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

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SECTION A. General description of project activity

A.1. Title of the project activity:

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Piyungan Landfill Gas Capture Project in Yogyakarta

Ver 1.0, 18/08/2008

A.2. Description of the project activity:

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In the project, it is planned to capture landfill gas (LFG) emitted on Piyungan Landfill Site in Bantul Regency of the Special Region of Yogyakarta in Indonesia and to combust and destroy methane gas, which is a flammable greenhouse gas (GHG) contained in the LFG, in a flare stack.

Piyungan Landfill Site was commissioned in a joint effort by Yogyakarta City, Sleman Regency and Bantul Regency in 1995, and it is scheduled to receive waste until the end of 2009.

The project proposes to install landfill gas (LFG) collection pipes on the landfill site, and to collect LFG to be combusted and destroyed via flare stack. Since combustion and destruction of LFG leads to conversion of methane gas into carbon dioxide, this will be effective in terms of reducing greenhouse gas emissions.

In the project, it is planned to commission the flaring system from July 2009.

Since earth covering will be carried out in the Project in order to realize the efficient collection of LFG, the project can be expected to improve the sanitary situation and general environment as well as mitigate the risk of disasters through improving storm water drainage, preventing odor, controlling outbreaks of flies, mosquitoes and pests, controlling flocks of birds and preventing slope failure, etc. Moreover, implementation of the project will contribute to local job creation.

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)
Indonesia (host)	Municipality of Bantul Regency / Public	No
Indonesia (host)	Municipality of Yogyakarta City / Public	No
Indonesia (host)	Municipality of Sleman Regency / Public	No
Indonesia (host)	Agency for the Assessment and Application of Technology(BPPT)/Public	No
Japan	Shimizu Corporation / Private	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):

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Republic of Indonesia

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

>>

Special Region of Yogyakarta

A.4.1.3. City/Town/Community etc.:

>>

Bantul Regency

Figure 1 shows the location of Indonesia and Bantul Regency

Source: http://www.lib.utexas.edu/maps/cia07/indonesia_sm_2007.gif

Figure 1 Location of Republic of Indonesia and Bantul Regency

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

>>

As an be seen in Figure 2, Piyungan Landfill Site is located in Sitimulyo Village in Bantul Regency approximately 12 km southeast of the center of Yogyakarta City. The latitude and longitude of Piyungan Landfill Site are as follows.

7º 52’ 10”S, 110º 25’ 45”E

The landfill site, which is a controlled type landfill, is owned by the Special Region of Yogyakarta and is jointly managed by the Municipality of Yogyakarta, Sleman Regency and Bantul Regency. A joint secretariat named KARTAMANTUL has been organized and conducts planning and coordination in order to smoothly advance the joint operation. In topographical terms, the site comprises a valley that is being filled in and it covers an area of approximately 7.4 ha. The site was commissioned in 1995 and it is scheduled to receive waste from the three municipalities until the end of 2009. The site facilitates a management office building, warehouse, pavement roads outside of dumping area and drainage canal system, dam and slope protection with stone wall, leachate treatment ponds and aeration facilities, dumping truck scale with a recorder, a buffer stop of dumping trucks, and other facilities. The amount of solid waste received each year during the target period is as indicated in Section B.6.3.

