



Monitoring report form
(Version 05.1)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" 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 monitoring report	Version 3.0	
Completion date of the monitoring report	14/06/2017	
Monitoring period number and duration of this monitoring period	7 th monitoring period: 01/01/2016~31/12/2016 (366 days)	
Project participant(s)	Hanwha Corporation	
Host Party	Republic of Korea	
Sectoral scope(s)	Scope 1. Energy industry Scope 13. Waste handling and disposal	
Selected methodology(ies)	Applied methodologies: - AMS I.D: Grid connected renewable electricity generation_V13 - AMS III. G: Landfill methane recovery_V06	
Selected standardized baseline(s)	N/A	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	26,630 tCO ₂ -eq	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0 tCO ₂ -eq	47,163 tCO ₂ -eq

SECTION A. Description of project activity**A.1. Purpose and 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 47,163 tons CO₂ over the 12 months (366 days, 01/01/2016~31/12/2016) 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 participant(s)**

Party involved (host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether 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. Reference of applied methodology and standardized baseline

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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
- Tool to calculate the emission factor for an electricity system_V01.1

A.5. Crediting period of project activity

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Start date: 18/02/2010

Length of crediting period: 10years

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

A.6. Contact information of responsible persons/entities

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SECTION B. Implementation of project activity**B.1. Description of implemented registered 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. And also, 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:

<Table B-1>Operation events history

Date	Duration		Operation events	Note
13/01/2016	18:33-19:08	34 min	Maintenance of facilities. • Error of ignition system.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.57 hours			

22/01/2016	09:42-11:30	107 min	Maintenance of facilities. → Replace engine oil. → Generator shift due to maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.78 hours			
26/01/2016	11:07-11:34	27 min	Generator Shift after maintenance. - From 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.45 hours			
29/01/2016	10:42-16:29	346 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	5.77 hours			
01/02/2016	19:41-21:23	101 min	Maintenance of facilities. • 1 st generator's trip occurred. → Replace spark plugs and sockets.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.68 hours			
04/02/2016	14:34-15:27	53 min	Maintenance of facilities. • Gas pipe was damaged.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.88 hours			
12/02/2016	13:23-13:44	21 min	Maintenance of facilities. • 1 st generator's trip occurred due to error of gas pressure.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.35 hours			
16/02/2016	11:45-12:55	69 min	Maintenance of facilities. • 1 st generator's trip occurred. → Replace spark plugs.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.15 hours			
25/02/2016	09:01-09:08	6 min	Maintenance of facilities. → Replace engine oil. → Generator shift due to maintenance. From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	09:28-09:51	22 min	Maintenance of facilities. • 2 nd generator's trip occurred.	
	0.47 hours			
26/02/2016	09:13-09:58	44 min	Generator Shift after maintenance of 2 nd generator. - From 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	10:05-10:16	10 min	Error of equipment. - 1 st generator's trip occurred.	
	0.90 hours			
09/03/2016	11:37-12:13	36 min	Maintenance of facilities. - Methane concentration data was unstable due to inspection of nozzle.	CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration data of the day was applied.
	12:33-12:36	2 min		
	0.63 hours			
21/03/2016	10:58-17:16	378 min	Maintenance of facilities. • Replace an actuator and ventilation filter.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	6.30 hours			
28/03/2016	10:52-11:00	8 min	Generator Shift after maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.13 hours			
30/03/2016	08:53-9:48	55 min	Generator shift from 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	10:29-11:15	46 min	• Emergency stop.	
	1.68 hours			

