Study into Utilization of Methane Gas at a Landfill Site in Amman, Jordan

Project Design Document

CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1. Title of the project activity:

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Ghabawi Landfill Gas Capture and Power Generation Project in Amman City, Jordan Ver001, 02/03/2007

A.2. Description of the project activity:

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Shimizu Corporation, a general construction and engineering firm based in Tokyo, the capital of Japan, was founded in 1804. Shimizu Corporation's business spans a wide range of activities including construction of buildings and plants, construction of tunnels, dams, bridges and roads, real estate, design and consulting, etc.

In the project, it is planned to capture landfill gas (LFG) emitted on Ghabawi Landfill Site in Amman City, Jordan, to supply methane gas, which is a flammable greenhouse gas (GHG) contained in the LFG, as fuel for generating electricity in a gas engine generator. Moreover, since the generated electric power will replace grid electricity, the project will also lead to reduction of CO2 emissions at thermal power plants.

Amman City owns Ghabawi Landfill Site. The project will be implemented in a part of Ghabawi Landfill Site referred to as "Cell 1." The project target area is approximately 11 ha. Operation here was started in 2003 and it is scheduled to carry in waste until 2007.

In the project, it is planned to install gas collection pipes on the site, and to collect and treat LFG before utilizing it for power generation in a gas engine generator (GEG). The generated power will be sold to the local grid. Meanwhile, LFG that cannot be used in the GEG will be combusted and destroyed via flare stacks. Since the power generated by this system will enable power stations within the grid to reduce consumption of fossil fuels, the project can be expected to have an effect in terms of energy saving and reduction of greenhouse gas emissions. Moreover, concerning the LFG that cannot be used in the GEG, since methane will be converted to carbon dioxide as a result of combustion and destruction in the flare stack, the greenhouse gas reduction effect will be further boosted.

In the project, it is planned to commission a flaring system from July of 2008. Moreover, introduction of a 1800 kW (1.8 MW) GEG is envisaged, however, this shall be determined upon first installing the LFG collection equipment, confirming the amount of generated LFG and re-examining the required GEG installation capacity according to that amount. If the amount of LFG is inadequate or fluctuates wildly, it is possible the GEG will not be installed and only flaring shall be carried out.

The project crediting period is 14 years, and the aggregate reduction of emissions during this period is estimated as 1,460,439 ton-CO_2 ("ton-CO_2" means "ton-CO_2 equivalent").

In addition to realizing reduced emissions of GHG, in Amman, it is anticipated the project will contribute to sustainable development in the following ways:

Environmental improvement through prevention of odor on the landfill site;
- Replacement of existing power generation systems through introduction of state-of-the-art generation technology;
- Improvement in human resources through introduction of new technology;
- Effective utilization of energy; and
- Creation of new employment through project realization (construction, operation)

A.3. Project participants:

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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)
Jordan (host)	**Municipality of Amman City**	**No**
Japan	**Private entity /** **・ Shimizu Corporation**	**No**

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

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The Hashemite Kingdom of Jordan

A.4.1.2. Region/State/Province etc.:

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N/A

A.4.1.3. City/Town/Community etc:

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Municipality of Amman City

Figure 1 shows the location of Amman and Jordan.

Source: The University of Texas at Austin Perry-Castañeda Library Map Collection (http://www.lib.utexas.edu/maps/jordan.html)

Figure 1 Location of Jordan and Amman City (the arrow points to Amman City)

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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Ghabawi Landfill Site, is located approximately 25 km east of Amman City center in the middle of a rocky desert, and there are no inhabited districts in the surrounding area. The overall landfill site covers an area of approximately 200 ha; site operation was started in 2003 and it is scheduled to close the site in 2027.

The project will be implemented in a part of Ghabawi Landfill Site referred to as “Cell 1” (see Figure 2). The project target area is approximately 11 ha and the maximum planned landfill depth is roughly 12 m. Operation on Cell 1 was started in 2003 and it is scheduled to carry in waste until 2007. Moreover, after Cell 1 is filled in, Cell 2 and so on will be successively used.

Ghabawi Landfill Site receives 3,360,000 m3 of solid waste from Amman City every year, and it implements planned landfill disposal as a managed disposal site.

Figure 2 Plan view of Ghabawi Landfill Site

A.4.2. Category(ies) of project activity:

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Fugitive gas capture and alternative / renewable energy
Out of 15 Sectoral Scope, this corresponds to 13: Waste handling and disposal and 1: Energy industries (renewable - / non-renewable sources).

A.4.3. Technology to be employed by the project activity:

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○ **LFG collection system technology**. This is composed of vertical collection holes, horizontal gas drains, gas collection pipes, airtight sheet, gasholders, measuring instruments, and blowers. It is a high-efficiency system in which an LFG collection efficiency of 60% or more can be anticipated.

○ **Biogas small-scale GEG technology**. This is composed of a gas engine capable of realizing stable operation using even a rarefied LFG like methane, generators, control panels, grid connection lines, and measuring instruments. The gas engine has generating efficiency of 30~40%, which is equivalent to or better than existing steam turbines in Jordan. In addition, high-level technology is required for a gas engine that can stably operate on a rare gas fuel such as LFG.

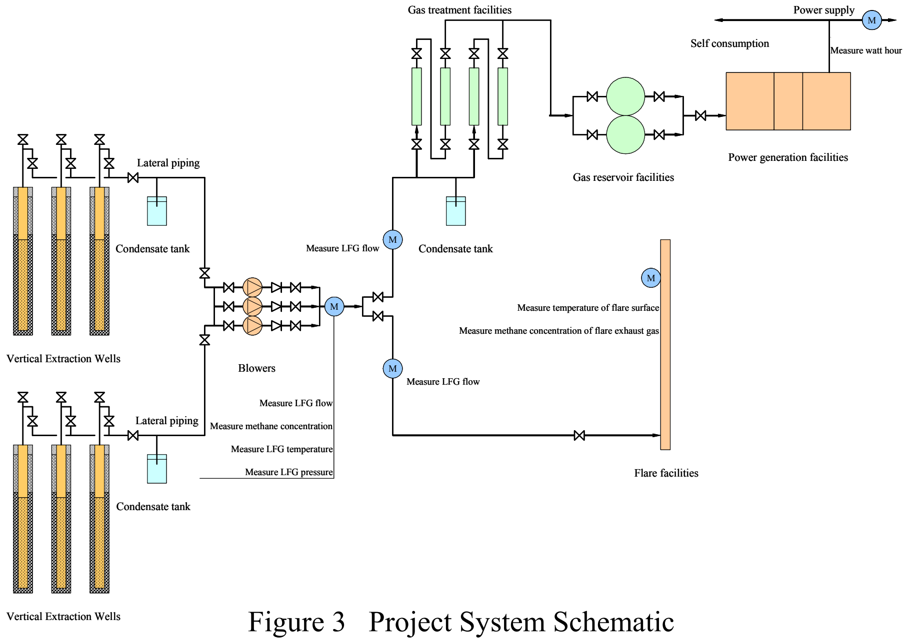

Figure 3 Project System Schematic

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

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The project crediting period is 14 years and the amount of reduction is calculated as follows.

Year	Annual estimation of emission reductions in tonnes of CO_2e
2008	74,535
2009	138,299
2010	144,589
2011	135,318
2012	126,717
2013	118,737
2014	111,334
2015	104,466
2016	98,094
2017	92,183
2018	86,698
2019	81,610
2020	76,701
2021	71,159
Total estimated reductions (tonnes of CO_2e)	1,460,439
Total number of crediting years	14
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	104,317

A.4.5. Public funding of the project activity:

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This project is not planned as an ODA undertaking and as such will not receive ODA funding.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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The following baseline and monitoring methodology shall be applied to the Project:

Revision to the approved consolidated baseline methodology ACM0001/Version05
“ Consolidated baseline methodology for landfill gas project activities”
and
Revision to the approved consolidated monitoring methodology ACM0001/Version05
“Consolidated monitoring methodology for landfill gas project activities”

Moreover, the following is referred to in ACM0001.