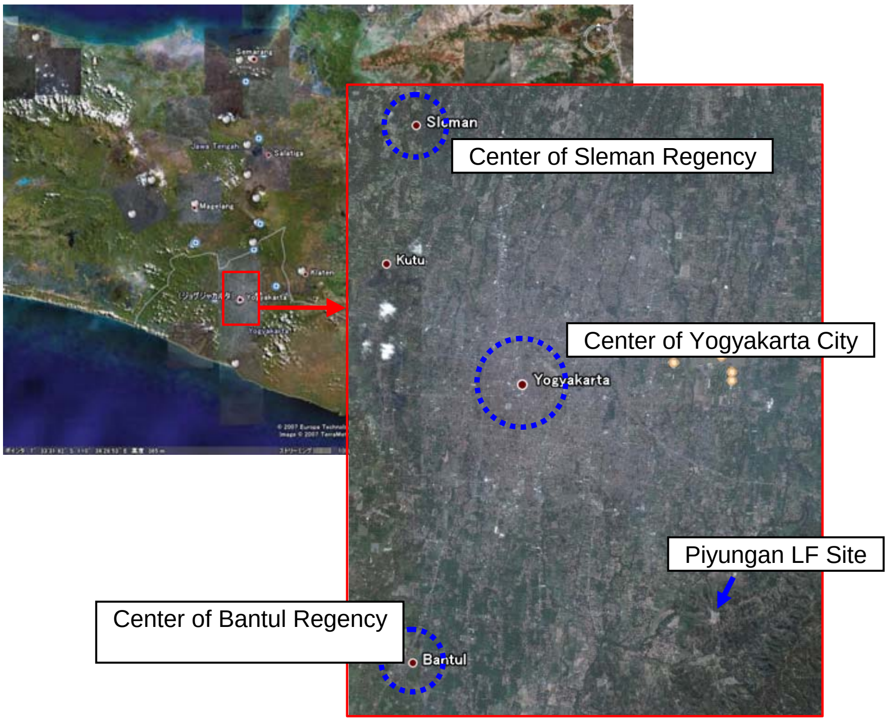

Figure 2 Location of Piyungan Landfill Site

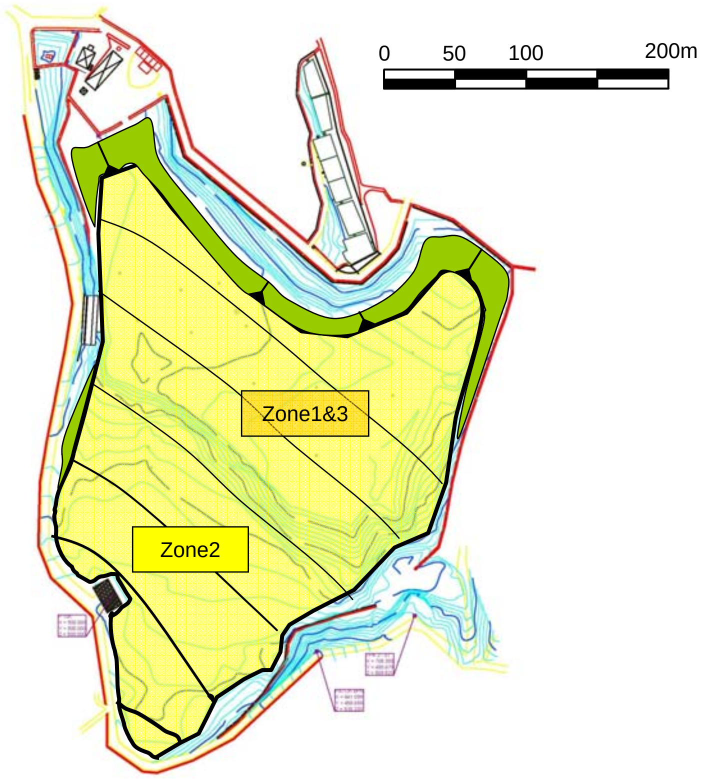

Figure 3 Top View of Piyungan Landfill Site

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

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Sectoral Scope 13: Waste handling and disposal

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, measuring instruments, blowers and gas treatment equipment. In this system, highly efficient LFG collection can be anticipated.

Flaring technology.

The flare facilities combust and thereby destroy any LFG. In order to stably combust and destroy LFG, the enclosed type flare facility is used.

These technologies have been widely applied in Japan, European and other developed countries, however, since they have so far hardly been adopted at all in Indonesia, they will contribute to the transfer of technology. In particular, Indonesia has so far not witnessed any examples of systems with very high flare efficiency that include vertical gas extraction wells.

