Study into Utilization of Methane Gas at a Landfill Site in Zhitomir, Ukraine

Project Design Document

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

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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

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Landfill Gas Capture and Power Generation Project in Zhitomir City, Ukraine 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 Zhitomir Landfill Site in Zhitomir City, Ukraine, 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.

Zhitomir City Regional Administration Bureau owns Zhitomir Landfill Site. The landfill site covers an area of around 19 ha and is divided into eight sections, which are being successively filled. On part of the site, bulldozers regularly implement earth covering. The site started accepting waste in 1960 and has no set schedule for closure, however, it is expected to continue operating for another 8~10 years.

The project proposes to install landfill gas (LFG) collection pipes on the landfill site, and to collect and treat LFG before utilizing it for power generation in a gas engine generator (GEG). The generated power will be connected 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 January 2008. Moreover, introduction of a 500 kW (0.5 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 15 years, and the aggregate reduction of emissions during this period is estimated as 513,593 ton-CO_2 ("ton-CO_2" means "ton-CO_2 equivalent").

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

- Environmental improvement through prevention of odor on the landfill site;
- Environmental improvement through prevention of fires 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:

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)
Ukraine (host)	**Municipality of Zhitomir City**	**No**
Japan	**Private entity / • Shimizu Corporation**	**No**

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

>>
Ukraine

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

>>
N/A

A.4.1.3. City/Town/Community etc:

>> Zhitomir City

Figure 1 shows the location of Zhitomir and Ukraine.

UNEP/GRID-Arendal Maps and Graphics Library (http://maps.grida.no/go/graphic/ukraine_topographic_map)

Figure 1 Location of Ukraine and Zhitomir City (the arrow points to Zhitomir 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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Zhitomir Landfill Site is located approximately 7 km from the center of Zhitomir on the edge of an industrial belt, and there are no inhabited districts nearby. The site is divided into eight sections and these are being filled in successively. Regular earth filling by bulldozer is being conducted on part of the site, and the maximum landfill depth is approximately 12~18 m. The site started accepting waste in 1960 and has no set schedule for closure, however, it is expected to continue operating for another 8~10 years.

Judging from past data, Zhitomir Landfill Site accepts on average 290,000 m^3 of solid waste every year, and as of 2006 it is estimated to have taken in a total of between 10~12 million m3 of waste.

Figure 2 Plan View of Zhitomir 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 extraction wells, 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.

Kura River

○ **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 better than existing old-fashioned steam turbines in Ukraine. In addition, high-level technology is required for a gas engine that can stably operate on a rare gas fuel such as LFG.

○ **Flaring technology**. The flare facilities combust and thereby destroy any LFG that could not be destroyed in the gas engine generator. In order to stably combust and destroy LFG, closed flare facilities are used.

Figure 3 shows a schematic view of the overall project system.

