MONITORING REPORT
Version 01 and 08-09-2010

Mokpo Landfill Gas Project for Electricity Generation
CDM Registration Reference Number: 2834
1st monitoring period: 18th February, 2010 ~ 17th August, 2010

SECTION A. General description of the project activity

A.1. Brief description of the project activity:

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Mokpo Landfill Gas Recovery Project for Electricity Generation is developed by Hanwha Corporation in the Republic of Korea. The purpose of this project is to collect the CH_4 in landfill gas at the landfill site as renewable energy and to utilize CH_4 for generating electricity.

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 m^2, waste disposal area is 180,000 m^2.

Prior to this proposed project, Mokpo Landfill emits landfill gas (LFG) into the atmosphere directly without recovery and utilization of LFG. The proposed project involves the installation of a highly efficient collecting system, transmitting system, pre-treatment system and two electricity generators. The two generators installed with a total capacity of 2.123 MW (1.065 MW and 1.058 MW). In terms of CO_2 emission reductions, the reductions are 17,242 tons CO_2 over the 6 month (181days, 18/02/2010~17/08/2010) of crediting period.

Date	Project Schedule
March 2008	Hanwha Corporation decided to invest in the 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)
April 2009	date of additional 1.058 MW generator
18, February 2010	Registered as a CDM project

A.2. Project Participants

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<Table A-1> Project Participants

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of KOREA (host)	Hanwha Corporation	No

A.3. Location of the project activity:

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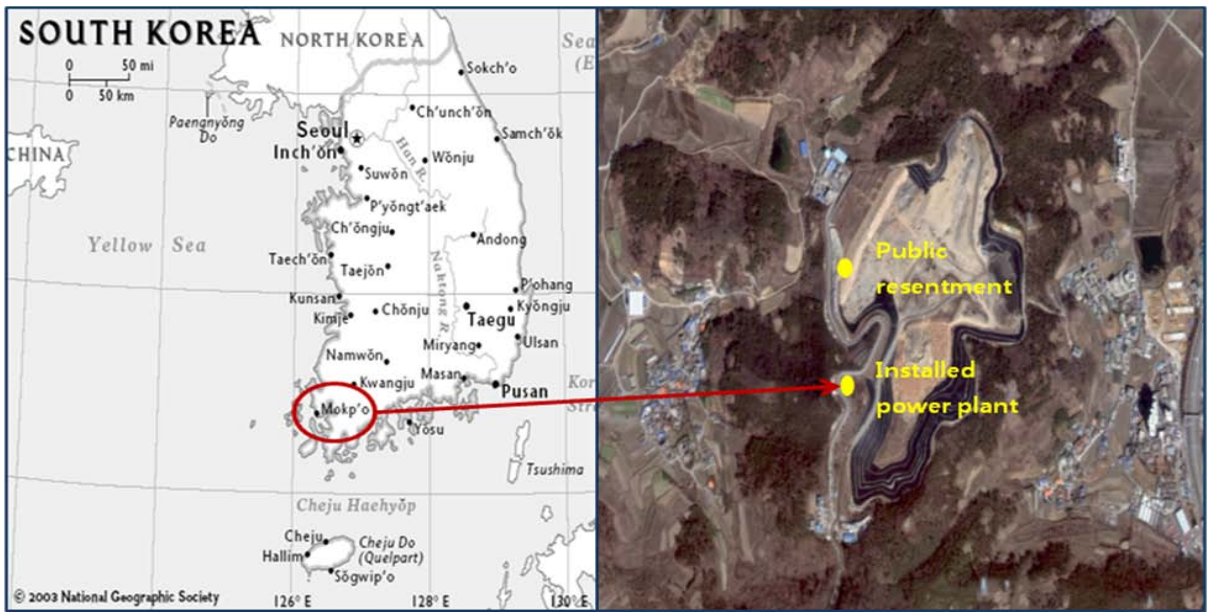
The site of the "Mokpo Landfill Gas Recovery Project for Electricity Generation" is located in Daeyang-dong, Mokpo City, Jeollanam-do, Republic of Korea. The facilities and equipment installed inside the Mokpo landfill. The coordinates are longitude of 34:49 N and latitude of 126:24 E. The coordinates are based on the power plant.