05/04/2016	10:08-10:43	35 min	There was black out.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	10:45-10:52	6 min		
	0.68 hours			
12/04/2016	02:46-03:26	40 min	Error of equipment. - 1 st generator's trip occurred.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	03:45-03:53	8 min	Error of equipment. - 1 st generator's trip occurred. → Generator shift from 1 st generator to 2 nd generator.	
	10:21-11:26	65 min		
	1.88 hours			
16/04/2016 ~ 23/04/2016	13:47- (16/04/2016)	10,128 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	14:35 (23/04/2016)			
	168.80 hours			
23/04/2016	14:35-15:11	35 min	Maintenance of facilities. → Generator shift from 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	16:27-17:15	48 min		
	17:29-17:49	20 min		
	19:31-19:49	17 min		
	20:37-20:47	10 min		
	2.17 hours			
24/04/2016 ~ 25/04/2016	08:22- (24/04/2016)	1,513 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	09:35 (25/04/2016)			
	25.22 hours			
25/04/2016	10:14-14:12	238 min	Error of equipment. • Intercooler was blocked. → Generator shift from 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	3.97 hours			
25/04/2016 ~ 02/05/2016	14:12- (25/04/2016)	9,902 min	Monitoring system error occurred. • Error of flow meter's communication port.	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate.
	11:15 (02/05/2016)			
	165.03 hours			
03/05/2016	13:50-14:00	9 min	Maintenance of facilities. • Replace an intercooler. → Generator shift from 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.15 hours			
28/05/2016 ~ 30/05/2016	19:49- (28/05/2016)	2,144 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	07:33 (30/05/2016)			
	35.73 hours			
02/06/2016	08:53-09:05	12 min	Maintenance of facilities. → Replace engine oil. → Generator shift due to maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.20 hours			
03/06/2016	08:26-08:58	31 min	Generator Shift from 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.52 hours			
07/06/2016	02:36-7:42	305 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	5.08 hours			

11/06/2016	07:08-16:15	546 min	Maintenance of facilities. • Error of cooling water pump.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	9.10 hours			
15/06/2016	00:05-08:15	489 min	Monitoring system error occurred.	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate.
	8.15 hours			
30/06/2016	08:55-09:21	26 min	Maintenance of facilities. → Replace engine oil. → Generator shift due to maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.43 hours			
01/07/2016	03:24-04:09	45 min	Monitoring system error occurred. → Generator shift after maintenance. - From 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to recording error. → Excluded for estimation of emission reduction.
	04:11-10:30	378 min		
	10:34-10:48	13 min		
	14.07 hours			
05/07/2016	09:37-09:44	6 min	Monitoring system error occurred. - Methane concentration data was unstable.	Flow rate and CH ₄ concentration data is not available due to recording error. → Excluded for estimation of emission reduction.
	13:07-13:16	8 min	Maintenance of facilities. • Error of gas pressure.	
	09:51-09:59	8 min	Monitoring system error occurred. - Methane concentration data was unstable.	CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration data of the day was applied.
	13:16-13:27	11 min		
	0.55 hours			
26/07/2016 ~ 27/07/2016	17:17- (26/07/2016) 08:30 (27/07/2016)	913 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	15.22 hours			
05/08/2016	09:20-10:28	67 min	Maintenance of facilities. → Replace engine oil. → Generator shift due to maintenance. From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	11:03-11:12	9 min	Maintenance of facilities. → Replace spark plugs.	
	1.27 hours			
08/08/2016	09:18-09:38	19 min	Generator Shift after maintenance. - From 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.32 hours			
16/08/2016 ~ 17/08/2016	16:22- (16/08/2016) 19:23 (17/08/2016)	1,621 min	Maintenance of facilities. • Regular inspection of Generators and calibration of watt-hour meters.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	27.02 hours			
17/08/2016	19:28-19:30	2 min	Generator Shift after maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.03 hours			
18/08/2016	14:16-16:35	138 min	Maintenance of facilities. • Regular inspection of 2 nd Generator by Korea Electrical Safety Corporation (KESCO).	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	16:51-16:58	6 min	Monitoring system error occurred. - Methane concentration data was unstable. → Generator shift after maintenance. - From 2 nd generator to 1 st generator.	
	2.40 hours			CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration data of the day was applied.