Figure 4 shows a schematic view of the overall project system.

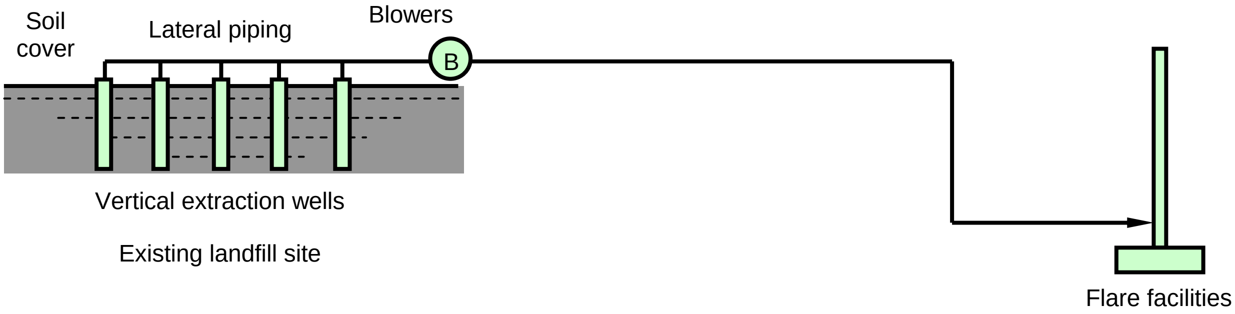

Figure 4 Project system schematic

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

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The project crediting period is 10 years and the amount of reduction is calculated as follows.

Year	Annual estimation of emission reductions in tonnes of CO_2e
2009.7~	42,144
2010	79,356
2011	73,465
2012	61,961
2013	52,874
2014	45,585
2015	39,654
2016	34,765
2017	30,687
2018	27,248
~2019.6	12,161
Total estimated reductions (tCO_2e)	499,901
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tCO_2e)	49,990

A.4.5. Public funding of the project activity:

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The project will not utilize any official funding from Annex I countries.

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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Methodology

Version 09 of ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities"

Tool

Version 05.1 of the "Tool for the demonstration and assessment of additionality"
Version 01 of the "Tool to determine project emissions from flaring gases containing methane"
Version 01 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
Version 04 of the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Version 01.1 of the "Tool to calculate the emission factor for an electricity system"

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

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This methodology ACM0001 states the following contents concerning applicability.

"This methodology 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); or
c) The captured gas is used to supply consumers through natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodologies AM0053.

In addition, the applicability conditions included in the tools referred to above apply.

Meanwhile, conditions in the Project are as follows:

① Currently, LFG collection is not carried out on the landfill site and all LFG is released into the atmosphere (Baseline).
② The project proposes to collect LFG on the landfill site and the captured gas is flared.

Therefore, since the project falls under applicability of (a) for the approved consolidated baseline methodology ACM0001, this methodology is applied.

According to the "Tool to determine project emissions from flaring gases containing methane," this tool is applicable under the following conditions: The residual gas stream to be flared contains no other combustible gases than methane, carbon monoxide and hydrogen. Meanwhile, landfill gas mainly comprises CO_2 and CH_4 with minor traces of CO, however, it contains no other combustible gases. Accordingly, this tool is applicable.

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

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According to ACM0001, the project boundary is the site of the project activity where the gas is captured and destroyed. In the project, however, since the electricity for project activity is sourced from the grid, the project boundary shall include all the power generation sources connected to the grid to which the project activity is connected. The project boundary here is as indicated in Figure 5.