<Fig. A-1> The location of landfill site and the whole site view of the project

A.4. Technical description of the project

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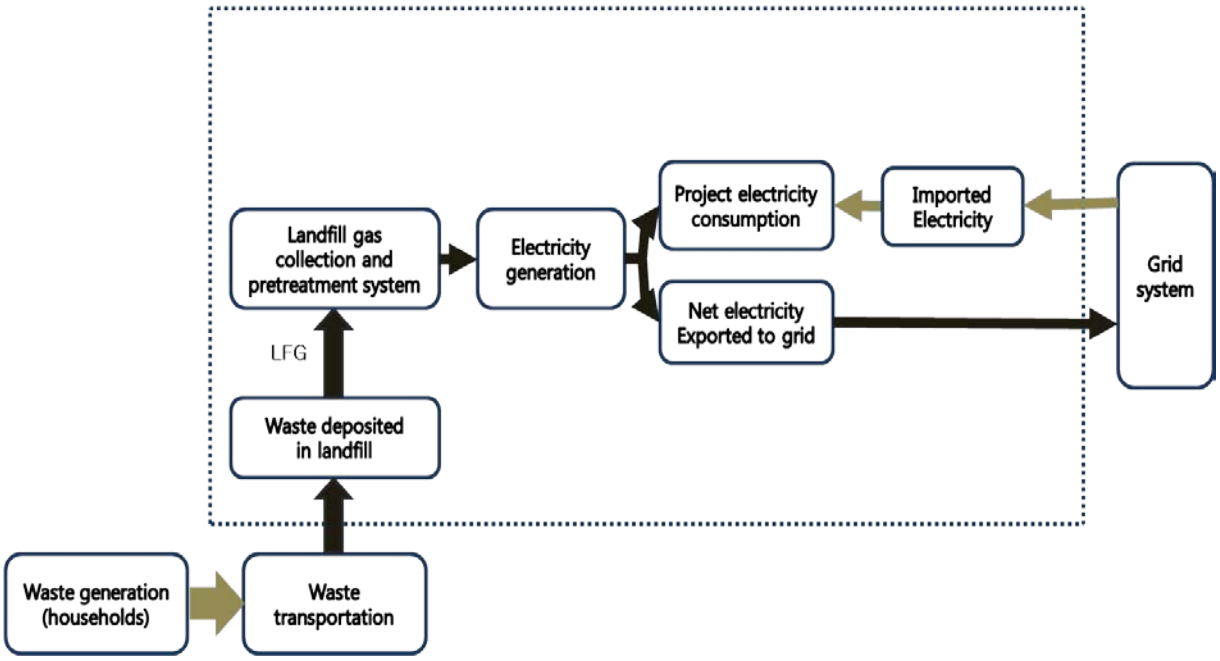
The description of the technology below:

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



<Fig. A-2> The main process of the proposed project

- ***Landfill Gas Collecting System***

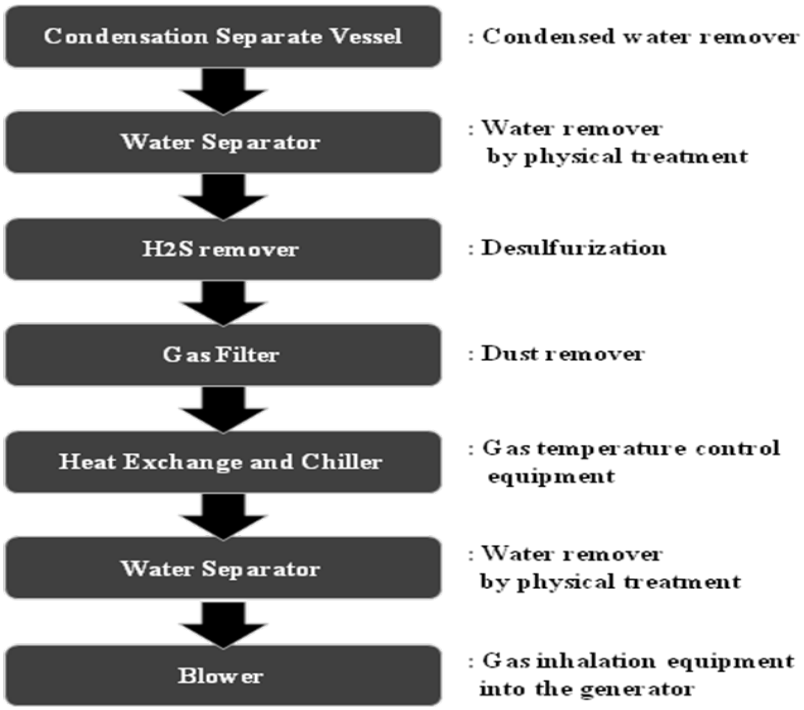
The landfill gas collecting system is a gas transportation network, consisting of gas collecting wells, lateral gas collecting sub-pipes and a main pipe to cover all the landfill. The landfill gas collected from the gas wells is delivered to the main-heater pipe through sub-pipes, and the gas from the landfill gas collecting system is delivered into the CSV (Condensate Separation Vessel). High-density polyethylene (HDPE) collecting system is installed to convey the landfill gas from the wells to the blower.

<Table A-2> The facilities of landfill gas collecting system

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

- ***Landfill Gas Pre-treatment System***

Prior to electricity generation, the landfill gas 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 H_2S and to protect the generators for this project. The pre-treatment consists of 1) CSV (Condensate Separation Vessel), 2) water separator, 3) H_2S remover, 4) gas filter, 5) heat exchange and chiller, 6) water separator, and 7) blower.



<Fig. A-3> The process of pre-treatment system

- ***Electricity Generation System***

Two generators with capacity of 2.123 MW (1.065 MW and 1.058 MW) 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 April 2009. The collected LFGs are sent to the generators and the electricity thereby generated is exported to the grid-connected system of the Korea Electric Power Corporation (KEPCO) supply system.

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

Engine	Capacity of 1.065 MW	Manufacturer	GE Jenbacher
		Engine type	JGC 320 GS-L.L-C81
		Gas volume	522 Nm^3/h
	Capacity of 1.058 MW	Manufacturer	GE Jenbacher
		Engine type	JGC 320 GS-L.L-B81
		Gas volume	450 Nm^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 %

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

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(1) The title of the project activity: Mokpo Landfill Gas Recovery Project for Electricity Generation

(2) Reference of the project activity: 2834

(3) Version of the baseline and monitoring methodology applied to the project activity:

According to Annex A of the Kyoto Protocol, this project fits in sectoral categories:
1. Energy Industry; and
13. Waste Handling and Disposal.

The approved small-scale CDM baseline methodologies;
- AMS I. D: Grid connected renewable electricity gerneration_V13
- AMS III. G: Landfill methane recovery_V06

And the tools referred by 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.6. Registration date of the project activity:

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18/02/2010

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

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Start date: 18/02/2010
Length of crediting period: 10years
Crediting period: 18/02/2010 ~ 17/02/2020

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

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The monitoring report is responsible by Hanwha corporation,as a LFG CDM project manager.
Mr. Changuk An.
Trade division, Business development department
renewables@hanwha.co.kr
+82-2-729-3713

The monitoring report is finished by Econetwork Co.,Ltd, as a consultant.
Ms. Seonyoung Moon.
Climate change business division
seonyoung225@econetwork.co.kr
+82-2-571-6155

SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

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Hanwha Corporation decided to invest in the proposed 2.123MW landfill gas generation project on March, 2008. Gas collecting system construction started on April, 2008.
September 2008, installation of 1.065MW generator completed and starts commercial operation. In April 2009, added 1.058MW generator in Mokpo landfill site. Therefore, total installed generator capacity is 2.123MW. The CDM project monitoring activity has been started since 18/02/2010. It's registered date for CDM project.
The project implementation is not phased.
The landfill gas collect equipment installed on site is as described in the registered PDD. The main component is the gas collecting system.
The project has been carried out in accordance with the registered PDD. And the monitoring is compliant with the monitoring plan as "Operating Manual-Mokpo LFG Power Plant".
"Operating Manual-Mokpo LFG Power Plant" is submitted to DOE.