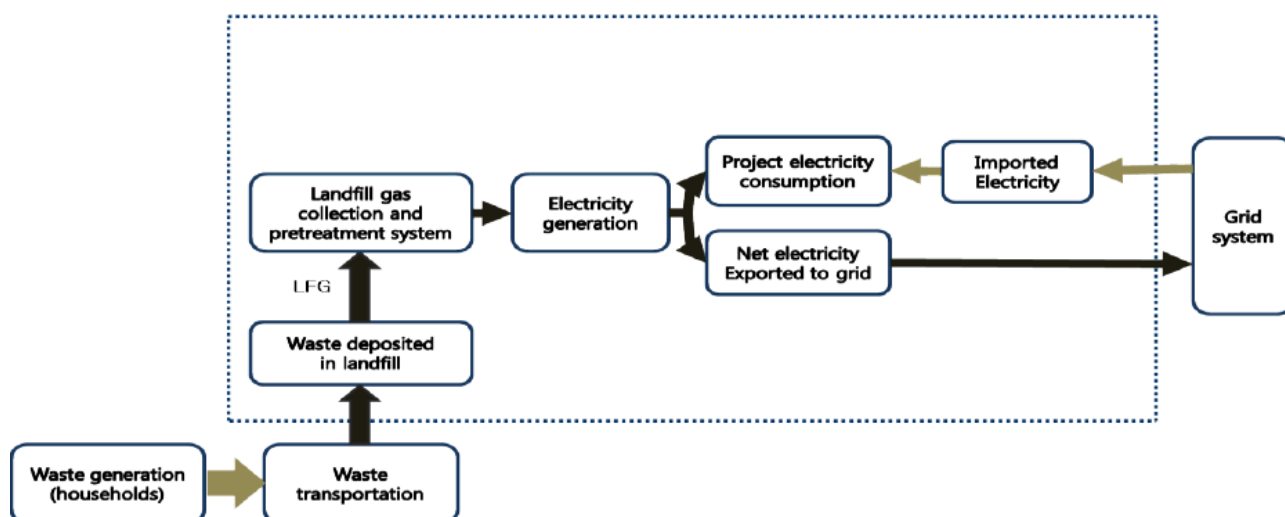
31/08/2016 ~ 01/09/2016	18:47- (31/08/2016) 08:44 (01/09/2016)	837 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	13.95 hours			
07/09/2016	09:50-10:05	14 min	Monitoring system error occurred.	CH ₄ data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.23 hours			
08/09/2016	03:47-08:25	277 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	4.62 hours			
09/09/2016	09:09-14:33	324 min	Maintenance of facilities. → Replace engine oil. → Replace Main flow meter and 1 st flow meter. → Generator Shift after maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	14:59-15:04	4 min	Error of equipment. • 2 nd generator's trip occurred.	
	5.47 hours			
09/09/2016 ~ 11/09/2016	15:41- (09/09/2016) 01:00 (11/09/2016)	1,999 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	33.32 hours			
12/09/2016 ~ 14/09/2016	08:57- (12/09/2016) 19:00 (14/09/2016)	3,482 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	58.03 hours			
14/09/2016 ~ 16/09/2016	19:00- (14/09/2016) 24:00 (16/09/2016)	3,180 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	53.00 hours			
17/09/2016 ~ 22/09/2016	00:00- (17/09/2016) 13:43 (22/09/2016)	8,025 min	Monitoring system error occurred.	Flow rate data is not available due to recording error. → Keep an hourly work log on the flow rate.
	133.75 hours			
22/09/2016	13:43-19:38	355 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	5.92 hours			
25/09/2016	10:07-14:06	239 min	Maintenance of facilities. • Error of gas pressure.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	14:07-14:23	15 min	Monitoring system error occurred. - Methane concentration data was unstable.	
	4.23 hours			

29/09/2016	06:04-08:14	130 min	Maintenance of facilities. • Coolant leakage occurred.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	08:15-08:17 2.20 hours	2 min	Monitoring system error occurred. - Methane concentration data was unstable.	CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration data of the day was applied.
05/10/2016	05:34-08:08	154 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	2.57 hours			
14/10/2016	09:25-09:41	16 min	Maintenance of facilities. → Replace engine oil. → Generator Shift after maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	11:00-12:49	108 min	Monitoring system error occurred.	Flow rate is not available due to recording error. → Keep an hourly work log on the flow rate.
	14:35-16:31	116 min		
	4.00 hours			
17/10/2016	09:34-09:51	16 min	Generator Shift from 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	09:52-10:03 0.45 hours	11 min	Monitoring system error occurred. - Methane concentration data was unstable.	CH ₄ concentration data is not available due to measurement error. → Only when the flow data is normal, the lowest CH ₄ concentration data of the day was applied.
03/11/2016	10:07-11:13	66 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Excluded for estimation of emission reduction.
	1.10 hours			
05/11/2016	12:38-13:31	53 min	Maintenance of facilities. • Coolant leakage occurred. → Generator shift due to maintenance. - From 1 st generator to 2 nd generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.88 hours			
07/11/2016	12:53-14:31	97 min	Maintenance of facilities. → Generator shift due to maintenance. - From 2 nd generator to 1 st generator.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.62 hours			
18/11/2016	08:59-10:54	115 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.
	1.92 hours			
28/11/2016	08:47-08:57	10 min	Maintenance of facilities. • Oxygen input occurred due to management of collecting system.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.17 hours			
29/11/2016	13:37-14:51	73 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	1.22 hours			