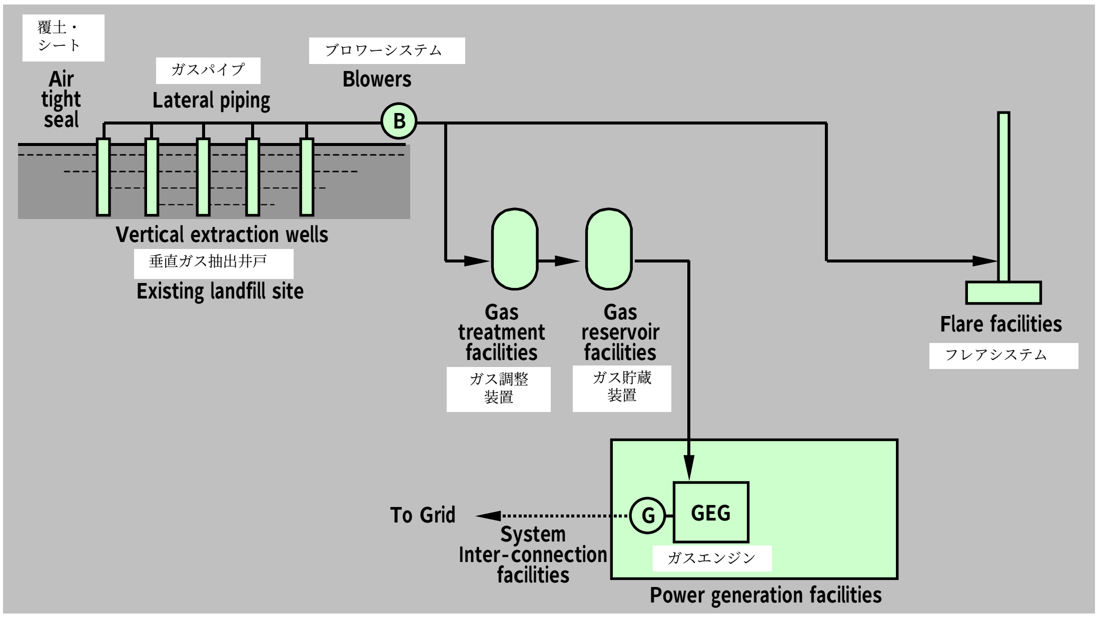

Figure 3 Project System Schematic

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	40,739
2009	37,789
2010	37,682
2011	47,684
2012	44,361
2013	41,278
2014	38,410
2015	35,749
2016	33,273
2017	30,973
2018	28,834
2019	26,850

Year	Annual estimation of emission reductions in tonnes of CO2e
2020	25,001
2021	23,283
Total estimated reductions (tonnes of CO_2e)	21,688
Total number of crediting years	513,593
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	15

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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Although this is a JI project, the baseline methodology that was approved in the preceding CDM Board Meeting shall be used.

Revision to the approved consolidated baseline methodology ACM0001/Version04
“ Consolidated baseline methodology for landfill gas project activities”
and
Revision to the approved consolidated monitoring methodology ACM0001/Version04
“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) ”

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 CDM 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/Version04: 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 Zhitomir Landfill Site and all LFG is released into the atmosphere. (Baseline)
② The project proposes to collect LFG on Zhitomir 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 0.5 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:

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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)

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 Zhitomir Landfill Site and that no GEG is established.

Scenario 2 : LFG recovery project. This scenario assumes that LFG from Zhitomir 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 Zhitomir 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 JI 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 Zhitomir Landfill Site and that no GEG is established.

Scenario 2 : **LFG recovery project**. This scenario assumes that LFG from Zhitomir 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 Zhitomir 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.
- Law on the protection of the environment (June, 1991)
- Ukrainian law on ‘On Municipal Waste’ (March 5, 1998)
- Ukrainian law ‘On Protection of Ambient Air’ (June 21, 2001)
- Law of Ukraine ‘On Alternative Liquid and Gas Fuels’ (January 14, 2000)
- President’s Decree ‘On measures concerning development of biofuel’ (September 26, 2003)

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

(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 ERU. 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, ERU 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, ERU 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 (after tax) to be a negative figure, 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 lower than 1%, 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 Ukraine (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 JI Registration

ERU economic value is introduced to the investment analysis that was implemented in Scenario 3. When ERU = 9.33 US$/t-$CO_2$ (equivalent to 7 EURO/t-CO2), the IRR (after tax) is 13.55%. This makes the project an attractive proposition for investment.

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 513,5933 ton-CO_2 over 15 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 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) $MD_{flared,y} = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE$

$LFG_{flare,y}$	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)
FE	The flare efficiency (the fraction of the methane destroyed)

(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:	40.0
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 Zhitomir, Ukraine 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 m^3/Mg. The value obtained on Zhitomir Landfill Site is 138.1, so the selected data is on the conservative side. 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:	Data provided by Zhitomir City Office
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 :	The value was set based on the carried amount of solid waste as obtained in the hearing survey at Zhitomir City Office.
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 04 “ 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:

$$(6)\quad M_{landfill,y} = D_{CH4} * \sum Q_{y,x} = D_{CH4} * \sum(k * R_x * L_0 * e^{-k(y-x)})$$

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.

