured and destroyed/gainfully used by the project activity in year 'y'.
MD _{reg,y}	tCO ₂ e	Methane emissions that would be captured and destroyed to comply with national or local safety requirements or legal regulations in the year 'y'.
EL _{EXP,PJT,y}	MWh	The quantity of electricity exported to the grid-connected system by this project activity during the year, 'y'.
CEF	tCO ₂ e/MWh	Combined emission factor in electricity generation by grid-connected system; weighted average of EF _{OM} and EF _{BM} .

CEF is 0.5375 tCO₂e/MWh and this is fixed factor during the crediting period.

$$MD_y = LFG_{electricity,y} * W_{CH_4,y} * D_{CH_4,y} * GWP_{CH_4}$$

Parameter	Unit	Description
LFG _{electricity,y}	N m ³	LFG flared or used as fuel in the year 'y'.
WCH _{4,y}	%	Methane content in LFG in the year 'y' (mass fraction).
DCH _{4,y}	kg/N m ³	Density of methane at normal conditions in the year 'y'. (Source: ACM0001 ver.11)
GWP _{CH₄}	tCO ₂ /tCH ₄	Global warming potential of methane

Density of methane in LFG is determined at the temperature and pressure of the LFG as described in AMS-III.G. However, LFG_{electricity,y} is automatically measured at normal condition by a flow meter, and the temperature and pressure are not monitored separately. Thus, density of methane at normal conditions in the year 'y' is measured in kg/ Nm³.

Methane content is measured by gas analyzer.

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

>>

$$PE_y = EL_{IMP,PJT,y} * CEF$$

Parameter	Unit	Description
EL _{IMP,PJT,y}	MWh	The quantity of imported electricity from grid-connected system to project activity during the year, 'y'.

CEF is 0.5375 tCO₂e/MWh and this is fixed factor during the crediting period

E.3. Calculation of leakage emissions

>>

Mokpo LFG has not been destructed by flaring and/or taken for any utilization before developing the proposed project. For this project, there is no leakage effect.

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

	Baseline GHG emissions or baseline net GHG removals (t CO ₂ e)	Project GHG emissions or actual net GHG removals (t CO ₂ e)	Leakage GHG emissions (t CO ₂ e)	GHG emission reductions or net anthropogenic GHG removals (t CO ₂ e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	48,220.595	2.490	0	0	48,218	48,218

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 ₂ e)	Amount estimated ex ante for this monitoring period in the PDD (t CO ₂ e)
48,218	12,688

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

>>

Year	ER _{y,estimated} , PDD	=	ER _{y,CH₄} , PDD	+	ER _{y,electricity} , PDD
2009	13,712	=	11,911	+	1,801
2010	24,220	=	21,038	+	3,182
2011	24,831	=	21,569	+	3,262
2012	25,350	=	22,020	+	3,331
2013	25,783	=	22,396	+	3,387
2014	26,137	=	22,703	+	3,434
2015	26,417	=	22,946	+	3,471
2016	26,630	=	23,131	+	3,499
2017	26,780	=	23,262	+	3,519
2018	26,874	=	23,343	+	3,531
2019	11,214	=	9,741	+	1,473

Detail Values estimated in ex-ante calculation of registered PDD over this 10th monitoring period are shown in the below table.

Year	ER _y	ER _{CH₄}				ER _{electricity}			
			BE _{y,CH₄}	PE _{y,CH₄}	Leakage		BE _{y,electricity}	PE _{y,electricity}	Leakage
2019 (365days)	11,214	9,741	9,741	0	0	1,473	1,473	1	0
2020 (48days)	1,475	0	0	0	0	0	0	0	0

E.6. Remarks on increase in achieved emission reductions

>>

Actual values reached during the monitoring period: 48,218 tCO₂e

Values applied in ex-ante calculation of the registered CDM-PDD: 12,688 tCO₂e

The emission reductions increased to 280.0% during the monitoring period compared to the expected emission reductions that are on the registered CDM-PDD.

The main causes of the increased emission reductions are as follows.

Updated value of GWP_{CH₄} to be applied for the secondary commitment period of the Kyoto protocol.

On the use of new global warming potential (GWP) factors agreed to be applied at the Durban Climate Change Conference (COP 17). Thus, updated value of GWP_{CH₄} applied after first commitment period.

- 21(to be applied for the first commitment period of the Kyoto Protocol)
- 25(to be applied for the secondary commitment period of the Kyoto Protocol)

Since the increase in the GWP, emission reduction had about 17.6% increase in this monitoring period.

CH₄ concentration

The PDD estimate was based on 50% CH₄ concentration but the actual concentration exceeds 53.618% in this monitoring period.

The increased CH₄ concentration had the greatest effect on increasing the emission reduction followed by the GWP update.

Since the increase in CH₄ concentration, emission reduction had increase in this monitoring period. The change of waste composition and maintenance for landfill is the biggest contributor for increase in CH₄ concentration.

Seasonal effect

Rain interrupts LFG emitting to atmosphere through cover soil layer. There were lots of torrential rain and abnormally high temperatures with humidity in the monitoring period especially in summer.

As the pressure of the cover soil layer was decreased, the extraction rate of LFG was increased.

Quantity of LFG generated from the landfill site.

The LFG flow was estimated to be 2.70 m³/min (on the registered CDM-PDD in 2018) but the actual average flow was 8.78 m³/min during the monitoring period. In other words, there was 192.22% of the difference between the theoretical and the actual values. When the 50% CH₄ concentration and 21 GWP were applied, the LFG_y per minute is 7.37 m³/min and the difference with theoretical and the actual values are 363.13%.

Content	Year	LFG _y (m ³ /min)	=	BE _{CH₄,SWDS,y}	/	GWP	/	D _{CH₄}	/	W _{CH₄,y}	/	MIN _{year}
PDD	2019	2.7	=	9,741	/	21	/	0.0007168	/	0.5	/	480,000
MR	2019	7.89	=	45,114	/	25	/	0.0007168	/	0.53	/	543,120

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

>> N/A

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

Project participant and/or responsible person/ entity	<input checked="" type="checkbox"/> Project participant <input checked="" type="checkbox"/> Person/entity responsible for completing the CDM-MR-FORM
Organization name	Hanwha Corporation
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Contact person	Jihyun Park
Title	
Salutation	Ms.
Last name	Park
Middle name	
First name	Jihyun
Department	Merchandise Business Department
Mobile	-
Direct fax	
Direct tel.	
Personal e-mail	

Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
07.0	31 May 2019	Revision to: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 <i>F-CDM-MR</i> to <i>CDM-MR-FORM</i>; • 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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