“Tool for the demonstration and assessment of additionality (Version02) ”
and
“Tool to determine project emissions from flaring gases containing methane (Version01) ”

Moreover, the following methodologies are applied for calculating the amount of reductions obtained as a result of supplying the generated electricity:

INDICATIVE SIMPLIFIED BASELINE AND MONITORING METHODOLOGIES FOR SELECTED SMALL-SCALE CMD PROJECT ACTIVITY CATEGORIES
TYPE I-RENEWABLE ENERGY PROJECTS-I.D./Version10
‘Grid connected renewable electricity generation’

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

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In the Project, the following large-size methodology is used: “Revision to the approved consolidated baseline methodology ACM0001/Version05: Consolidated baseline methodology for landfill gas project activities.”

This methodology (ACM0001) is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:

a) The captured gas is flared; or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or
c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the ACM0002 "Consolidated Methodology for Grid-Connected Power Generation from Renewable." If capacity of electricity generated is less than 15MW and/or substituted thermal energy is 54 TJ (15 GWh) or less, small-scale CDM methodology will be applicable.

Meanwhile, conditions in the Project are as follows:

<1> Currently, LFG collection is not carried out on Ghabawi Landfill Site and all LFG is released into the atmosphere.
<2> The project proposes to collect LFG on Ghabawi Landfill Site and the captured gas is flared.
<3> The captured gas is used to produce energy (electricity), and emission reductions are claimed for displacing energy generation from other sources.

Therefore, since the project falls under applicability of (a) and (c) for the approved consolidated baseline methodology ACM0001 "Consolidated baseline methodology for landfill gas project activities" (hereinafter referred to as the consolidated methodology), this methodology is applied.

Moreover, due to the power generation and grid supply stated under condition (c) of the consolidated methodology, concerning claims for emissions reductions resulting from use of other energy sources, because the generator planned for installation has capacity of 1.8 MW, which is less than 15 MW, the indicative simplified baseline and monitoring methodology for selected small-scale CDM project activity categories (hereinafter referred to as the small-scale CDM methodology) is applied. Specifically speaking, out of the grid connected renewable electricity generation stated in the small-scale CDM methodology, the methodology given in paragraph 9 (a) is set.

B.3. Description of the sources and gases included in the project boundary

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The generation sources and gases included in the project boundary are as indicated below.

	Source	Gas	Included?	Justification/ Explanation
Baseline	The atmospheric release of the gas from the LFG site	CH_4	Yes	-
	Generation of power for supply to the power grid that the project is connected to.	CO_2	Yes	-
Project Activity	The atmospheric release of the gas from the LFG site	CH_4	Yes	-
	Electricity consumed in the project	CO_2	Yes	
	Flare incomplete combustion	CH_4	Yes	
	The combustion of fuel for transport of generated heat	CO_2	No	No transport of heat

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

>>

The baseline scenario is set and additionality is demonstrated according to the following methodology:

Tool for the demonstration and assessment of additionality (Version 02)

Details concerning determination of the baseline scenario are described in the examination of additionality in section B.5. Accordingly, the following paragraphs give an outline description.

Step 1 Identification of alternatives to the project activity consistent with current laws and regulations）

Here, the following scenarios were examined:

Scenario 1 : Maintain the status quo. This scenario assumes that LFG is emitted into the atmosphere without conducting any management, collection or utilization at all on Ghabawi Landfill Site and that no GEG is established.

Scenario 2 : LFG recovery project. This scenario assumes that LFG from Ghabawi Landfill Site is recovered and combusted by flaring in the interests of the environment and safety.

Scenario 3 : This project. This scenario assumes that LFG is recovered from Ghabawi Landfill Site and that methane, which is a GHG contained in the landfill gas, is combusted in a GEG with a view to generating electricity.

Step 2 Investment Analysis

As a result of conducting investment analysis, it became clear that Scenario 2 and Scenario 3 are not worth investing in. Accordingly, it was decided that the only plausible baseline is Scenario 1, i.e. maintenance of the status quo.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

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The baseline scenario is set and additionality is demonstrated according to the following methodology:

Tool for the demonstration and assessment of additionality (Version 02)

(a) Step 0: Preliminary screening based on the starting date of the project activity

Since the project is not scheduled to start before December 31, 2005, this step can be skipped.

(b) Step 1: Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a: Define alternatives to the project activity

The following alternative scenarios are raised here.

Scenario 1 : **Maintain the status quo.** This scenario assumes that LFG is emitted into the atmosphere as at present without conducting any management, collection or utilization at all on the Ghabawi Landfill Site and that no GEG is established.

Scenario 2 : **LFG recovery project**. This scenario assumes that LFG from Ghabawi Landfill Site is recovered and combusted by flaring in the interests of the environment and safety.

Scenario 3 : **This project.** This scenario assumes that LFG is recovered from Ghabawi Landfill Site and that methane, which is a GHG contained in the landfill gas, is combusted in a GEG with a view to generating electricity.

Sub-step 1b: Enforcement with applicable laws and regulations

Laws, regulations and guidelines connected to Scenarios 1~3 above are as follows.
- National Energy Efficiency Strategy
- Jordan's Energy Master Plan
- General Electricity Law for the Year 2002
- Environmental Protection Law (2002, 12)
  -- Regulation of Water Protection
  -- Regulation of Air Protection
  -- Regulation of Management of Solid Wastes
  -- Regulation or Environmental Impact Assessment

Upon examining the above, Scenarios 1~3 are deemed to comply with existing legislation in Jordan.

(c) Step 2: Investment Analysis

Sub-step 2a: Determine appropriate analysis method

Scenario 3, which expresses the CDM project, contains income (for sale of electricity) other than CER. Therefore, Option I (Apply simple cost analysis) cannot be adopted, so it is necessary to select from either Option II (Apply investment comparison analysis) or Option III (Apply benchmark analysis). Here Option III is adopted.

Sub-step 2b, Option II. Apply investment comparison analysis

IRR can be calculated either as project IRR or equity IRR. Here, we adopt project IRR, because we have not yet decided source of funding.

Sub-step 2c: Calculation and comparison of financial indicators

First, analysis of Scenario 2 is carried out. Here, CER income is not considered in accordance with the additionality demonstration tool. In Scenario 2, there is investment, but no corresponding returns can be anticipated. Since returns corresponding to the investment cannot be expected, this means that this baseline scenario is unfeasible.

Next, the analysis of Scenario 3 is carried out. Here, CER income is not considered in accordance with the additionality demonstration tool. In Scenario 3, there is investment but the problem concerns whether or not appropriate return (income from sale of electricity) can be expected. Since IRR calculation showed the IRR to be less than 2%, it is clear that Scenario 3 is not worth investing in. Accordingly, the above analysis shows that Scenario 3 is not the baseline scenario. The preconditions and results of the calculation as well as the results of sensitivity analysis are indicated in Annex 3 (BASELINE INFORMATION).

Sub-step 2d: Sensitivity analysis

Sensitivity analysis is carried out assuming the parameters of construction cost, running cost, unit price of power sale, and generated amount of LFG. The range of fluctuation shall be -10%～+10% for the construction cost, running cost and unit price of power sale, and -20%～+20% for the generated amount of LFG. As a result of the sensitivity analysis, the IRR is either minus or less than 4%, indicating that the forecast results in sub-step 2c remain the same irrespective of the surrounding conditions. Details of the sensitivity analysis are given in Annex 3 (BASELINE INFORMATION).

(d) Step 3: Barrier Analysis

Since Step 2 was implemented, Step 3 can be skipped.

(e) Step 4: Common Practice Analysis）

There is no evidence to suggest that a similar project has been, is being, or will be implemented in Jordan (excluding the examination as CDM project) (text of the additionality demonstration tool: “in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc.”)

(f) Step 5: Impact of CDM Registration

CER economic value is introduced to the investment analysis that was implemented in Scenario 3. When CER = 8 US$/t-$CO_2$, the IRR is 11.15%. This is a feasible level for investors.

To sum up, the above analysis shows that neither Scenario 2 nor Scenario 3 can be the baseline, and Scenario 1 was determined as the baseline scenario. Because the examination estimates that the project will realize aggregate emission reductions of 1,460,439 ton-CO_2 over 14 years, the project can be said to be additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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Based on ACM0001, the following expression is used to calculate the emission reductions.

(1) $ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y * CEF_{electricit,y} - ET_y * CEF_{thermal,y}$

Here, each item is defined as shown below.