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

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

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

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 supply of generated power to the grid in the project:

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

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	35,781	76,520	0	40,739
2009	41,354	79,143	0	37,789
2010	46,536	84,218	0	37,682
2011	38,924	86,608	0	47,684
2012	44,561	88,922	0	44,361
2013	49,892	91,170	0	41,278
2014	54,940	93,350	0	38,410
2015	59,727	95,476	0	35,749
2016	64,272	97,546	0	33,273
2017	68,596	99,568	0	30,973
2018	63,638	92,472	0	28,834
2019	59,038	85,888	0	26,850
2020	54,771	79,772	0	25,001
2021	50,811	74,094	0	23,283
2022	47,138	68,826	0	21,688
Total (tonnes of CO_2e)	779,978	1,293,571	0	513,593

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

B.7.1 Data and parameters monitored:

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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 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: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:	FE
Data unit:	%
Description:	Flare/combustion efficiency, determined by (1) the operation hours (judged by measuring temperature of surface of flare stack) and (2) the methane content in the exhaust gas
Source of data to be used:	(1) Thermometer - Surface temperature of flare stack Tf (K) (2) Methane fraction meter - Methane concentration of flare exhaust gas $w_{EX,CH4,y}$ （—） (3)Carbon dioxide fraction meter - Carbon dioxide concentration of LFG $w_{CO2,y}$ （—） - Carbon dioxide concentration of flare exhaust gas $w_{EX,CO2,y}$ （—） Measured on site /Calculated from measured data
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.995 This value is based on the guaranteed specifications provided by the equipment maker.
Description of measurement methods and procedures to be applied:	(1)Measured continuously and recorded once a month (2)Measured yearly, with the first measurement to be made at the time of installation. Data archive: electronic How long archive: during 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: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 methods and procedures to be applied:	Measured continuously and recorded once a month 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:	Thermometer 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 government of Ukraine
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 government of Ukraine, data was used from "Operational Guidelines for Project Design Documents of Joint Implementation Projects, Volume 1: General guidelines, Version 2.3, Ministry of Economic Affairs of the Netherlands May 2004." Moreover, following the above guidance, values for 2013

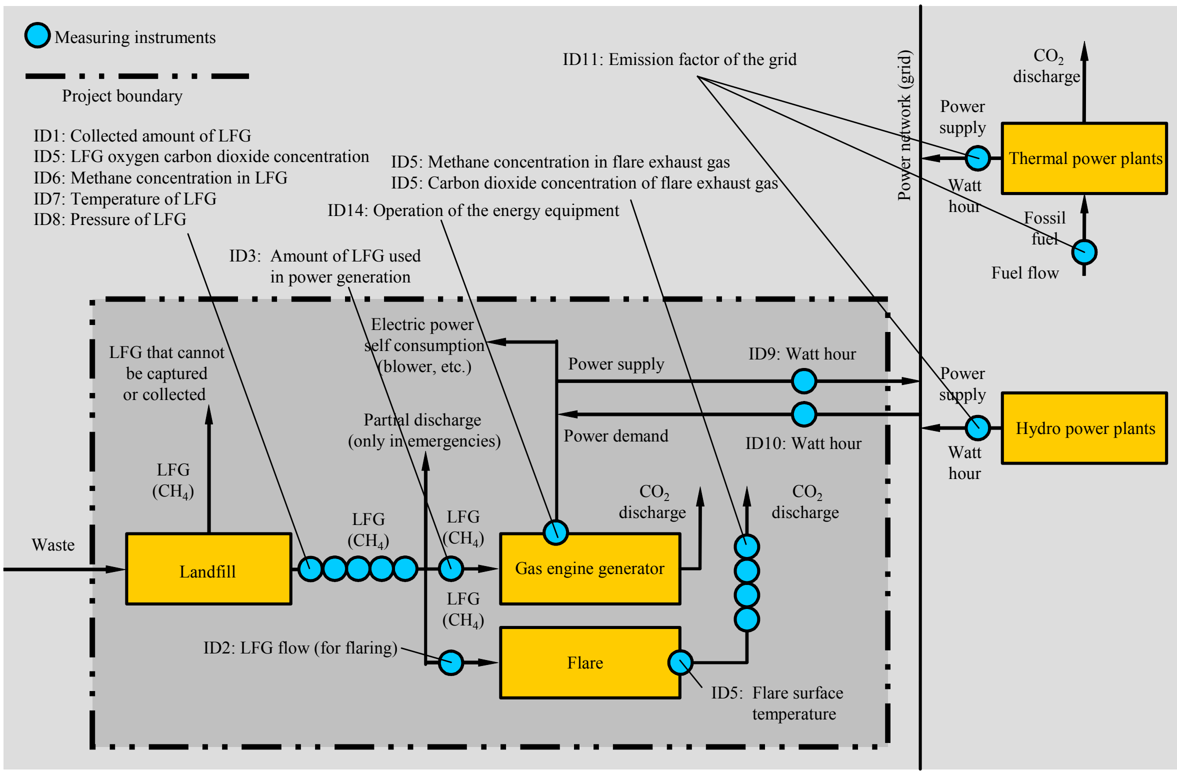
	onwards were extrapolated from the figures for 2011 and 2012 in order to secure conservativeness.
Description of measurement methods and procedures to be applied:	Data received once a year, on regular basis As specified in AMS.1.D
QA/QC procedures to be applied:	-
Any comment:	If it cannot be obtained 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 Ukraine
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.