07/12/2016	06:40-07:58	78 min	Maintenance of facilities. • Defect of automatic voltage controller.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	08:09-08:44	34 min		
	08:54-09:01	7 min		
	09:09-09:13	4 min		
	09:21-10:17	56 min		
	2.98 hours			
14/12/2016	08:28-13:21	292 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.
	4.87 hours			
21/12/2016	13:00-16:59	239 min	Monitoring system error occurred.	Flow rate and CH ₄ concentration data is not available due to recording error. → Keep an hourly work log on the flow rate and CH ₄ concentration.
	3.98 hours			
25/12/2016	20:30-21:39	69 min	Maintenance of facilities. • Error of gas pressure.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	1.15 hours			
30/12/2016	11:27-11:36	8 min	Maintenance of facilities. • Temperatures of gas mixer rose.	Flow rate and CH ₄ concentration data is not available due to measurement error. → Excluded for estimation of emission reduction.
	0.13 hours			

The description of the technology

The main process of the project is comprised of a LFG collecting system, a LFG pretreatment 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. And about 87% of the landfill is in progress. in December 2016.

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

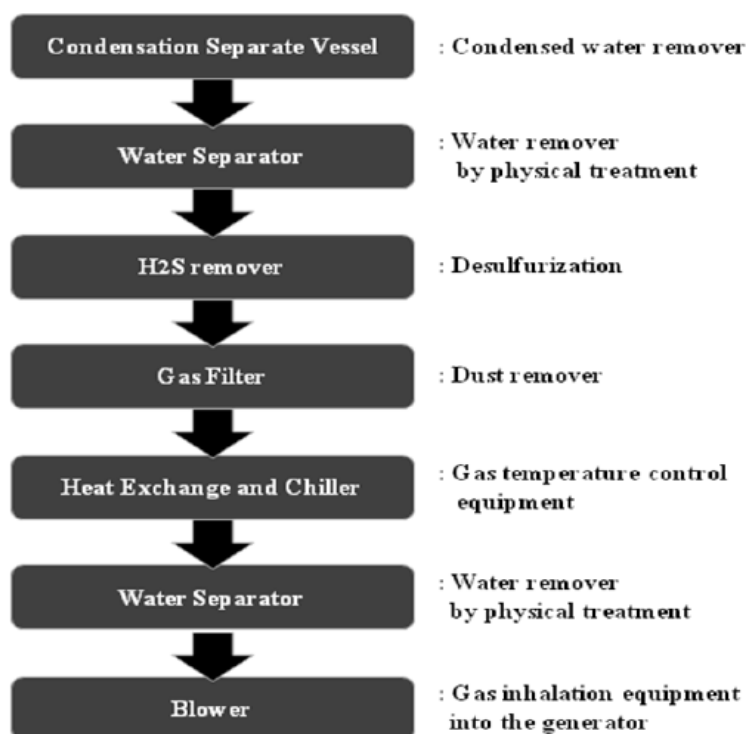
<Table B-2> History of the LFG collecting system

Date	Well			J-Trap
	Wellhead	Well	Uwell	
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

* The management of LFG collecting system was carried out, but there was no change in the number of wells.

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 registered monitoring plan, applied methodology or applied standardized baseline**

>>

N/A

B.2.2. Corrections

>>

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

And the PRC is submitted with issuance of CERs of this monitoring period.

B.2.3. Changes to start date of crediting period

>>

N/A

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

>>

N/A

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

>>

The post-registration changes was requested during verification period for 4th monitoring and was approved on March 6th, 2014. PRC ref is PRC-2834-001.

B.2.6. Changes to project design of registered project activity

>>

There are 1 of post-registration changes.

(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. Thus, the quantity of facility of collecting system could be changed by this maintenance.

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. Types of changes specific to afforestation or reforestation project activity