ER_y	The GHG emissions reduction, in tonnes of CO_2 equivalents (tCO_2e)
$MD_{project, y}$	The amount of methane that would have been destroyed/combusted during the year, in, tonnes of methane (tCH_4)
$MD_{reg, y}$	The amount of methane that would have been destroyed/combusted during the year in the absence of the project, in, tonnes of methane (tCH_4)
GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is $21tCO_2e/tCH_4$
EL_y	Net quantity of electricity exported during year y, in megawatt hours (MWh).
$CEF_{electricity, y}$	CO_2 emissions intensity of the electricity displaced, in tCO_2e/MWh.
ET_y	Incremental quantity of fossil fuel, defined as difference of fossil fuel used in the baseline and fossil use during project, for energy requirement on site under project activity during the year y, in TJ.
$CEF_{thermal, y}$	CO_2 emissions intensity of the fuel used to generate thermal/mechanical energy, in tCO_2e/TJ

Here, since the project does not include thermal utilization, Equation (1) is modified in the manner shown in (1').

(1') $ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y * CEF_{electricit,y}$

Where each item is defined as follows.

(1a) $EL_y = EL_{EX, LFG} - EL_{IMP}$

$EL_{EX, LFG}$	Net quantity of electricity exported during year y, produced using landfill gas, in megawatt hours (MWh).
EL_{IMP}	Net incremental electricity imported, defined as difference of project imports less any imports of electricity in the baseline, to meet the project requirements, in MWh

(2) $MD_{reg,y} = MD_{project,y} * AF$

AF	Adjustment Factor

(3) $MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y}$

$MD_{flared,y}$	The quantity of methane destroyed by flaring, in tCH_4
$MD_{electricity,y}$	The quantity of methane destroyed by generation of electricity, in tCH_4
$MD_{thermal,y}$	The quantity of methane destroyed for the generation of thermal energy, in tCH_4

Here, since the project does not include thermal utilization, Equation (3) is modified in the manner shown in (3').

(3') $MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$

Here, $MD_{flared,y}$ and $MD_{electricity,y}$ can be calculated using expressions (4) and (5) below.

(4) $MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$

$LFG_{flare,y}$	The quantity of landfill gas fed to the flare during the year measured in cubic meters (m^3)
$w_{CH4,y}$	The average methane fraction of the landfill gas as measured during the year and expressed as a fraction (m^3 CH_4 / m^3 LFG)
D_{CH4}	The methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)
$PE_{flare,y}$	The project emissions from flaring of the residual gas stream in year y (tCO_2e)

(5) $MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$

$LFG_{electricity,y}$	The quantity of landfill gas fed into electricity generator (m^3)

B.6.2. Data and parameters that are available at validation:

(Copy this table for each data and parameter)

Data / Parameter:	EqC
Data unit:	%
Description:	Landfill gas collection efficiency
Source of data used:	NEDO Overseas Report 811, Shimizu Corporation, Feasibility Study on The Utilization of Methane(CH_4) Gas and Power Generation of Municipal Wastes in Yerevan Armenia」2002 P2-45、P2-46
Value applied:	60.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	Since these data are either guaranteed specifications from the equipment maker or values based on experience, the selected data are appropriate.
Any comment:	The amount of gas taking into account EqC shall be measured in monitoring.

Data / Parameter:	k
Data unit:	1/y
Description:	Methane generation rate
Source of data used:	McBean, Rovers & Farquhar 1995 "Solid Waste Landfill Engineering

	And Design, Englewood Cliffs, New Jersey: Prentice Hall PTR;" NEDO & Technical Consultants Co., Ltd. Research of Waste Electricity Generation Using Landfill Gas in Samarkand 2000,P 4-9, 4-15; Shimizu Corporation, Feasibility Study on The Utilization of Methane(CH_4) Gas and Power Generation of Municipal Wastes in Yerevan Armenia 2002, P2-41
Value applied:	0.0750
Justification of the choice of data or description of measurement methods and procedures actually applied :	Since the value is set based on the value used in Armenia after taking waste composition and climate in Georgia into account, the selected data are appropriate.
Any comment:	The amount of gas taking into account k shall be measured in monitoring.

Data / Parameter:	L_0
Data unit:	Nm^3/Mg
Description:	Methane generation potential
Source of data used:	Revised 1996 IPCC Guidelines for National Green house Gas Inventories: Reference Manual CHAPTER 6 WASTE
Value applied:	73.18
Justification of the choice of data or description of measurement methods and procedures actually applied :	In the IPCC Guidelines, L0 is generally given between 100 m^3/Mg and 200 m3/Mg. The calculated value here is slightly below this range, however, it shall be adopted as is here. Moreover, the calculation method is indicated in Annex 3: BASELINE INFORMATION.
Any comment:	This shall be measured as methane gas concentration in monitoring.

Data / Parameter:	Rx
Data unit:	t/year
Description:	Amount of waste carried in year x
Source of data used:	Waste Landfill Plan of Amman City
Value applied:	This is indicated in Annex 3: BASELINE INFORMATION.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Ghabawi Landfill Site is a managed landfill site. The project target area of Cell 1 started receiving waste in 2003 (during that year) and has since received 3,360,000 m^3 per year. As of 2007, Cell 1 has received a total of 15,150,000 m^3, and landfilling is progressing according to plan.
Any comment:	-

Data / Parameter:	GWP_{CH4}
Data unit:	-
Description:	Global Warming Potential of methane
Source of data used:	IPCC Second Assessment Report : Climate Change 1995
Value applied:	21

Justification of the choice of data or description of measurement methods and procedures actually applied :	Since the selected data are based on the IPCC report, they are considered to be appropriate.
Any comment:	The latest information shall be checked for in monitoring.

Data / Parameter:	D_{CH4} （standard state）
Data unit:	$tCH_4/Nm^3\ CH_4$
Description:	Methane density at standard temperature and pressure
Source of data used:	Revision to the approved consolidated monitoring methodology ACM0001/Version 05 “ Consolidated monitoring methodology for landfill gas project activities”
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied :	Since the value adopted in the approved consolidated methodology is used, the selected data are considered to be appropriate.
Any comment:	Changes in the approved methodology shall be checked for in monitoring.

B.6.3 Ex-ante calculation of emission reductions:

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Step1. Estimate of GHG emissions by sources:

In the project, since the monitoring plan entails directly measuring the amount of emissions reductions in the case where the project is implemented, there will be no measurement of the actual amount of emissions. However, project emissions can be sought through subtracting the amount of methane destroyed in the project from the amount of methane occurring within the project boundary, and then adding the emissions resulting from the additional consumption of electricity in the project.

The amount of methane occurring within the project boundary $M_{landfill,y}$ (tCH4) can be estimated as shown in expression (6) through using the First Order Decay Model indicated in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE.

Moreover, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories have been disclosed, however, they have been revised in order to predict the generated amount of LFG more accurately according to reality. The project intends to directly measure the reduction in greenhouse gas emissions at the time of project implementation based on the collected and used amounts of LFG, so calculations at present only indicate the predicted reduction. Moreover, since the conventional calculation technique gives a more conservative result, this method shall be adopted. The expression for this is given below:

(6) $M_{landfill,y} = D_{CH4} * \sum Q_{y,x}$

$= D_{CH4} * \sum(k * R_x * L_0 * e^{-k(y-x)})$

The project emissions MPE_y (tCH_4) can be sought through subtracting the amount of methane destroyed in the project from the generated amount in expression (6), and then adding the amount of emissions resulting from the additional electricity used in the project.

$$\begin{aligned}(7)\ MPE_y &= M_{landfill,y} - MD_{project,y} + EL_{IMP} * CEF_{electricity,y} / GWP_{CH4} \\ &= D_{CH4} * \sum(k * R_x * L_0 * e^{-k(y-x)}) - (MD_{flared,y} + MD_{electricity,y}) \\ &\quad + EL_{IMP} * CEF_{electricity,y} / GWP_{CH4}\end{aligned}$$

Accordingly, project emissions PE_y (tCO_2e) are obtained through the following expression:

$$\begin{aligned}(8)\ PE_y &= GWP_{CH4} * (D_{CH4} * \sum(k * R_x * L_0 * e^{-k(y-x)}) - (MD_{flared,y} + MD_{electricity,y})) \\ &\quad + EL_{IMP} * CEF_{electricity,y}\end{aligned}$$

Step2. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

In the project, since it is planned to adopt monitoring methodology that measures emission reductions in the case of project implementation, there will be no measurement of baseline emissions. However, concerning trial calculation of the baseline emissions, these can be calculated as the sum of methane emissions at the baseline in Equation (6) and the emissions reductions through power generation and supply to the grid in the project:

$$\begin{aligned}(9)\ BE_y &= GWP_{CH4} * (M_{landfill,y} - MD_{reg,y}) + EL_{EX.LFG} * CEF_{electricity,y} \\ &= GWP_{CH4} * (D_{CH4} * \sum(k * R_x * L_0 * e^{-k(y-x)}) - MD_{reg,y}) + EL_{EX,LFG} * CEF_{electricity,y}\end{aligned}$$

Step3. Estimated leakage:

Based on the applied consolidated methodology, there is no leakage in the Project.