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.

Figure 4 Flow Chart of Monitoring Plan

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 Zhitomir City will bear full responsibility for project operation and management (monitoring, facilities operation and maintenance, accounting, ERU 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) $MD_{flared,y} = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE$

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 the flare efficiency (FE＝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) FE = FTf * Fwf

Explanation: Flare efficiency (FE) is calculated from the flare operating rate (FTf) and the destruction efficiency of flaring (Fwf).

(12) FTf $= f$(Tf)

Explanation: The flare operating rate (FTf) is determined by continuously measuring the flare surface temperature (Tf) and judging whether or not the flare has gone out.

(13) $Fwf = 1 - (Q_E * w_{EX,CH4,y}) / (Q_L * w_{CH4,y})$

Explanation: The destruction efficiency of flaring (Fwf) is measured while the flare is combusting and is calculated from the methane gas concentration in flare exhaust gas and the methane concentration of LFG directed to the flare. Moreover, the amount of LFG (Q_L) directed to the flare and the amount of flare exhaust gas (Q_E) are measured in the standard state and calculated as follows:

(14) $Q_L = LFG_{flared,y} * (P / 101.3) / (T / 273.15)$

Explanation: The amount of LFG that is flared in the standard state (Q_L) is obtained through correcting the flared amount of LFG ($LFG_{flare,y}$＝ID2) by the LFG temperature (T = ID7) and LFG pressure (P = ID8).

Here, the change in methane gas within the flare system can be expressed as follows:

(a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Explanation: Methane gas in the LFG joins with oxygen in the combustion in order to produce carbon dioxide and water.

(15) $Q_L * w_{CO2,y} + Q_L * w_{CH4,y} = Q_E * w_{EX,CO2,y}$

(15’) $Q_E = (Q_L * w_{CO2,y} + Q_L * w_{CH4,y}) / w_{EX,CO2,y}$

Explanation: The physical balance of carbon dioxide is calculated taking into account the increase in carbon dioxide resulting from combustion of methane gas. By altering the expression, the amount of flare exhaust gas (QE) is obtained.
LFG contains methane and CO_2, as well as N_2 and minute amounts of H_2S. According to the system maker, the amount of No_x derived from N_2 that is generated in the flaring is 150 mg/m^3 (approximately 0.007~0.01 vol% when converted into the stable gas state), which is negligible. Meanwhile, the reaction with H_2S is expressed as follows:

(b) $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

The maximum concentration of H2S in LFG is around 0.1%. Therefore, even though this reaction causes volumetric capacity to fall somewhat, this change can be disregarded in the calculation of QE.

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 01/01/2008.

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

>>

The expected operational lifetime of the project is set at 15 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:

>>

N/A

C.2.1.2. Length of the first crediting period:

>>

N/A

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>

01/01/2008

C.2.2.2. Length:

>>

15 years

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 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 Ukraine is implemented according to the Ukrainian law 'On Protection of Ambient Air' (June 21, 2001). 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 Law On Protection of Ambient Air 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 JI projects in Ukraine, it is obligatory 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. Zhitomir Municipality - Administrative Services Department, Environmental Protection Department and other related officers
2. No. 0628 Urban Transportation Corporation: The landfill site operator in charge of collecting, hauling and allocating urban solid waste (MSW) on Zhitomir Landfill Site
3. The Ukrainian Ministry of Environmental Protection
4. Representatives of academic groups, the education sector and non-government organizations

When the project developers and investors visited Zhitomir Landfill Site, they held a number of meetings with the stakeholders.