<Fig. A-4> The gas flow meter

<Fig. A-5> The gas analyzer

<Fig. A-6> The monitoring system

<Fig. A-7> The watt-hour meter

B.2. Revision of the monitoring plan

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Revision will be applied for this monitoring plan.
Revision of monitoring plan performed on the basis of applied methodology (AMS-III.G version 06 and AMS-I.D version 13) and "Procedures for revising monitoring plans in accordance with paragraph 57 of the modalities and procedures for the CDM(version 02)" in annex 28 of EB49 meeting report.
Some parameters in the registered monitoring plan are excluded and some parameters are modified in the revised monitoring plan. These parameters are as follows:

- Excluded parameters: **T** and **P, Wx, pn,j,x** and **z** parameters
- Modified parameter: $\mathbf{LFG}_{\mathbf{electricity,\,y}}$ parameter

Revising monitoring plan will be submitted to DOE on September, 2010. This revision is expected to proceed.

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

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The monitoring plan was not deviated and on deviation is pending.

B.4. Notification or request of approval of changes

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No notification or request of approval of changes has been made.

SECTION C. Data and parameters monitored

C.1. Data and parameters used to calculate baseline emissions

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Data / Parameter:	**F**
Data unit:	-
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
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 of data:	0
Brief description of measurement methods and procedures to be applied:	Monitored annually
QA/QC procedures:	Not applied.
Any comment:	Not applied.

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e / t CH_4
Description:	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
Source of data:	Decisions under UNFCCC and the Kyoto Protocol
Value of data:	21(to be applied for the first commitment period of the Kyoto Protocol)
Brief description of measurement methods and procedures to be applied:	Monitored annually
QA/QC procedures:	Not applied.
Any comment:	Not applied.

Data / Parameter:	**$LFG_{electricity, y}$**
Data unit:	Nm^3/y
Description:	Amount of landfill gas combusted in power plant
Source of data:	Measured by using gas flow meters
Value of data :	Not applied.
Brief description of measurement methods and procedures to be applied:	Measured automatically by continuous flow meters. The measured data is monitored in a computer and Mokpo Operation team should check the measured data continuously. - Accuracy is +/- 1.0 of F.S - Sensor response time is one second - Flow rate is 1,400 Nm3/h - Temperature is 50 ℃ - Pressure is 200 mmbar

QA/QC procedures to be applied:	The flow meters are subject to a regular maintenance and testing, to ensure accuracy. Calibrate the meter every three year
Any comment:	Archived data is kept during the crediting period and two years after. Daily data is documented in paper an archived in electronic file. No separate monitoring of temperature and pressure when expressing LFG volumes in normalized cubic meters

Data / Parameter:	$w_{CH4,y}$
Data unit:	%
Description:	Methane fraction in LFG
Source of data:	Measured by using a methane analyzer
Value of data :	50% (IPCC default value)
Brief description of measurement methods and procedures to be applied:	Methane fraction is measured with continuous gas analysers. The measured data is monitored in a computer and Mokpo Operation team should check the measured data continuously. - Linearity is +/- 0.5% of F.S - Zero drift is +/- 1% of F.S - Span Drift is +/- 2% of F.S - Response time is 15~30 seconds - Operating condition's temperature is – 5 ℃to 45 ℃
QA/QC procedures to be applied:	The gas analyzer is subject to a regular maintenance and testing regime in accordance with the manufacturer's specification at once, to ensure accuracy Calibrate the meter every three year
Any comment:	Archived data are to be kept during the crediting period and two years after. Daily data is documented in paper and archived in electronic file.