Step4. The sum of Step 1 and Step 3 representing the project activity emissions:

>>This is the same as in Step 1.

The preconditions and results of the calculation are indicated in Annex 3 (BASELINE INFORMATION). It should be noted, however, that these figures are estimate values and not actual emissions.

B.6.4 Summary of the ex-ante estimation of emission reductions:

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The following table gives a summary of the ex-ante estimation of emission reductions caused by the project. It should be noted, however, that these figures are estimate values and not actual emissions. Actual emission reductions are directly measured in the monitoring.

<Total>

Year	(ton-CO_2e) Estimation of project activity emission (tonnes of CO_2e)	(ton-CO_2e) Estimation of baseline emission (tonnes of CO_2e)	(ton-CO_2e) Estimation of leakage (tonnes of CO_2e)	(ton-CO_2e) Estimation of emission reductions (tonnes of CO_2e)
2008	201,521	276,057	0	74,535
2009	117,811	256,110	0	138,299
2010	103,045	247,633	0	144,589
2011	95,147	230,465	0	135,318
2012	87,820	214,537	0	126,717
2013	81,023	199,760	0	118,737
2014	74,717	186,051	0	111,334
2015	68,866	173,332	0	104,466
2016	63,438	161,532	0	98,094
2017	58,403	150,585	0	92,183
2018	53,731	140,429	0	86,698
2019	49,397	131,007	0	81,610
2020	45,448	122,149	0	76,701
2021	42,164	113,323	0	71,159
Total (tonnes of CO_2e)	1,142,530	2,602,969	0	1,460,439

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

>>

The following table shows the data and parameters in the monitoring. Incidentally, the ID numbers of monitoring items in the consolidated methodology ACM0001 are also given under “Any comment.” Because the project entails no use of boilers or supply of heat using methane gas, monitoring items ID4, ID12 and ID15 out of the consolidated methodology have been omitted.
Moreover, in the project, concerning the flare equipment efficiency, the default value for closed flare equipment indicated in the methodology, i.e. 0.9, has been adopted.

(Copy this table for each data and parameter)

Data / Parameter:	$LFG_{total,y}$
Data unit:	m^3
Description:	Total amount of landfill gas captured
Source of data to be used:	Flow meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION).
Description of measurement methods and procedures to be	Measured continuously and recorded once a month Data archive: electronic

applied:	Length of archiving: the crediting period and two years after
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	ID number:1 $LFG_{total}=LFG_{flare} + LFG_{electricity}$: this measures the reliability of the flow meter data.

Data / Parameter:	$LFG_{flare,y}$
Data unit:	m^3
Description:	Amount of landfill gas flared
Source of data to be used:	Flow meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION).
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month Data archive: electronic Length of archiving: the crediting period and two years after
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	ID number:2

Data / Parameter:	$LFG_{electricity,y}$
Data unit:	m^3
Description:	Amount of landfill gas combusted in generator
Source of data to be used:	Flow meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION).
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month Data archive: electronic Length of archiving: the crediting period and two years after
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	ID number:3

Data / Parameter:	$PE_{flare,y}$
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year y (1) Flare exhaust gas temperature T_{flare} (2) Amount of LFG in flaring (1 hour) $LFG_{flare,h}$ (3) Ratio of methane in LFG $w_{CH4,h}$ (4) Flare efficiency $\eta_{flare,h}$

Source of data to be used:	(1) N-type thermocouple (2) Flow meter (3) Gas analyzer (4) Default value 0.9 Measured on site/ Calculated from measured data
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION).
Description of measurement methods and procedures to be applied:	(1) Measured continuously. (2) Measured continuously. Values to be averaged hourly. (3) Measured continuously. Values to be averaged hourly. (4) Checked that the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour h and the manufacturer's specifications on proper operation of the flare are met continuously during the hour h. Data archive: electronic How long archive: during the crediting period and two years after
QA/QC procedures to be applied:	(1) Thermocouples should be replaced or calibrated every year. (2) Flow meters are to be periodically calibrated according to the manufacturer's recommendation. (3) Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard certified gas.
Any comment:	(1) A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating. An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. (2)(3)Ensure that the same basis (dry or wet) is considered for the measurement of $LFG_{flare,h}$ and the measurement of $w_{CH4,h}$. ID number:5

Data / Parameter:	w_{CH4}
Data unit:	m^3CH_4/m^3LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Methane fraction meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.5
Description of measurement	Measured continuously and recorded once a month

methods and procedures to be applied:	Measure according to the wet standard.
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	Measured by continuous gas quality analyser. ID number:6

Data / Parameter:	T
Data unit:	K
Description:	Temperature of the landfill gas
Source of data to be used:	Thermo meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	ID number:7

Data / Parameter:	P
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data to be used:	Pressure gauge Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	Measured to determine the density of methane DCH_4. Using flow meters that automatically measure temperature and pressure. Expressing LFG volumes in normalized cubic meters. ID number:8

Data / Parameter:	$EL_{EX,LFG}$
Data unit:	MWh
Description:	Total amount of electricity exported out of the project boundary.
Source of data to be used:	Watt hour meter

	Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION).
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	Required to estimate the emission reductions from electricity generation from LFG. ID number:9

Data / Parameter:	EL_{IMP}
Data unit:	MWh
Description:	Total amount of electricity imported to meet project requirement.
Source of data to be used:	Watt hour meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION). Moreover, since the electric power requirement in the project is included in the system power consumption (10% of generated power) deducted from the electric power generated in the gas engine, imported power is 0.
Description of measurement methods and procedures to be applied:	Measured continuously and recorded once a month
QA/QC procedures to be applied:	Instruments are periodically tested in order to secure accuracy.
Any comment:	Required to determine CO_2 emissions from use of electricity or other energy carriers to operate the project activity. ID number:10

Data / Parameter:	$CEF_{electricity,y}$
Data unit:	tCO_2 /MWh
Description:	CO_2 emissions intensity of the electricity displaced
Source of data to be used:	Data received from the DNA in Jordan
Value of data applied for the purpose of calculating expected emission reductions in section B.5	This is indicated in Annex 3 (BASELINE INFORMATION). Moreover, since data cannot currently be received from the DNA, data was used from “Electric Utilities in Overseas Countries, 2nd Edition,” (2005, Overseas Electricity Survey Corporation).
Description of measurement methods and procedures to be applied:	Data received once a year, on regular basis As specified in AMS.1.D
QA/QC procedures to be applied:	-
Any comment:	If it cannot be obtained from the previous year’s data, used the latest available data.
	ID number:11

Data / Parameter:	Regulatory requirements relating to landfill gas projects
Data unit:	Test
Description:	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the credit period.
Source of data to be used:	Information received from the Government of Jordan
Value of data applied for the purpose of calculating expected emission reductions in section B.5	AF: 0.000
Description of measurement methods and procedures to be applied:	Information received once a year, on regular basis
QA/QC procedures to be applied:	-
Any comment:	ID number:13

Data / Parameter:	Operation of the energy plant
Data unit:	Hours
Description:	This is monitored to ensure methane destruction is claimed for methane used in electricity equipment when it is operational.
Source of data to be used:	Watt hour meter Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Once a year, on regular basis
QA/QC procedures to be applied:	-
Any comment:	From the cumulative amount of electric energy, estimate the operating time of generating equipment and make sure it is consistent with the destroyed amount of methane gas actually measured. ID number:14

B.7.2 Description of the monitoring plan:

>>

Figure 4 shows the monitoring plan in the project.