The first meeting was held in Zhitomir municipal offices and was attended by the Vice Mayor of Zhitomir, chief of the civic services department, vice chairman of the municipal assembly / chairman of the civic services commission, vice manager of the sanitary and epidemiological station, chief of the urban environmental inspection department, deputy chief of the civic services department, director of No. 0628 Urban Transportation Corporation, and experts of the civic services department.

The second meeting was held with representatives of the local heating utility "Zhytomirteplokomunenergo."

In these meetings, detailed explanations were given on the technical and organizational aspects of the project.

E.2. Summary of the comments received:

>>

The stakeholders who attended the meetings displayed an interest in the project and understood the environmental, economic and social benefits that it will impart.

Comments from the representatives of "Zhytomirteplokomunenergo":

If the tariff proposed in the project is cheaper than the tariffs of the local gas and electricity supply companies, we will consider purchasing landfill gas or electric power.

Comments from municipal officials:

If power generation is carried out in this project, the city intends to purchase the generated electricity. Since the city owns part of the urban grid, it would be possible to connect the project generator to the power grid.

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, 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
Mobile:	- -
Direct FAX:	+81-3-5441-0469
Direct tel:	+81-3-5441-0137
Personal E-Mail:	kurita@shimz.co.jp

Project Participant 2

Organization:	Municipality of Zhitomir 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

The amount of waste that is carried into Zhitomir Landfill Site is measured based on the capacity and the number of trucks. The annual amount of incoming waste was set based on data provided in the hearing survey at Zhitomir municipal offices.

Table A3.1 shows the amount of solid waste obtained after converting from volume to weight. Incidentally, amounts of waste carried in before 1990 have been omitted.

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

Year x	Disposed amount R_x	Cumulative amount	Year x	Disposed amount R_x	Cumulative amount
	t/year	t		t/year	t
1990	62,795	62,795	2004	74,208	1,025,315
1991	63,549	126,344	2005	75,099	1,100,414
1992	64,311	190,655	2006	76,000	1,176,414
1993	65,083	255,738	2007	76,912	1,253,326
1994	65,864	321,602	2008	77,835	1,331,161
1995	66,654	388,256	2009	78,769	1,409,930
1996	67,454	455,710	2010	79,714	1,489,644
1997	68,264	523,974	2011	80,671	1,570,315
1998	69,083	593,057	2012	81,639	1,651,954
1999	69,912	662,969	2013	82,618	1,734,572
2000	70,751	733,720	2014	83,610	1,818,182
2001	71,600	805,320	2015	84,613	1,902,795
2002	72,459	877,779	2016	85,629	1,988,424
2003	73,328	951,107			

Note: Waste from before 1990 has been excluded from the above.

○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 Zhitomir 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	35.0	C
Paper, cardboard	37.5	A
Wood	1.5	D
Ferrous and non-ferrous metal	4.0	-
Textiles	4.0	A
Bones	1.5	B
Glass	2.5	-
Leather, rubber	1.0	B
Stones	1.0	-
Plastic	4.5	-
Other	1.5	C
Screening (less than 15 mm)	6.0	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) = 41.5, (B) = 8.5, (C) = 36.5 and (D) = 1.5, and DOC = 0.240.

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,

$$L_0 = 1.0 \times 0.240 \times 0.55 \times 0.5 \times 16 \div 12 \div 0.7168 \times 1000 = 138.1 m^3/Mg$$

This falls within the range of $100m^3/Mg$ to $200m^3/Mg$ given in the IPCC Guidelines. Accordingly, it has been decided to adopt $100m^3/Mg$, which is the lower limit value for general disposal sites, based on the IPCC guidelines.

○ **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. Moreover, trial calculation is carried out assuming the case where gas collection facilities are increased.