>>

N/A

SECTION C. Description of monitoring system

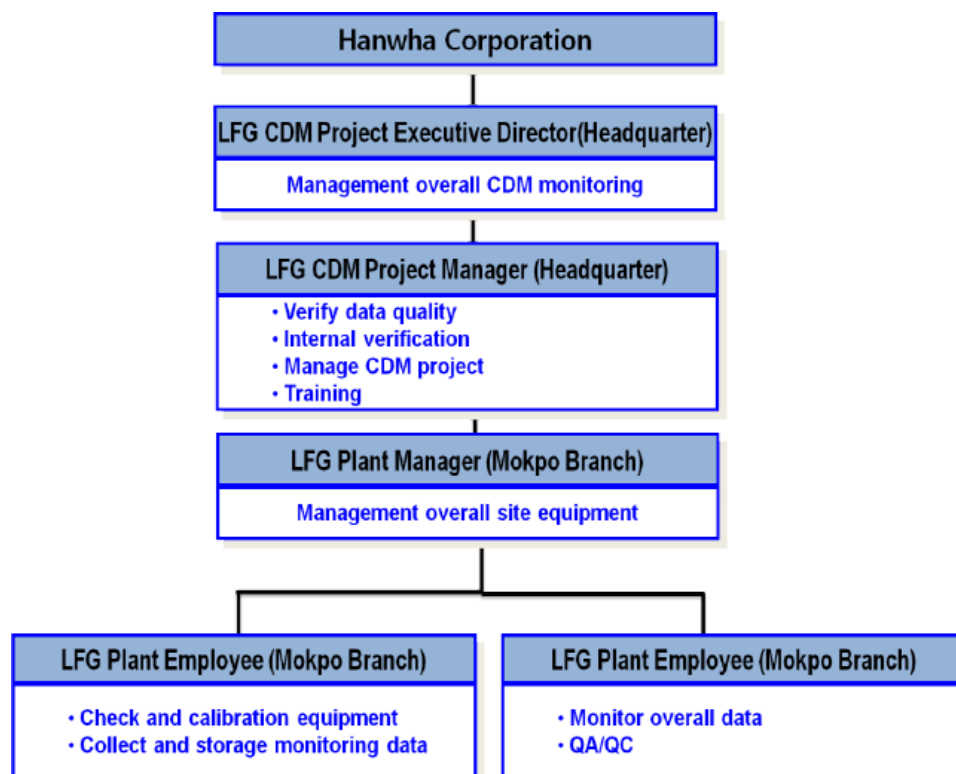
>>

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	
	Watt-hour meter Responsible person/department for the project:	Responsible person/department for the project : • LFG plant employee / Mokpo operating team of HWC Mokpo branch
		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 : <ul style="list-style-type: none"> LFG CDM project executive director / Green & Renewable energy business team of HWC Headquarter
Task coordination	<ul style="list-style-type: none"> LFG plant manage / 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 : <ul style="list-style-type: none"> LFG plant manager / Mokpo operating team of HWC Mokpo branch LFG CDM project manager / Environment / Green & Renewable energy business team of HWC Headquarter

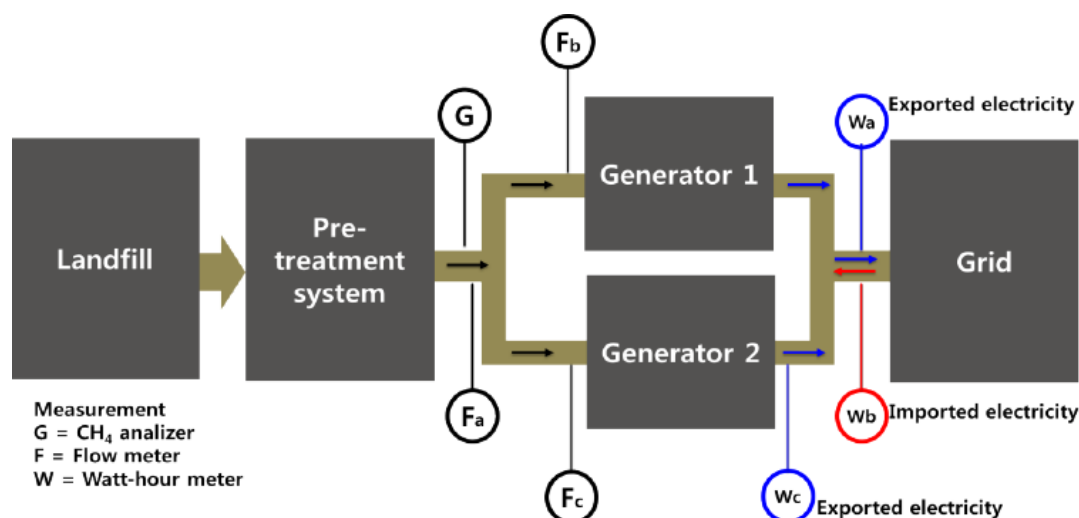
The monitoring equipment to measure the amount of methane and electricity

- 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.
- For last monitoring period, 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, it happened 3 times and was conservatively treated.

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.

In this monitoring period, there were replacements of main flow meter and 1st flow meter on September 9th, 2016.