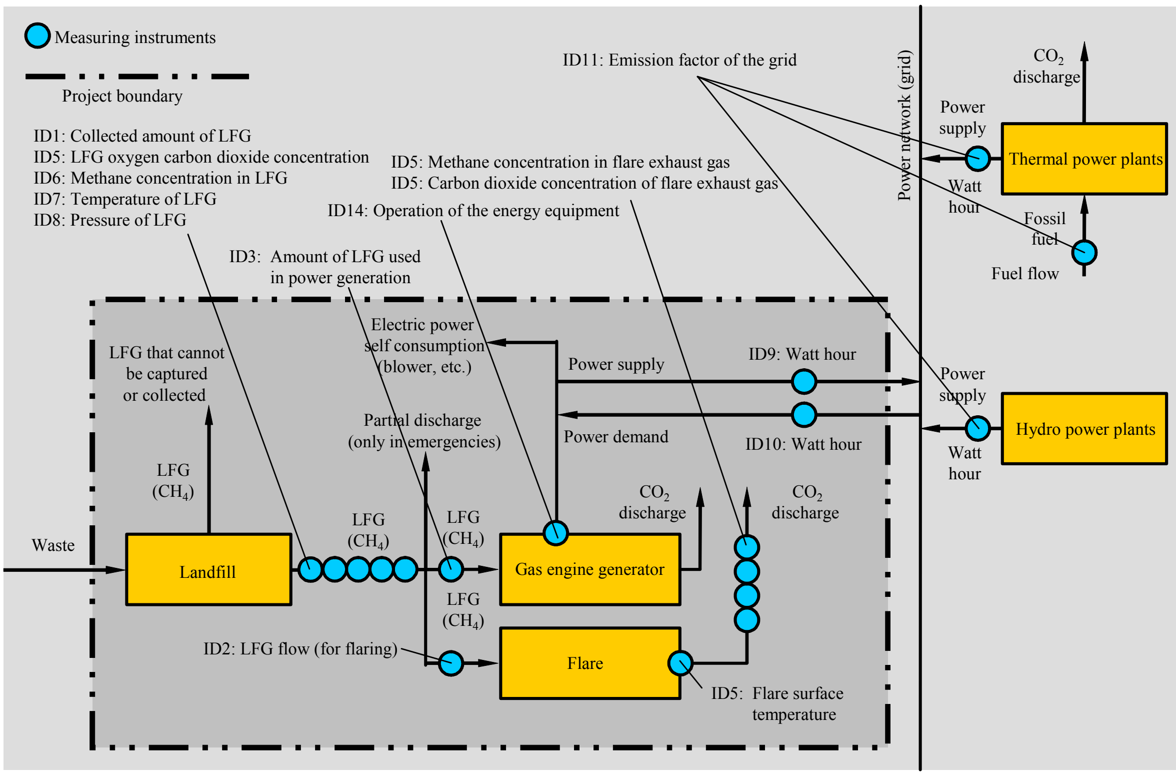

Figure 4 Flow chart of monitoring plan

Note: Blue circles indicate measuring instruments, and staggered line indicates the project boundaries. Moreover, ID numbers correspond to the monitoring items in the consolidated methodology.

The amount of sold electricity (ID9) measured in this monitoring plan is the amount obtained after subtracting electricity used in the system from the amount of electric energy generated.

The Municipality of Amman City will bear full responsibility for project operation and management (monitoring, facilities operation and maintenance, accounting, CER control, subcontracting, personnel affairs, reporting, etc.).

In the project, quality control and quality assurance shall be carried out by the following methods.

○ The project implementing organization will consist of operating personnel and management.
○ Management will prepare written procedures for operating facilities.
○ Written procedures, containing daily work contents, periodic maintenance methods and judgment criteria, etc., will be compiled according to appropriate formats.
○ Management will check reports from operating personnel and determine there are no problems according to the procedures. If problems are found in such checks, management will implement the appropriate countermeasures with appropriate timing.

○Management will everyday file and store reports from operating personnel according to the procedures.
○ In the event of accidents (including the unforeseen release of GHG), management will ascertain the causes, implement and instruct countermeasures to the operating personnel.
○ In cases of emergency (including the unforeseen release of GHG), operating personnel will take stopgap measures and implement countermeasures according to instructions from management.
○ Measuring instruments will be periodically and appropriately calibrated according to the procedures. Calibration timing and methods will be in accordance with "the monitoring plan".
○ Measured data will be disclosed and open to public comment. Received comments and the steps taken in response to them will also be disclosed.
○ Measured data will also be subject to audit by government agencies in the host country.

From the results of the monitoring, the following method is used to calculate emission reductions in the Project.

(1') $ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y * CEF_{electricity,y}$

Explanation: ER_y is the greenhouse gas emission reduction achieved by the project activity during a given year "y". This formula makes it possible to directly calculate the quantity of emissions reductions in the Project. In Item 1, from the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$), the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$) is deducted and then Global Warming Potential value for methane (GWP_{CH4}) is multiplied. This corresponds to Phase A described in Section B. Item 2 is obtaining by subtracting the amount of imported electricity (EL_{IMP} = ID10) required for the project activities from the amount of electricity exported outside of the project boundary ($EL_{EX,LFG}$ = ID9) and multiplying by the grid emission coefficient ($CEF_{electricity,y}$ = ID11).

(2) $MD_{reg,y} = MD_{project,y} * AF$

Explanation: The amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$) is the product of the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and an "Adjustment Factor" (AF = ID11).

(3') $MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$

Explanation: The amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) is the sum of the quantity of methane destroyed by flaring and the quantity of methane destroyed by generation of electricity.

(4) $MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$

Explanation: The quantity of methane destroyed by flaring ($MD_{flared,y}$) is the quantity of landfill gas flared during the year ($LFG_{flare,y}$ = ID2), the methane fraction of the landfill gas ($w_{CH4,y}$ = ID6), the methane density (D_{CH4}) and project emissions from the flare ($PE_{flare,y}$＝ID5).

(5) $MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$

Explanation: The quantity of methane destroyed by generation of electricity ($MD_{electricity,y}$) is the quantity of landfill gas fed into electricity generator ($LFG_{electricity,y}$ = ID3), the methane fraction of the landfill gas ($w_{CH4,y}$ = ID6) and the methane density (D_{CH4}).

(10) $D_{CH4} = 0.0007168 * (P/101.3) * (273.15/T)$

Explanation: The methane density (D_{CH4}) is the specific gravity (0.0007168t/Nm^3) (according to the consolidated monitoring method) of methane gas in the standard state (101.3kPa, 0℃ = 273.15K) with correction for the LFG temperature (T = ID7) and LFG pressure (P = ID8).

(11) $PE_{flare,y} = \sum_{(h=1\sim8760)} LFG_{flare,h} * w_{CH4,h} * D_{CH4} * (1 - \eta_{flare,h}) * GWP_{CH4}$

Explanation: Project emissions from the flare ($PE_{flare,y}$) are obtained by multiplying the amount of methane emitted without being destroyed in the flare, obtained by correcting the sum of landfill gas flared every hour ($LFG_{flare,h}$ = ID5), the methane fraction of the landfill gas ($w_{CH4,y}$) and the methane density (D_{CH4}) corrected with the flare efficiency ($\eta_{flare,h}$＝ID5), by the global warming coefficient of methane (GWP_{CH4}), and finding the annual total of the resulting hourly emissions.

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

>>
Date: 02/03/2007
General Manager : Kurita Hiroyuki, and
Manager : Maruyama Kazuhide
Manager: Yashio Akira
Shimizu Corporation
GHG Project Department
SEAVANS SOUTH, 1-2-3
Shibaura, Minato-ku, Tokyo 105-8007
03-5441-0137（in Japan）
+81-3-5441-0137（from overseas）
（Japanese HP）http://www.shimz.co.jp/
（English HP）http://www.shimz.co.jp/english/index.html

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>>

The project start date is 01/07/2008.

C.1.2. Expected operational lifetime of the project activity:

>>

The expected operational lifetime of the project is set at 14 years 0 months.

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

>>

7 years 0 months

C.2.1.2. Length of the first crediting period:

>>

N/A

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>

N/A

C.2.2.2. Length:

>>

N/A

SECTION D. Environmental impacts

>>

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>

The following paragraphs describe the results of environmental impact analysis.

The project can be expected to impart positive environmental improvement in terms of preventing odor on the landfill site, reducing fuel consumption for electricity generation in the energy system, and thereby reducing emissions of pollutants into the atmosphere. Having said that, concern also exists over the following impacts, so the measures described will need to be taken in order to minimize their impact.