Table A3.3 Main Specifications of the Gas Engine Generator

<table>
<tr><th colspan="2">Item</th><th>Unit</th><th>Value</th><th>Source or BAsis</th></tr>
<tr><td colspan="2">Equipment capacity</td><td>kW</td><td>500</td><td>Estimated value from the project design</td></tr>
<tr><td colspan="2">Annual operating time</td><td></td><td>8,040</td><td>Estimated value from the project design</td></tr>
<tr><td colspan="2">EqE: generating efficiency based on LHV</td><td>%</td><td>35.0</td><td>Specification of the gas engine generator</td></tr>
<tr><td colspan="2">Rated methane gas consumption</td><td>Nm^3/h</td><td>144</td><td>Specification of the gas engine generator</td></tr>
<tr><td colspan="2">Power self consumption rate</td><td>%</td><td>10.0</td><td>Specification of the gas engine generator</td></tr>
<tr><td rowspan="2">Constant</td><td>Methane gas lower heating value</td><td>8,560</td><td>8,560</td><td>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</td></tr>
<tr><td>Unit conversion: power ⇔ calories</td><td>860</td><td>860</td><td>Science Almanac</td></tr>
</table>

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	15	TOTAL
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
$Q_{y,x}$		Nm^3	5,083,420	5,257,692	5,425,870	5,588,472	5,745,983	5,898,849	6,047,481	6,192,276	6,333,587	6,471,757	6,004,131	5,570,293	5,167,803	4,794,396	4,447,969	84,029,979
$LFG_{total,y}$		Nm^3	5,457,913	5,063,543	4,697,669	6,040,579	5,604,108	5,199,174	4,823,500	4,474,971	4,151,625	3,851,643	3,573,337	3,315,140	3,075,599	2,853,367	2,647,193	64,829,360
ER_y		tCO_2e	40,739	37,789	37,682	47,684	44,361	41,278	38,410	35,749	33,273	30,973	28,834	26,850	25,001	23,283	21,688	513,593
	$MD_{project,y}$	tCH_4	1,946	1,806	1,679	2,158	2,003	1,858	1,724	1,600	1,485	1,378	1,278	1,186	1,101	1,022	948	23,172
	$MD_{flared,y}$	tCH_4	1,946	1,806	852	1,331	1,175	1,031	897	773	657	551	451	359	274	195	121	12,420
	$LFG_{flare,y}$	Nm^3	5,457,913	5,063,543	2,389,792	3,732,702	3,296,230	2,891,297	2,515,623	2,167,094	1,843,748	1,543,766	1,265,460	1,007,263	767,722	545,490	339,316	34,826,957
	FE	-	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	
	$MD_{electricity,y}$	tCH_4	0	0	827	827	827	827	827	827	827	827	827	827	827	827	827	10,753
	$LFG_{electricity,y}$	Nm^3	0	0	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	2,307,877	30,002,403
	$MD_{reg,y}$	tCH_4	0	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	0	
	EL_y	MWh	-193	-193	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	3,626	46,756
	$EL_{EX,LFG}$	MWh	0	0	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	3,819	49,647
	EL_{IMP}	MWh	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	2,891
	$EL_{IMP,B}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	$EL_{IMP,P}$	MWh	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	2,891
	$CEF_{electricity,y}$	tCO_2e/MWh	0.695	0.680	0.666	0.651	0.636	0.622	0.607	0.593	0.578	0.563	0.548	0.534	0.519	0.504	0.490	
PE_y		tCO_2e	35,781	41,354	46,536	38,924	44,561	49,892	54,940	59,727	64,272	68,596	63,638	59,038	54,771	50,811	47,138	779,978
BE_y		tCO_2e	76,520	79,143	84,218	86,608	88,922	91,170	93,350	95,476	97,546	99,568	92,472	85,888	79,772	74,094	68,826	1,293,571
BE_y-PE_y		tCO_2e	40,739	37,789	37,682	47,684	44,361	41,278	38,410	35,749	33,273	30,973	28,834	26,850	25,001	23,283	21,688	513,593
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	0.6	
	GWP_{CH4}	tCO_2e/tCH_4	21	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	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	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)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
$Q_{y,x}$		Nm^3	5,083,420	5,257,692	5,425,870	5,588,472	5,745,983	5,898,849	6,047,481	6,192,276	6,333,587	6,471,757	6,004,131	5,570,293	5,167,803	4,794,396	4,447,969	84,029,979
$LFG_{total,y}$		Nm^3	5,457,913	5,063,543	4,697,669	6,040,579	5,604,108	5,199,174	4,823,500	4,474,971	4,151,625	3,851,643	3,573,337	3,315,140	3,075,599	2,853,367	2,647,193	64,829,360
ER_y		tCO_2e	40,739	37,789	35,051	45,111	41,845	38,816	36,005	33,398	30,979	28,736	26,654	24,723	22,932	21,271	19,730	483,780
	$MD_{project,y}$	tCH_4	1,946	1,806	1,675	2,154	1,998	1,854	1,720	1,596	1,481	1,374	1,274	1,182	1,097	1,018	944	23,119
	$MD_{flared,y}$	tCH_4	1,946	1,806	1,675	2,154	1,998	1,854	1,720	1,596	1,481	1,374	1,274	1,182	1,097	1,018	944	23,119
	$LFG_{flare,y}$	Nm^3	5,457,913	5,063,543	4,697,669	6,040,579	5,604,108	5,199,174	4,823,500	4,474,971	4,151,625	3,851,643	3,573,337	3,315,140	3,075,599	2,853,367	2,647,193	64,829,360
	FE	-	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	
	$MD_{electricity,y}$	tCH_4	0	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	0
	$MD_{reg,y}$	tCH_4	0	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	0	
	EL_y	MWh	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-2,891
	$EL_{EX,LFG}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	EL_{IMP}	MWh	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	2,891
	$EL_{IMP,B}$	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	$EL_{IMP,P}$	MWh	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	2,891
	$CEF_{electricity,y}$	tCO_2e/MWh	0.695	0.680	0.666	0.651	0.636	0.622	0.607	0.593	0.578	0.563	0.548	0.534	0.519	0.504	0.490	
PE_y		tCO_2e	35,781	41,354	46,623	39,011	44,648	49,979	55,026	59,813	64,359	68,683	63,725	59,125	54,857	50,898	47,225	781,107
BE_y		tCO_2e	76,520	79,143	81,675	84,122	86,493	88,794	91,032	93,211	95,338	97,418	90,379	83,849	77,790	72,169	66,954	1,264,886
BE_y-PE_y		tCO_2e	40,739	37,789	35,051	45,111	41,845	38,816	36,005	33,398	30,979	28,736	26,654	24,723	22,932	21,271	19,730	483,780
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	0.6	
	GWP_{CH4}	tCO_2e/tCH_4	21	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	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	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 ERUs 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 January 2008 and the project implementation period will be 16 years from 2007 to 2022 (the credit period will be 15 years from 2008 to 2022). Accordingly, the Project IRR was calculated for 16 years.