<Table C-2> Related flow meters

Tag	F _a (main)		F _b (1 st generator)	
	Before the replacement	After the replacement	Before the replacement	After the replacement
Serial No	812003	GR-160994	906044B	GR-160995
Accuracy level	1%	0.5%	1%	0.5%
Type	Thermal Mass Flow Meter			

- 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 electricity market" of 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 29, 2016.

Internal training for the monitoring was done by LFG CDM project manager of headquarter on November 29, 2016.

SECTION D. Data and parameters¹

D.1. Data and parameters fixed ex ante or at renewal of crediting period

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	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	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	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:	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:	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)		
		F _b	F _c	F _b + F _c
	01/01/2016 ~ 18/01/2016	236,841.200	0.000	236 ,841.200
	19/01/2016 ~ 18/02/2016	350,116.300	44,128.600	394,244.900
	19/02/2016 ~ 18/03/2016	369,295.900	11,176.800	380,472.700
	19/03/2016 ~ 18/04/2016	288,112.700	95,475.900	383,588.600
	19/04/2016 ~ 18/05/2016	188,896.100	144,189.400	333,085.500
	19/05/2016 ~ 18/06/2016	399,846.200	11,666.325	411,512.525
	19/06/2016 ~ 18/07/2016	364,030.900	8,522.400	372,553.300
	19/07/2016 ~ 18/08/2016	350,997.200	43,619.600	394,616.800
	19/08/2016 ~ 18/09/2016	396,319.000	30,100.300	426,419.300
	19/09/2016 ~ 18/10/2016	345,214.200	29,116.200	374,330.400
	19/10/2016 ~ 18/11/2016	381,359.900	18,602.500	399,962.400
	19/11/2016 ~ 18/12/2016	339,555.600	0.000	339,555.600
	19/12/2016 ~ 31/12/2016	164,690.100	10.200	164,700.300
	01/01/2016 ~ 31/12/2016	4,175,275.300	436,608.225	4,611,883.525

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.

All measured data for the crediting period has been submitted to the DOE as a spread sheet named "Mokpo_7th MR_2834_Emission Reduction".