○**Noise and vibration:** Installation of the blowers for LFG collection and the GEG will create noise and vibration. However, since these facilities will be located sufficiently apart from houses around the landfill site, there shouldn't be any problems. Rather, the only problem will be that concerning the working environment (impact on hearing, etc.) for operators on the site. This can be resolved by installing appropriate soundproof covers and vibration-proof frames.

○**Air pollution resulting from GEG exhaust gases:** It is possible that operation of the GEG will lead to pollution of the atmosphere by SOx and NOx contained in the exhaust gases. However, since these facilities will be located sufficiently apart from houses around the landfill site, they shouldn't pose any problems. Having said that, it will be necessary to install appropriate LFG desulfurization equipment and NOx reduction technology (on the generating machinery side) to avert any pollution.

○**Risk of fire from installation of flaring equipment:** Installation of flaring equipment and the artificial collection of methane gas may increase the risk of fires occurring along pipe routes and around the flaring equipment. This can be resolved by measuring and monitoring oxygen concentration inside LFG collection pipes, stopping the system when the oxygen concentration becomes too high, and stabilizing flame by means of burner combustion control of the flare equipment.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

Environmental impact assessment in Jordan is implemented according to the Regulation of Environmental Impact Assessment that was established based on the Environmental Protection Law (December 2002). However, since the project intends to improve the environment, the host government has indicated that there will be no need to implement the prescribed EIA procedure.

Having said that, in cases where discharge of air pollutants in excess of standards prescribed in the Jordanian air pollution prevention law is recognized in monitoring, it will be necessary to take improvement measures.

SECTION E. Stakeholders' comments

>>

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

In CDM projects in Jordan, it is necessary to collect comments from stakeholders and include these in the PDD. However, there are no particular stipulations regarding who can become stakeholders.

Accordingly, comments were collected from the following stakeholders considered to be appropriate at the present time.

1. Amman City Municipality: owner of the landfill site
2. Landfill site operating company: the company in charge of collecting, hauling and allocating urban solid waste (MSW) on landfill sites in Amman
3. Ministry of Energy: the department in charge of managing power stations belonging to the ministry

E.2. Summary of the comments received:

>>

1. Comments from Amman City Municipality:

Amman City Municipality has high hopes for this CDM project.

Through collecting and destroying landfill gases that are currently allowed to escape into the atmosphere, the project can mitigate the impact of greenhouse gases on global warming. Moreover, since part of the captured methane will be used as fuel to generate electricity in a GEG, for a country such as Jordan which does not have great petroleum resources, great expectation is placed on the utilization of such alternative energy in terms of energy policy.

2. Comments from the landfill site operating company

On hearing the intentions of Amman City, we are prepared to cooperate with this CDM project. Through further improving landfill site management, we hope the project will help improve the work environment for local operators. We are currently striving to appropriately manage the disposal site according to the wishes of the city and we anticipate that the project will support this in both technical and economic terms.

3. Comments from the Ministry of Energy

Based on the policy of the Jordanian Government, the Energy Ministry is prepared to support the implementation of CDM projects in the country.

In the project, it is planned to generate electricity in a GEG using captured methane. Since utilization of alternative energy is one of the principles of energy policy in Jordan, the project conforms with this.

Moreover, when it comes to implementing the project, we hope that ample consultation is held with the local power distribution company, etc. and that adequate consideration is given to other environmental impacts.

E.3. Report on how due account was taken of any comments received:

>>

According to the comments that have been provided, all stakeholders are positive about this project, however, and it is not necessary to take any particular steps regarding the comments given.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Project Participant 1

Organization:	Shimizu Corporation
Street/P.O.Box:	1-2-3, Shibaura
Building:	SEAVANS SOUTH
City:	Minato-ku
State/Region:	Tokyo
Postfix/ZIP:	105-8007
Country:	Japan
Telephone:	81-3-5441-1111 03-5441-1111
FAX:	- -
E-Mail:	- -
URL:	http://www.shimz.co.jp/english/index.html http://www.shimz.co.jp/
Represented by:	-
Title:	General Manager
Salutation:	Mr.
Last Name:	Kurita
Middle Name:	- -
First Name:	Hiroyuki
Department:	GHG Project Department
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Personal E-Mail:	kurita@shimz.co.jp

Project Participant 2

Organization:	Municipality of Amman City
Street/P.O.Box:	
Building:	
City:	
State/Region:	
Postfix/ZIP:	
Country:	
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	
Salutation:	
Last Name:	
Middle Name:	
First Name:	
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

This project has obtained no ODA fund from Japanese Government, and is completely irrelevant to Japanese funding obligation.

Annex 3

BASELINE INFORMATION

Rx: the quantity of landfilled solid waste

Ghabawi Landfill Site is a managed landfill site. The project target area of Cell 1 started receiving waste in 2003 (during that year) and has since received 3,360,000 m3 per year (840,000 tons in terms of weight). As of 2007, Cell 1 has received a total of 15,150,000 m3, and landfilling is progressing according to plan. Table A3.1 shows the amount of solid waste following conversion from hauled volume to weight.

Table A3.1 Past and Future Predicted Quantities of Solid Waste Landfill

Year x	Disposed amount R_x	Cumulative amount
	t/year	t
2002	0	0
2003	420,000	420,000
2004	840,000	1,260,000
2005	840,000	2,100,000
2006	840,000	2,940,000
2007	840,000	3,780,000
2008	0	3,780,000

○L_0: Methane generation potential

The value of the methane generation potential (L_0) is determined by the composition of solid waste and climate of the area where the landfill site is located.

In the project, survey has been carried out on the composition of solid waste carried into Ghabawi Landfill Site so far, and the results are as shown in Table A3.2.

Table A3.2 Composition of Waste

Waste category	Mass portion %	Component code
Food waste	53.0	C
Paper, cardcoard	17.0	A
Wood	0.0	D
Ferrous and non-ferrous metal	8.0	-
Textiles	0.0	A
Bones	0.0	B
Glass	5.0	-
Leather, rubber	0.0	B
Stones	0.0	-
Plastic	12.0	-
Other	5.0	C
Screening (less than 15 mm)	0.0	B
Total	100.0	

Note: Waste categories are taken from the IPCC Guidelines.

Concerning L_0, based on the composition shown in Table A3.2, this is estimated as follows using Expressions 1 and 3 from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories : Reference Manual CHAPTER 6 WASTE.

$$L_0 = MCF \times DOC \times DOC_F \times F \times 16 \div 12 \div D_{CH4}$$

MCF	Methane correction factor
DOC	Fraction of degradable organic carbon
DOCF	Fraction DOC dissimilated
F（$=w_{CH4,y}$）	Ratio of methane gas in landfill gas (default value is 0.5)

According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE, the default value for MCF is 1.0 in managed landfill sites (anaerobic).

Calculation of DOC according to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE is performed using expression 2.

$$DOC = 0.4 \times (A) + 0.17 \times (B) + 0.15 \times (C) + 0.30 \times (D)$$

(A)	Rate of paper and textiles in solid waste (%)
(B)	Rate of waste in garden, park, other perishable waste other than food in solid waste (%)
(C)	Rate of food in solid waste (%)
(D)	Rate of wood and straw in solid waste (%)

Out of the components given in Table A3.2, upon dividing organic waste partially into (B), (C) and (D), each value works out as follows: (A) = 17.0, (B) = 0.0, (C) = 58.0 and (D) = 0.0, and DOC = 0.155.

The IPCC recommends that 0.77 be used for DOC_F. However, in recent research, it is claimed that 0.77 can only be used when the lignin in solid waste is removed from the calculation in advance, whereas a value somewhere between 0.5~0.6 is more appropriate in cases where lignin cannot be removed. Accordingly, DOC_F has been set at 0.55.

Therefore,

$$L_0 = 1.0 \times 0.155 \times 0.55 \times 0.5 \times 16 \div 12 \div 0.7168 \times 1000 = 79.29 m^3/Mg$$

This is slightly less than the range of $100m^3/Mg$ to $200m^3/Mg$ given in the IPCC Guidelines, however, it shall be adopted here.

○ **Calculation of reduction in emissions**

Table A3.3 shows the main specifications of the gas engine generator used in the calculation, while Table A3.4 shows the results of calculating the amount of emissions reductions. Moreover, Table A3.5 shows the results of the emissions reductions in the case where the gas engine generator is not installed due to insufficiency or extreme instability of the LFG flow.