Data / Parameter:	$EL_{EXP, PJT, y}$
Data unit:	MWh
Description:	Total amount of electricity exported out of the project
Source of data:	Read from watt-hour meter
Value of data :	The estimation result is presented in B.6.3
Brief description of measurement methods and procedures to be applied:	The amount of exported electricity is measured automatically by certified meter. The measured data are transferred to Korea Power Exchange and are checked and achieved daily, weekly, monthly in electronic way by Mokpo Operation team. Measured by watt-hour meter

QA/QC procedures to be applied:	The watt-hour meter is subject to a regular maintenance and testing regime to ensure accuracy. Comply with "Act for measurement", "Regulation for operation of electricity market" of South Korea. Calibrate the meter every two year.
Any comment:	Archived data are to be kept during the crediting period and two years after. Daily data is documented in paper and archived in electronic file.

C.2. Data and parameters used to calculate project emissions

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Data / Parameter:	**$EL_{IMP, PJT, y}$**
Data unit:	MWh
Description:	Total amount of electricity imported to meet project requirement
Source of data:	Measurement by watt-hour meter
Value of data :	The estimation result is presented in B.6.3
Brief description of measurement methods and procedures to be applied:	The amount of imported electricity will be measured automatically by certified 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. Measured by watt-hour meter
QA/QC procedures to be applied:	The watt-hour meter is subject to a regular maintenance and testing regime to ensure accuracy. Comply with "Act for measurement", "Regulation for operation of electricity market" of South Korea. Calibrate the meter every two year.
Any comment:	Archived data are to be kept during the crediting period and two years after. The monthly data is archived in paper bill from KEPCO.

SECTION D. Description of the monitoring system

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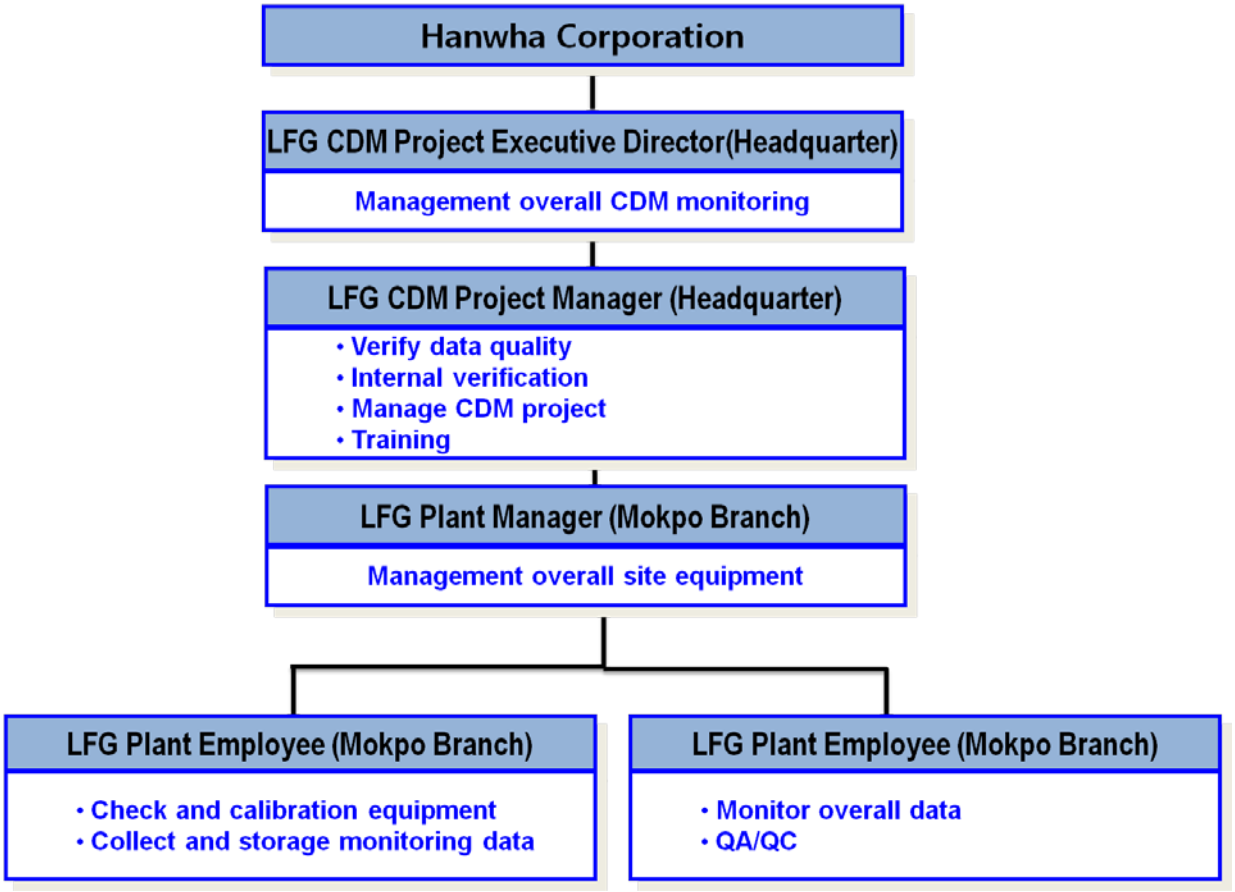
Data and parameters provided in Section C.
Monitoring data and parameters will be monitored and their measurement method will be referred to "Operating Manual-Mokpo LFG Power Plant". The relevant document is submitted to DOE.