Monitoring equipment	Tag	F _a (main)		F _b (1 st generator)		F _c (2 nd generator)
		Before the replacement	After the replacement	Before the replacement	After the replacement	
	Serial No	812003	GR-160994	906044B	GR-160995	906044A
	Accuracy level	1%	0.5%	1%	0.5%	1%
	Type	Thermal Mass Flow Meter				
	Calibration Frequency	3 years				
	Date of installation	-	09/09/2016	-	09/09/2016	-
	Date of last calibration	31/03/2015 ~ 01/04/2015	02/09/2016	31/03/2015 ~ 01/04/2015	02/09/2016	31/03/2015 ~ 01/04/2015
	Validity	30/03/2018	01/09/2019	30/03/2018	01/09/2019	30/03/2018
	Calibration Entity	Flow Technology Co., Ltd.	Golden Rules Co., Ltd.	Flow Technology Co., Ltd.	Golden Rules Co., Ltd.	Flow Technology 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.The main flow meter and 1st generator's flow meter were replaced with new ones on September 9th, 2016.To ensure accuracy, the flow meters are subject to regular maintenance and testing. The flow meter 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. <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:	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>01/01/2016 ~ 31/12/2016</td><td>53.214</td></tr> </tbody> </table> <p>All measured data for the crediting period has been submitted to the DOE as a spread sheet.</p>	Date	Measured CH ₄ (%) (Weighted average CH ₄ concentration)	01/01/2016 ~ 31/12/2016	53.214												
Date	Measured CH ₄ (%) (Weighted average CH ₄ concentration)																
01/01/2016 ~ 31/12/2016	53.214																
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>26/03/2015</td></tr> <tr> <td>Validity</td><td>25/03/2018</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	26/03/2015	Validity	25/03/2018	Calibration Entity	National Metrology Institute
Tag	G																
Serial No	A8M7282T																
Accuracy level	Linearity 1%, Repeatability 0.5%																
Type	Infrared gas analyzer																
Calibration frequency	3 years																
Date of last calibration	26/03/2015																
Validity	25/03/2018																
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:	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	Date	W_a	W_c	Total EL_{EXP} (MWh)			
	01/01/2016 ~ 18/01/2016	308.620	0.000	308.620			
	19/01/2016 ~ 18/02/2016	451.486	54.551	506.037			
	19/02/2016 ~ 18/03/2016	478.790	13.311	492.101			
	19/03/2016 ~ 18/04/2016	364.707	115.604	480.311			
	19/04/2016 ~ 18/05/2016	252.087	183.566	435.654			
	19/05/2016 ~ 18/06/2016	509.411	13.232	522.643			
	19/06/2016 ~ 18/07/2016	494.992	14.243	509.235			
	19/07/2016 ~ 18/08/2016	443.996	50.507	494.503			
	19/08/2016 ~ 18/09/2016	479.491	37.810	517.301			
	19/09/2016 ~ 18/10/2016	459.198	41.145	500.343			
	19/10/2016 ~ 18/11/2016	497.284	26.994	524.278			
	19/11/2016 ~ 18/12/2016	418.134	0.000	418.134			
	19/12/2016 ~ 31/12/2016	219.097	0.000	219.097			
	01/01/2016 ~ 31/12/2016	5,377.294	550.962	5,928.256			
	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.						
Monitoring equipment	Tag	W_a	W_c				
	Serial No	95246742	50339836				
	Accuracy level	0.5s	0.5s				
	Type	Watt-hour meters					
	Calibration Frequency	Performed at least once in 2 years					
	Date of last calibration	17/08/2016 ~ 19/08/2016	17/08/2016 ~ 19/08/2016				
	Validity	16/08/2018	16/08/2018				
	Calibration Entity	KTC (Korea Testing Certification)					
	<ul style="list-style-type: none"> Two watt-hour meters were installed to measure the amount of exported electricity. The amount of exported electricity is measured automatically by certified watt-hour meters. The measured data is transferred to KPX. It is checked and achieved daily, weekly, monthly in electronic way by the Mokpo operation team. This project involves the installation of two exported electricity watt-hour meters. W_a watt-hour meter had been installed as measure of the amount of exported electricity in Mokpo LFG plant. Additionally a watt-hour for 2nd generator (W_c) was installed on January 27th, 2013. W_c added requested it under the "Act on the promotion of the development, use and diffusion of new and renewable energy". In previous 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. 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. 						
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 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:	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)
	01/01/2016 ~ 18/01/2016	0.096
	19/01/2016 ~ 18/02/2016	0.288
	19/02/2016 ~ 18/03/2016	0.072
	19/03/2016 ~ 18/04/2016	0.264
	19/04/2016 ~ 18/05/2016	0.360
	19/05/2016 ~ 18/06/2016	0.314
	19/06/2016 ~ 18/07/2016	0.072
	19/07/2016 ~ 18/08/2016	0.362
	19/08/2016 ~ 18/09/2016	0.168
	19/09/2016 ~ 18/10/2016	0.168
	19/10/2016 ~ 18/11/2016	0.096
	19/11/2016 ~ 18/12/2016	0.360
	19/12/2016 ~ 31/12/2016	0.240
	01/01/2016 ~ 31/12/2016	2.860
	<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>01/01/2016 to 31/12/2016, 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	1 st
		17/06/2014
	Validity	2 nd
		17/08/2016 ~ 19/08/2016
	Calibration Entity	1 st
		16/06/2016
		2 nd
		16/08/2018
	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.kepc.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. But in this 7th monitoring, 2 months of validity period was invalidity. Thus, in order to calculate conservatively, 0.5% of accuracy level was additionally applied between 19/05/2016 and 18/08/2016. 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:	Calculation of Project emission
Additional comments:	Not applied.

D.3. Implementation of sampling plan

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N/A

SECTION E. Calculation of emission reductions or GHG removals by sinks**E.1. Calculation of baseline emissions or baseline net GHG removals by sinks**

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

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'.
$w_{CH_4,y}$	%	Methane content in LFG in the year 'y' (mass fraction).
$D_{CH_4,y}$	kg/N m ³	Density of methane at normal conditions in the year 'y'. (Source: ACM0001 ver.11)
GWP_{CH_4}	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 GHG removals by sinks

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

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

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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. Summary of calculation of emission reductions or net GHG removals by sinks

Date	ER _y	LFG _{electricity,y}	W _{CH₄}	D _{CH₄,y}	GWP _{CH₄}	MD _{reg,y}	EL _{EXP,PJT,y}	EL _{IMP,PJT,y}	CEF	Leakage
01/01/2016 ~ 31/12/2016	47,163.357	4,611,883.525	53.214	0.0007168	25	0	5,928.256	2.860	0.5375	0