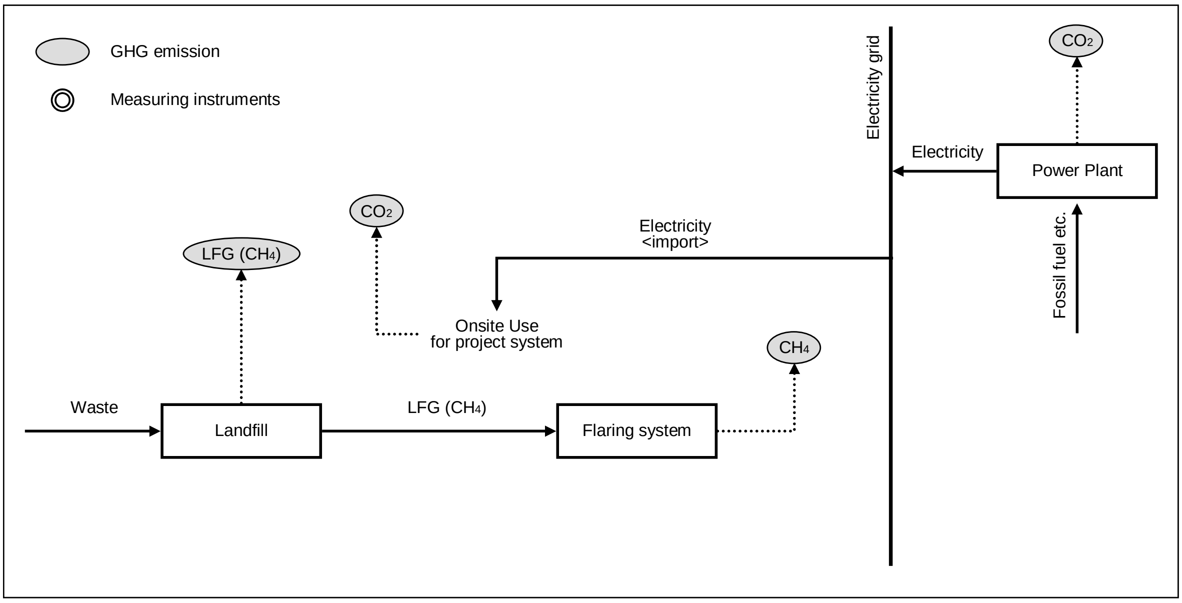

Figure 5 Project boundary

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

	Source	Gas	Included ?	Justification/ Explanation
Baseline	Emissions from decomposition of waste at the landfill site	CH_4	Yes	The major source of emissions in the baseline
		N_2O	NO	N_2O emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
	Emissions from electricity consumption	CO_2	NO	There is no electricity generation in the project.
		CH_4	NO	Excluded for simplification. This is conservative.
		N_2O	NO	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	NO	There is no thermal energy generation in the project.
		CH_4	NO	Excluded for simplification. This is conservative.
		N_2O	NO	Excluded for simplification. This is conservative.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	NO	There is no consumption of fossil fuels in the project activity.
		CH_4	NO	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	NO	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	Yes	Electricity may be consumed from the grid in the project activity.
		CH_4	NO	Excluded for simplification. This is conservative.
		N_2O	NO	Excluded for simplification. This is conservative.

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 based on *ACM0001*.

<u>STEP 1: Identification of alternative scenarios.</u>

According to *ACM0001*, *Step 1* of the *"Tool for the demonstration and assessment of additionality"* is used to identify the baseline options.

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

Out of the scenarios indicated in *ACM0001*, upon considering conditions in the host country and current legislation and so on, the following are selected as the realistic and credible baseline alternatives. Incidentally, since there is no demand for heat utilization in the local area, this is not considered in the alternatives.

Scenario	Baseline			Description of situation
	LFG	electricity	Heat	
1	LFG2	-	-	Atmospheric release of LFG, no capture based on legislation, etc. (Maintenance of status quo)
2	LFG1	-	-	In the case where the proposed project activity is undertaken without being registered as a CDM project activity, capture the LFG and combust by flaring.
3	LFG1	P1	-	Power generated from landfill gas undertaken without being registered as CDM project activity.