Monitoring organization and the role of each party

The following figure describes the operational and management structure that monitor the project activity and the table below shows the responsible party for each task of monitoring.



<Figure D-1>The structure of monitoring system

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

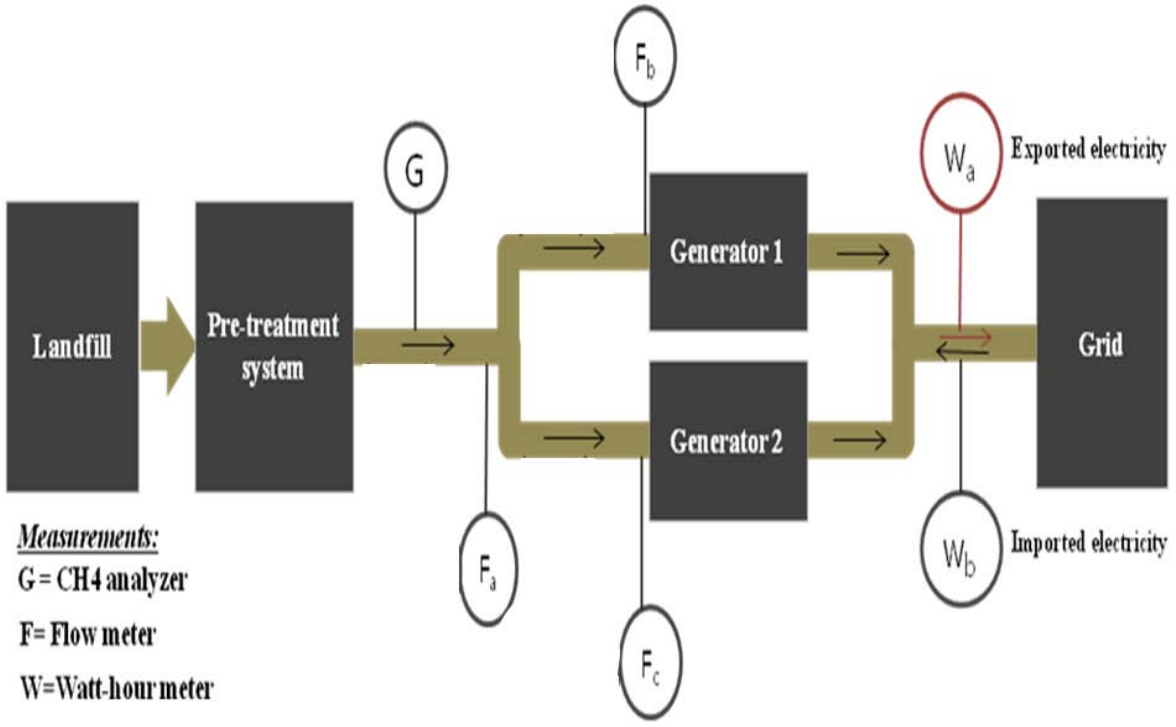
Item	Sub-item	Responsible person
Measure & Archive	**$LFG_{electricity, y}$**	Responsible person/department for the project : LFG Plant Manager / Mokpo Operating Team of HWC Mokpo branch
	$W_{CH4,y}$	
	$EL_{EXP, PJT, y}$	
	$EL_{IMP, PJT, y}$	
Measuring instrument check & Calibration	**Centralized monitoring 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: Korea Power Exchange (According to "Law regarding measurement" and : act on operation of electricity market")
Establish monitoring plan		Responsible person/department for the project : LFG CDM Project Executive Director / Environment /Renewable Team of HWC Headquarter LFG Plant Manage / Mokpo Operating Team of HWC Mokpo branch LFG CDM Project Manager / Environment /Renewable Team of HWC Headquarter
Task coordination		
Monitoring report		Responsible person/department for the project : LFG Plant Manager / Mokpo Operating Team of HWC Mokpo branch LFG CDM Project Manager / Environment /Renewable Team of HWC Headquarter