Item	Baseline emissions or baseline net GHG removals by sinks (t CO ₂ e)	Project emissions or actual net GHG removals by sinks (t CO ₂ e)	Leakage (t CO ₂ e)	GHG emission reductions or net GHG removals by sinks (t CO ₂ e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total (01/01/2016 ~ 31/12/2016)	47,164.894	1.537	0	0	47,163.357	47,163

E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (tCO ₂ e)	26,630 tCO ₂ e	47,163 tCO ₂ e

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 7th 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
2016 (366days)	26,630	23,131	23,131	0	0	3,499	3,500	1	0

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

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Actual values reached during the monitoring period: 47,163 tCO₂e**Values applied in ex-ante calculation of the registered CDM-PDD: 26,630 tCO₂e**

The emission reductions increased to 77% during the monitoring period compared to the expected emission reductions which 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 18% increase in this monitoring period.

Expected data in registered PDD calculated using conservative data.

In PDD, $BE_y = BE_{CH_4,SWDS,y} - MD_{reg,y}$ The methane emission potential of a solid waste disposal site, $BE_{CH_4,SWDS,y}$ in tCO₂e, is undertaken using the equation in the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site."

Therefore, the expected LFG by waste composition analysis is differs from actual LFG generation on monitoring system.

The LFG flow was estimated to be 6.40 m³/min (on the registered CDM-PDD: 366days in 2016) but the actual average flow was 8.77 m³/min during the monitoring period. In other words, there was 37% of the difference between the theoretical and the actual values.

Quantity of waste for LFG

The starting year of Mokpo landfill is in 1996, and the ending year is expected in 2022.

Compared table between the actual quantity and the expected quantity waste are shown below.

Year	Expected waste estimation (ton)	The actual quantity waste (ton)
2007	66,627	91,099
2008	66,134	68,720
2009	65,644	70,732
2010	65,158	70,737
2011	64,676	66,686
2012	64,197	59,712
2013	63,722	61,292
2014	63,251	58,361
2015	62,783	56,416
2016	62,318	53,249
Total	644,510	657,004

The amount of waste quantity (91,099ton, up 37%) was a lot more than the expected quantity (66,627 ton) in 2007 due to the waste brought from other landfill. The actual quantity of waste was increased compared to the expected quantity of waste which is on the registered CDM-PDD until 2011. Thus quantity of waste was increased methane content in LFG by its 1st order decay model. The emission reduction was calculated using actual amount of landfill considering the registered PDD.

The difference between the emission reduction in the monitoring period and on the registered PDD can be explained by the difference of quantity of waste in landfill. This factor can serve as a main cause. The increase in quantity of waste causes the increase in actual LFG generation. So, conservative assumption for the expected amount of waste in landfill is the reason for the difference. And starting in 2005, it is forbidden to bury food waste in landfill. Although food wastes

were forbidden to bury, quantity of waste has been more than expectation. This tendency of increase can affect LFG generation.

CH₄ concentration

The PDD estimate was based on 50% CH₄ concentration but the actual concentration exceeds 53.214% 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.

Maintenance of LFG collecting system

Another reason for increase in emission reduction is the overall optimization of landfill operation. Emission reduction can be increased depending on the amount of LFG.

In addition, the conservative assumptions for the landfill operating conditions including operating hour and the optimization of the LFG power generation can also be the reasons for the difference. The overall and comprehensive environment was optimized for the landfill, although the theoretical model considered less methane fraction in the LFG.

Therefore, the emission reduction is not increased proportionally in accordance with only one factor. And the biggest cause is the difference of the prediction of LFG.

Amount of exported electricity

The amount of exported electricity was estimated to be 6,713 MWh (on the registered CDM-PDD: 366days in 2016) but the actual amount of exported electricity was 5,928 MWh during the monitoring period. In other words, there was 13% of the difference between the theoretical and the actual values. For this project activity, amount of exported electricity is the only factor for revenue. In a point of additionality of this project activity, increasing of treated methane gas is not directly related to income of this project activity. Thus regarding to this change, this change was not occurred intentionally as it does not have influence on revenue and this increasing also does not effect to the additionality of this project activity.

And in PDD, the amount of expected electricity is not calculated by assuming an operating rate. To calculate the amount of exported electricity, only expected capacity and operating hours are a factor. Thus, the predicted results and the actual results has been a gap.

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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Last name	Park
Middle name	
First name	Jihyun
Department	Merchandise Business Department
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Direct fax	
Direct tel.	
Personal e-mail	