Table A3.6 Preconditions for Calculation of Financial Indicators

Item	Unit	Value	Source or Basis
Initial cost	US$	3,050,173	Estimated value from the project design
Running cost (operating cost)	US$/y	38,122	Estimated value from the project design
Running cost (maintenance cost)	US$/y	34,655	Estimated value from the project design
Verification cost	US$/y	20,000	Estimated value from the project design
Tax (corporate profit tax rate)	%	20	Government of Ukraine
Depreciation rate	%	90	Estimated value from the project design
Power tariff	US$cent/kWh	5.0	Purchase price from the power supply and distribution company
Exchange rate Yen ⇔US$	Yen/US$	116.0	

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	0.14

Variable: Amount of generated LFG

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

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 FE Flare efficiency

The flare efficiency FE is calculated from the flare operating rate (FTf) and the flare destruction efficiency (Fwf).

First, the flare operating rate FTf is calculated from the flare surface temperature. Usually if the flare is operating, there is no major variation in the flare surface temperature, however, once the flame goes out, the temperature drops rapidly. From this it is possible to judge whether the flare is operating or the flame has gone out. In other words, the flare operating rate FTf shows the ratio of flare operating time.

Next, the flare destruction efficiency Fwf can be obtained from the methane concentration in flare exhaust gas and methane concentration in LFG. Inciently, the amount of flare exhaust gas used in the calculation and the amount of LFG used in flaring are the amounts in the standard state. Based on the above:

Flare operating rate FTf = Flare operating time ÷ (Flare operating time + Flare flame out time)

Flare destruction efficiency Fwf = (Methane concentration in LFG – Methane concentration in flare exhaust gas) ÷ Methane concentration in LFG

Flare efficiency FE = Flare operating rate FTf x Flare destruction efficiency Fwf

Flare efficiency FE is calculated at the time of installation and once per year after that.