The monitoring equipments to measure amount of methane and electricity

- Gas flow meters are installed between the blower and generating facility to measure LFG flow rate, LFG volumes expressing in normalized cubic meters.

-A methane analyzer is located before the above flow meter to measure the fraction of methane in LFG volume fed into the gas engine.

-Electricity measuring meters are to be set-up transparently in accordance with "Law regarding measurement" and "Act on operation of electricity market". Thereafter, the meter is calibrated when installed behind the generator and sealed up after affirmation of Korea Power Exchange. The certified sheet of measurement registration is submitted to DOE.



<Fig. D-2> The Location of the Monitoring facilities

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 data storage, equipment calibration and maintenance, corrective action, and Emergency procedures for unintended emissions.

- Three gas flow meters installed to ensure that if one of the meters has a problem to measure LFG flow rate, the two remainings are measured to calculate the amount of landfill gas.

- The amount of electricity exported (Wa) to the grid-connected system is measured by watt-hour meter. The measured data is simultaneously transferred to Korea Power Exchange and the amount of imported electricity (Wb) is measured by a meter, as well. They are collected daily, weekly and monthly.

Data records and storage:

The measured data is monitored on a computer and Mokpo Operation team should check them 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. The equipment, related to CDM project could be calibrated by LFG Plant Manager if necessary.

- The watt-hour meter is subject to a regular maintenance and testing regime to ensure accuracy. This is in compliance with the “Act for measurement” and “Regulation for operation of electricity market” of South Korea; under this regulation, the calibration period is every two years.

Corrective action:

LFG Plant manager will report all issues and data related to plant operation to LFG CDM Project manager (Environment/renewable team).

Operation review, internal audit and corrective action is carried out by Environment/renewable 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 in knowledge/information of operating equipment and monitoring by skilled technician from the Generator manufacturer, and/or participate in training programs. The employees should attain a comprehensive knowledge with regard to the general and technical aspects of CDM project.

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

28/05/2010~29/05/2010, 1st internal training has been done by headquarters' LFG CDM project manager on the monitoring.

29/05/2010, external training for monitoring equipment has been done by experts.

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

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

Parameter	Unit	Description
MD_y	tCO_2e	CO_2 equivalent of the methane captured and destroyed/ gainfully used by the project activity in year y;
$MD_{reg,y}$	tCO_2e	Methane emissions that would be captured and destroyed to comply with national or local safety requirements or legal regulations in the year 'y'
$EL_{EXP, PJT, y}$	tCO_2e	The quantity of electricity exported to the grid-connected system by this project activity during the year, y(MWh)
CEF	tCO_2e	Combined emission factor in electricity generation by grid-connected system; weighted average of EF_{OM} and EF_{BM}.