Table A3.4 Main Specifications of the Gas Engine Generator

Item		Unit	Value	Source or BAsis
Equipment capacity		kW	1,800	Estimated value from the project design
Annual operating time			8,040	Estimated value from the project design
EqE: generating efficiency based on LHV		%	35.0	Specification of the gas engine generator
Rated methane gas consumption		Nm^3/h	517	Specification of the gas engine generator
Power self consumption rate		%	10.0	Specification of the gas engine generator
Constant	Methane gas lower heating value	$kcal/Nm^3$	8,560	Thermal and Nuclear Power Generation Handbook 1991, supervised by the Thermal and Nuclear Power Engineering Society, Ministry of International Trade and Industry, and Agency for Natural Resources, P158
	Unit conversion: power ⇔ calories	kcal/h/kW	860	Science Almanac

Table A3.4 Results of Calculating Emissions Reductions (with power generation)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
$Q_{y,x}$	Nm^3	18,339,226	17,014,097	15,784,718	14,644,169	13,586,033	12,604,353	11,693,607	10,848,667	10,064,781	9,337,535	8,662,837	8,036,890	7,456,173	6,917,416	164,990,501
$LFG_{total,y}$	Nm^3	11,003,535	20,416,917	18,941,662	17,573,003	16,303,239	15,125,224	14,032,328	13,018,401	12,077,737	11,205,041	10,395,404	9,644,269	8,947,407	8,300,899	186,985,066
ER_y	tCO_2e	74,535	138,299	144,589	135,318	126,717	118,737	111,334	104,466	98,094	92,183	86,698	81,610	76,701	71,159	1,460,439
$MD_{project,y}$	tCH_4	3,549	6,586	6,408	5,966	5,557	5,177	4,824	4,497	4,194	3,912	3,651	3,409	3,180	2,951	63,859
$MD_{flared,y}$	tCH_4	3,549	6,586	3,430	2,988	2,579	2,199	1,846	1,519	1,216	934	673	431	237	220	28,408
$LFG_{flare,y}$	Nm^3	11,003,535	20,416,917	10,633,304	9,264,645	7,994,881	6,816,866	5,723,970	4,710,043	3,769,379	2,896,684	2,087,046	1,335,911	735,403	682,266	88,070,851
$PE_{flare,y}$	tCO_2e	8,282	15,367	8,003	6,973	6,017	5,131	4,308	3,545	2,837	2,180	1,571	1,005	553	514	66,286
$\eta_{flare,h}$	-	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
$MD_{electricity,y}$	tCH_4	0	0	2,978	2,978	2,978	2,978	2,978	2,978	2,978	2,978	2,978	2,978	2,943	2,731	35,451
$LFG_{electricity,y}$	Nm^3	0	0	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,308,358	8,212,004	7,618,633	98,914,215
$MD_{reg,y}$	tCH_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AF	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EL_y	MWh	0	0	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	12,874	11,944	155,065
$EL_{EX,LFG}$	MWh	0	0	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	13,025	12,874	11,944	155,065
EL_{IMP}	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$EL_{IMP,B}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$EL_{IMP,P}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$CEF_{electricity,y}$	tCO_2e/MWh	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	
PE_y	tCO_2e	201,521	117,811	103,045	95,147	87,820	81,023	74,717	68,866	63,438	58,403	53,731	49,397	45,448	42,164	1,142,530
BE_y	tCO_2e	276,057	256,110	247,633	230,465	214,537	199,760	186,051	173,332	161,532	150,585	140,429	131,007	122,149	113,323	2,602,969
BE_y-PE_y	tCO_2e	74,535	138,299	144,589	135,318	126,717	118,737	111,334	104,466	98,094	92,183	86,698	81,610	76,701	71,159	1,460,439

constant	EqC	-	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
	GWP_{CH4}	tCO_2e/tCH_4	21	21	21	21	21	21	21	21	21	21	21	21	21	21	
	$w_{CH4,y}$	Nm^3CH_4/Nm^3LFG	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	$D_{CH4,y}$	tCH_4/Nm^3CH_4	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	

Table A3.5 Results of Calculating Emissions Reductions
(case where the gas engine generator is not installed due to insufficiency or extreme instability of the LFG flow)

Item	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
$Q_{y,x}$	Nm^3	18,339,226	17,014,097	15,784,718	14,644,169	13,586,033	12,604,353	11,693,607	10,848,667	10,064,781	9,337,535	8,662,837	8,036,890	7,456,173	6,917,416	164,990,501
$LFG_{total,y}$	Nm^3	11,003,535	20,416,917	18,941,662	17,573,003	16,303,239	15,125,224	14,032,328	13,018,401	12,077,737	11,205,041	10,395,404	9,644,269	8,947,407	8,300,899	186,985,066
ER_y	tCO_2e	74,535	138,299	128,306	119,035	110,434	102,455	95,052	88,184	81,812	75,900	70,416	65,328	60,608	56,228	1,266,592
$MD_{project,y}$	tCH_4	3,549	6,586	6,110	5,668	5,259	4,879	4,526	4,199	3,896	3,614	3,353	3,111	2,886	2,678	60,314
$MD_{flared,y}$	tCH_4	3,549	6,586	6,110	5,668	5,259	4,879	4,526	4,199	3,896	3,614	3,353	3,111	2,886	2,678	60,314
$LFG_{flare,y}$	Nm^3	11,003,535	20,416,917	18,941,662	17,573,003	16,303,239	15,125,224	14,032,328	13,018,401	12,077,737	11,205,041	10,395,404	9,644,269	8,947,407	8,300,899	186,985,066
$PE_{flare,y}$	tCO_2e	8,282	15,367	14,256	13,226	12,270	11,384	10,561	9,798	9,090	8,433	7,824	7,259	6,734	6,248	140,732
$\eta_{flare,h}$	-	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
$MD_{electricity,y}$	tCH_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$LFG_{electricity,y}$	Nm^3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$MD_{reg,y}$	tCH_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AF	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EL_y	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$EL_{EX,LFG}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EL_{IMP}	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$EL_{IMP,B}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$EL_{IMP,P}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$CEF_{electricity,y}$	tCO_2e/MWh	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	
PE_y	tCO_2e	201,521	117,811	109,298	101,400	94,074	87,276	80,970	75,119	69,691	64,656	59,984	55,650	51,629	47,898	1,216,977
BE_y	tCO_2e	276,057	256,110	237,604	220,436	204,508	189,731	176,022	163,303	151,503	140,556	130,400	120,978	112,236	104,126	2,483,569
BE_y-PE_y	tCO_2e	74,535	138,299	128,306	119,035	110,434	102,455	95,052	88,184	81,812	75,900	70,416	65,328	60,608	56,228	1,266,592

constant	EqC	-	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
	GWP_{CH4}	tCO_2e/tCH_4	21	21	21	21	21	21	21	21	21	21	21	21	21	21	
	$w_{CH4,y}$	Nm^3CH_4/Nm^3LFG	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	$D_{CH4,y}$	tCH_4/Nm^3CH_4	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	

○Calculation of financial indicators

Table A3.6 shows the preconditions required for calculation. Table A3.7 shows the results of Project IRR sensitivity analysis in the case where CERs are not taken into account. Parameters in the sensitivity analysis were set as -10%～+10% for the construction cost, running cost and unit price of power sale, and -20%～+20% for the generated amount of LFG.

Incidentally, the project is expected to commence operation in July 2008 and the project implementation period will be 15 years from 2007 to 2021 (the credit period will be 14 years from 2008 to 2021). Accordingly, the Project IRR was calculated for 15 years.

Table A3.6 Preconditions for Calculation of financial indicators

Item	Unit	Value	Source or Basis
Initial cost	1000 JD	5,117	Estimated value from the project design
	1000 US$	7,226	
Running cost	1000 JD	210	Estimated value from the project design
	1000 US$/y	297	
Tax (corporate profit tax rate)	%	25	Government of Jordan
Depreciation rate	%	90	Estimated value from the project design
Power tariff	JD/kWh	0.0309	JEPCO purchase price
	US$cent/kWh	4.370	
Exchange rate JD ⇔US$	JD/US$	0.708	
Exchange rate Yen ⇔US$	Yen/US$	122.55	

Note: JD = Jordan dollar
Initial cost includes the cost of registering with the UN.
Running cost includes operating cost, maintenance cost, verification cost and UN registration cost.