○ID5 Tf Surface temperature of flare stack
○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 stack surface temperature, a thermocouple is preferable to a resistance thermometer. Since the flare stack surface temperature reaches many hundreds of degrees, a thermocouple with high heat resistance is suitable.

The flare stack surface 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.

○ID5 $w_{EX,CH4,y}$ Methane concentration in flare exhaust gas
○ID6 $w_{CH4,y}$ Methane concentration in LFG

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 shall as a rule be checked once a week for abnormal readings and recorded once every month to coincide with recording of the LFG flow.

Assuming flare efficiency to be 99% and air ratio to be 1.0, the methane concentration of flare exhaust gas is no more than 0.1% (1,000 ppm), whereas the concentration that needs to be measured is less than this. For example, as a realistic value, when flare efficiency is assumed to be 99.5% and air ratio to be 1.2, the methane concentration of flare exhaust gas works out to be 0.03% (300 ppm). Accordingly, since this cannot be measured in the same range as the methane concentration in LFG, care is needed.

Meanwhile, according to the monitoring methodology, the monitoring frequency of methane concentration in flare exhaust gas can be far less than that for the methane concentration in LFG. The infrared methane gas analyser helps stabilize measurements by being in constant use, and its life is affected if start and stop are frequently repeated. For this reason, it is not suited to low frequency measurements such as methane concentration in flare exhaust gas. Since this measuring instrument needs to be kept constantly on even though measuring frequency is low, it is more costly than it needs to be. From the cost cutting viewpoint, rather than purchasing an infrared methane gas analyser, the methane concentration in flare exhaust gas can be measured by analysing with a gas chromatograph whenever required. Moreover, the host country Ukraine has agencies and operators that can implement gas chromatograph analysis.

In this project, it shall be possible to select analysis either by the infrared methane gas analyser or by the gas chromatograph.

Methane concentration in flare exhaust gas shall be measured when the flare equipment is installed and once per year after that. (If the infrared methane gas analyser is adopted, 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).

○ID5 $w_{CO2,y}$ **Carbon dioxide concentration in LFG**
○ID5 $w_{EX,CO2,y}$ **Carbon dioxide concentration in flare exhaust gas**

Methods for measuring the volumetric concentration of carbon dioxide in gas include portable chemical gas analyser (Orsat gas analyser) and, as equipment used for continuous analysis, infrared absorption-type carbon dioxide analyser, electrical carbon dioxide analyser, specific gravity carbon dioxide analyser and so on.

The performance requirements for the carbon dioxide 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. Moreover, it is preferable to adopt a type that can easily conduct measurements and does not require much time and effort in calibration.

The types of apparatus indicated above are all widely used in Japan and satisfy the said requirements. The features of each type can be described as follows. The Orsat gas analyser is portable and can conduct measurements whenever they are needed. Since there is no need to conduct continuous measurements here, this apparatus is particularly advantageous in this case. However, because the carbon dioxide concentration measured here is the dry gas concentration, it will be necessary to separately measure the moisture content in order to obtain an accurate measurement. The infrared absorption-type carbon dioxide analyser utilizes light absorption in the infrared spectrum and is used for continuous measurement as a rule. The electric carbon dioxide analyser utilizes the fact that the heat conductivity of carbon dioxide is much smaller than that of other gases, and this too is used for continuous measurement as a rule. The specific gravity carbon dioxide analyser utilizes the fact that the specific gravity of carbon dioxide is much smaller than that of other gases, and this too is used for continuous measurement as a rule
In the project, any one out of the Orsat gas analyser, infrared absorption-type carbon dioxide analyser, electrical carbon dioxide analyser and specific gravity carbon dioxide analyser can be used.

Carbon dioxide concentration in flare exhaust gas shall be measured when the flare equipment is installed and once per year after that. (If the infrared methane gas analyser is adopted, 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).

○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 JI 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 Government of Ukraine 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 Ukraine once per year.

○ In the absence of any international calibration standards for the above calibration items, calibration shall be conducted based on standards of the instrument makers.

○ Monitoring data shall be totalled as annual data based on the methodology. Where data is collected every month, the monthly amounts shall be summated to give annual totals.

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