CEF is 0.5375 tCO_2e/MWh and this is fixed factor during crediting period.

$$MD_y = LFG_{electricity,y} * wCH_{4,y} * DCH_{4,y} * GWP_{CH4}$$

Parameter	Unit	Description
$LFG_{electricity,y}$	Nm^3	Landfill gas flared or used as fuel in the year 'y'
$W_{CH4,y}$	%	Methane content in landfill gas in the year 'y'(mass fraction)
$D_{CH4,y}$	ton/ m^3	Density of methane at the temperature and pressure of the landfill gas in the year 'y'
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane

Density of methane is measured by flower meter continuously and no separate monitoring of temperature and pressure when expressing LFG volumes in normalized cubic meters. Methane content is measured by gas analyzer.

E.2. Project emissions calculation

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

Parameter	Unit	Description
$EL_{IMP, PJT, y}$	tCO_2e	The quantity of electricity imported from gird-connected system by project activity during the year, y(MWh)

CEF is 0.5375 tCO_2e/MWh and this is fixed factor during crediting period

E.3. Leakage calculation

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Mokpo landfill gas has not been destructed by flaring and/or taken utilisation before developing the proposed project. For this project, there is no leakage effect.

E.4. Emission reductions calculation / table

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

Date	ER_y	$LFG_{elecricity,y}$	$wCH_{4,y}$	$DCH_{4,y}$	GWP_{CH4}	$MD_{reg,y}$	$EL_{exp,y}$	$EL_{imp,y}$	CEF	Leakage
18/02/2010 ~ 17/08/2010	17,241.567	2,143,655.800	0.489	0.0007168	21	0	2749.586	2.071	0.5375	0

Monitoring periods	Emission reductions achieved in each monitoring period (tCO_2e)	The accumulated emission reductions achieved by the project activity (tCO_2e)
18/02/2010~17/08/2010 (181 days)	17,242	17,242

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

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Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
$BE_{CH4,SWDS,y}$ / MD_y (Nm^3/181days)	1,516,925	2,143,656
EG_y/EL_{exp} (MWh)	1,591	2,750
$EL_{imp,PJT,y}$ (MWh)	1	2
Emission reductions (tCO_2e)	12,110	17,242

E.6. Remarks on difference from estimated value

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Actual values reached during the monitoring period: 17,242 tCO_2e
Values applied in ex-ante calculation of the registered CDM-PDD(2010): 12,110 tCO_2e

There was 29.76% increased in the actual emission reductions achieved during the monitoring period compared to the 2nd crediting period in registered CDM-PDD.
The relevant cause of the increase in Emission Reductions is as follows.

Registered PDD calculated using conservative data expected anti-post.
In PDD, $BE_y=BE_{CH4,SWDS,y}-MD_{reg,y.}$ The methane emission potential of a solid waste disposal site, $BE_{CH4,SWDS,y}$ in tCO_{2e}, 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 differing from actual LFG generation on monitoring system.

Caused by Climate
Actual monitoring date is from 18/02/2010 to 17/08/2010.
Most of the time of monitoring period is hot summer in South Korea. We cannot ignore the impact of summer temperatures. If the temperature rises, the quantity of methane gas production tends to be activated.

Collecting equipment for LFG
In registered PDD, baseline emission based on the natural emissions for landfill gas by methodology. Meanwhile during the actual monitoring period, the landfill gas production is based on the draft force using collecting wells in site. When using the collecting well, initial landfill gas under the site collected by collecting wells. As initial landfill gas extraction by draft force, landfill gas will increase more than expected for only initial landfill. Compared to natural emissions, draft force collection by collecting well brings an increase in the landfill gas production. Increased landfill gas production will also increase power generation.

Quantity of waste for LFG
Mokpo landfill starting year was in 1996, and expected completing year will be 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**	**72,145**
2008	**66,134**	**74,264**
2009	**65,644**	**70,032**
2010(1~8)	**43,439**	**50,860**

There was 14.59% increased in the actual quantity of waste achieved during the monitoring period compared to the expected quantity of waste in registered CDM-PDD.
Due to the optimization of overall environment for landfill during the monitoring period, emission reduction increased in this project.