Table A3.7 Results of Sensitivity Analysis

Variable: Construction cost

			Reference		
Variation rate	-10%	-5%	±0%	＋5%	＋10%
IRR	Minus	Minus	Minus	Minus	Minus

Variable: Running cost

			Reference		
Variation rate	-10%	-5%	±0%	＋5%	＋10%
IRR	Minus	Minus	Minus	Minus	Minus

Variable: Unit price of power sale

			Reference		
Variation rate	-10%	-5%	±0%	＋5%	＋10%
IRR	Minus	Minus	Minus	Minus	Minus

Variable: Amount of generated LFG

			Reference		
Variation rate	-20%	-10%	±0%	＋10%	＋10%
IRR	Minus	Minus	Minus	Minus	Minus

Annex 4

MONITORING INFORMATION

Below is indicated the monitoring plan for each item based on the monitoring methodology.

○ID1 $LFG_{total,y}$ Collected amount of LFG
○ID2 $LFG_{flare,,y}$ Flared amount of LFG
○ID3 $LFG_{electricity,y}$ Amount of LFG used in power generation
○ID5 $LFG_{flare,h}$ Flared amount of LFG (hour)

There are various types of flow meters; meanwhile, the target measurements here are the instantaneous flow rate and integrated flow rate for volumetric flow rate of a gas. The instantaneous volumetric flow rate of a gas can be measured by a differential pressure type flow meter (orifice, etc.), an area type flow meter (float, etc.), an ultrasonic type flow meter or a vortex type flow meter. The performance requirements for the flow meter here are relatively low price (i.e. a widely available type), accuracy, no major loss in precision even if the flow rate varies somewhat, durability and easy maintenance. The vortex type flow meter fulfils these requirements. As is explained below, the flow meter must be capable of outputting to a computing unit.

The vortex type flow meter measures instantaneous flow rate, however, this is the flow rate at that pressure and temperature and not the rate in the normal state (standard condition). Here, it is necessary to measure pressure and temperature at the same time with flow rate, in order to correct the measurement to the normal state value, and thereby assess volumetric flow using the same scale. Accordingly, a pressure gage and thermometer are required as well as a computing unit for correcting values into the normal state.

The features of the vortex type flow meter are that it has no movable parts and there is almost no fear of accuracy deteriorating over time. However, it is essential to make sure that no foreign objects get caught in the vortex generator. Accordingly, although there is no need to periodically calibrate the flow meter unit, it is necessary to check for foreign objects and also make sure that output and input signals between the transmitting terminal attached to the flow meter and the receiving terminal attached to the computing unit are being transmitted accurately. This calibration can be done by inputting mock signals to the transmitter to check and adjust the accuracy of output signals from the transmitter, and likewise inputting mock signals to the computing unit to check and adjust the accuracy of flow rate display on the computing unit side.

Measurement of flow is made possible by connecting the above flow meter, pressure gage, thermometer and computing unit by wiring. The computing unit shall be capable of displaying the instantaneous flow rate as well as the integrated flow rate.

The flow rate is continuously measured and automatically integrated by the computing unit. Since the accumulated integrated flow and not the instantaneous flow rate needs to be known, there is no need to make frequent visual checks and record value. As a rule, checking for abnormalities in the display shall be conducted at least once per week and records shall be taken once per month. Moreover, the flared amount of LFG will be recorded once every hour.

○ID5 T_{flare} Temperature of flare exhaust gas
○ID7 T Temperature of LFG

Concerning thermometers, there are again various types, for example, thermocouple, resistance type, thermistor type, radiation type, glass pipe type, filled type, bimetal type, crystal oscillating type, fluorescent type, optical fibre distribution type and magnetic type. The performance requirements for the thermometer here are relatively low price (i.e. a widely available type), accuracy, no major loss in precision even if temperature varies somewhat, durability, easy maintenance and ability to output to a computing unit (i.e. fitting with a terminal). The resistance type thermometer fulfils these requirements.

Concerning the thermometer, since a temperature sensor uses a resistive element made from platinum, etc., there is a risk that resistive element degradation will diminish the accuracy of temperature measurements. Therefore, it is necessary to calibrate the thermometer by preparing liquid of known temperature with a thermostatic chamber and reference thermometer. It is also necessary to make sure that output and input signals between the thermometer terminal and the computing unit terminal are being transmitted accurately. This calibration can be done by inputting mock signals to the computing unit to check and adjust the accuracy of temperature display on the computing unit side.

The temperature of LFG is continuously measured. As a rule, the display is checked for no abnormalities once per week, while the temperature is recorded once per month.

Concerning the flare exhaust gas temperature, a thermocouple is preferable to a resistance thermometer. Since the flare exhaust gas temperature reaches many hundreds of degrees, a thermocouple with high heat resistance is suitable.

The flare exhaust gas temperature is recorded in a recorder (pen recorder or data logger). In other words, automatic recording is performed continuously. As a rule, recording shall be performed to coincide with recording of the LFG flow rate, and checking for abnormalities in records shall be conducted at least once per week and records shall be taken once per month.

○ID8 P Pressure of LFG

Different types of pressure gage are the liquid column type, the plumb bob type and the elasticity type. The performance requirements for the pressure gage here are relatively low price (i.e. a widely available type), accuracy, no major loss in precision even if the pressure varies somewhat, durability, easy maintenance and ability to output to a computing unit (fitted with a transmitter). The elasticity type pressure gage fulfils these requirements.

As for the pressure gage, since this uses a pressure transmitter that utilizes a diaphragm, there is a risk that diaphragm degradation shall diminish the accuracy of pressure measurements. Therefore, it is necessary to calibrate the pressure gage by preparing liquid of known pressure with a mobile pump. It is also necessary to make sure that output and input signals between the pressure transmitter terminal and the computing unit terminal are being transmitted accurately. This calibration can be done by inputting mock signals to the computing unit to check and adjust the accuracy of pressure display on the computing unit side.

The pressure of LFG is continuously measured. As a rule, the display is checked for no abnormalities once per week, while the pressure is recorded once per month.

The pressure of air used in LFG flaring, and the pressure of flare exhaust gas, shall be measured when the flare equipment is installed and once per year after that.

○ID6 $w_{CH4,y}$ Methane concentration in LFG
○ID5 $wf_{CH4,h}$ Methane concentration in LFG (hourly)

Methods for measuring the volumetric concentration of methane in gas include gas chromatograph analysis, solid sensor gas analyser, optical sensor gas analyser, hydrogen flame ionisation detector, and so on. The performance requirements for the gas analyser here are relatively low price (i.e. a widely available type), accuracy, no major loss in precision even if the concentration level varies somewhat, durability and easy maintenance. Measured concentration here is in the order of 0~70% and are not measured in ppm. Easy measurement and easy calibration are also desired. The optical sensor gas analyser fulfils these requirements, and in particular the infrared type is appropriate.

The infrared methane gas analyser can be easily calibrated. It is possible to calibrate an infrared methane gas analyser by preparing a cylinder of reference methane gas of known concentration and a cylinder of zero methane concentration for zero calibration purposes. In other words, the infrared methane gas analyser can be calibrated in any place that is accessible to gas cylinders.

It is desirable that the infrared methane gas analyser can also measure the oxygen concentration. This is because, although not directly linked to the monitoring, since there is risk of explosion if the oxygen concentration of LFG rises to abnormal levels, it is necessary to stop the system.

The methane concentration of LFG shall be measured continuously and recorded once every hour.

○ID9 $EL_{EX,LFG}$ Amount of electricity exported outside of the project boundary
○ID10 EL_{IMP} Amount of imported electricity required for the project activity

The watt-hour meter shall be used for selling and purchasing electricity as well as monitoring in the CDM project. Accordingly, the meter demanded or provided by the grid owner shall be installed, and the calibrations that are required or implemented by the grid owner shall be carried out.

Electric energy is continuously measured and automatically integrated. Since the integrated electricity and not the instantaneous electricity needs to be known, there is no need to make frequent visual checks and record values. As a rule, recording shall be performed to coincide with recording of the LFG flow rate, and checking for abnormalities in the display shall be conducted at least once per week and records shall be taken once per month.

○ID11 $CEF_{electricity,y}$ CO_2 emissions intensity of the electricity displaced

The necessary data shall be received from the DNA of the Government of Jordan once per year.

○ID13 AF Adjustment factor

The AF is the ratio, adjustment factor between the amount of LFG that should be collected under the law and the amount of LFG that is collected in the Project. The necessary data shall be received from the Government of Jordan once per year.

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