Moreover, the current laws, regulations and guidelines that apply to the above scenarios are as follows.
<Laws, regulations and guidelines (hereinafter referred to as "general items)>

- The National Energy Policy 2003-2020: KEN (March 2004)
- A Policy on Renewable Energy Development and Energy Conservation (Green Energy Development) (December 2003)
- The Environmental Management Law (1997 Law No. 23)
- The Ordinance on Environmental Impact Assessment (1999 No. 27)
- The Ordinance on Water Pollution Prevention and Water Quality Management (2001 No. 82)
- The Ordinance on Air Pollution Prevention (1999 No. 41)
- The Waste Management Law (2008 No. 18)

Currently, landfill gas collection is not carried out on landfill sites in Indonesia, and there is no legislation that requires the collection of landfill gas. The Indonesian authorities hope to implement controlled dumping in the future, however, open dumping is generally conducted at present.

Since existing legislation imposes no obligations regarding the collection of landfill gas, it is not necessary to consider the adjustment factor (AF) here.

STEP 2: Identify the fuel for the baseline choice of energy source taking into account the national and/or sectoral policies as applicable.

Concerning the baseline energy, no energy is used in Scenario 1. Electric power is used in Scenarios 2 and 3, however, since part of the generated power is used or power is obtained from the grid, there is no restriction on the supply.

There is no fuel use in Scenarios 1, 2 or 3.

STEP 3: assess which of alternatives should be excluded from further consideration.

According to *ACM0001*, *Step 2* and/or *Step 3* of the *"Tool for the demonstration and assessment of additionality"* are used.

(Step 2: Investment Analysis)

(sub-step 2a Determine appropriate analysis method)

Scenario 3 includes income (from sale of electricity). 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 according to the "Guidance on the Assessment of Investment Analysis".

(sub-step 2b Option III: Apply benchmark analysis)

IRR can be calculated either as project IRR or equity IRR. Here, we adopt project IRR.

(sub-step 2c Calculation and comparison of financial indicators)

First, analysis of Scenario 2 is carried out. In Scenario 2, there is investment, but since there are no returns, this cannot be the baseline scenario.

Next, the analysis of Scenario 3 is carried out. In Scenario 3, since purchase of PLN power is conditional on stable supply over 10 years, it was assumed that a 620 kW gas engine is introduced in consideration of reducing the potential generating capacity. In Scenario 3, there is investment, but the problem is whether or not corresponding returns (revenue from power sales) can be anticipated. Here the benchmark is set as the rate of "Indonesian National Bond", 8.03%. As a result of calculating the IRR, which is for the period as the same range of CDM projects as 11 years(including construction period), the IRR was found to be in minus and less than the benchmark, and it became clear that the investment is not worthwhile. Furthermore, the similar calculation for 15 years, which is deemed as project period as limited by the life period of gas engine generator, is made and it leads the same IRR as minus and it makes clear that the investment is not worthwhile also.Therefore, it was demonstrated that Scenario 3 is not the baseline.

The preconditions and results of the calculation are indicated in Annex 3: BASELINE INFORMATION.

(sub-step 2d Sensitivity analysis)

In Scenario 2, since there is investment but no returns, this means that this cannot become the baseline scenario. Accordingly, sensitivity analysis is only carried out on Scenario 3.
In Scenario 3, it is assumed that a 620 kW gas engine is introduced. Sensitivity analysis is carried out assuming the parameters of initial cost, running cost, unit price of power sale and generated amount of LFG. The range of fluctuation shall be -10%~+10% for the initial cost and running cost, and -20%~+20% for the unit price of power sale and the generated amount of LFG. As a result of the sensitivity analysis, the IRR for every case is minus for the project period of both 10 years and 15 years, 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.

Out come of Investment Analysis
After the sensitivity analysis it is concluded that the scenario 3 is unlikely to be financially attractive.

(Step 3 Barrier Analysis)

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

STEP 4: determine baseline scenarios

STEP 3 showed that Scenarios 2 and 3 cannot become the baseline. Moreover, since the host country has no legal obligation or funding regarding the collection of methane, it is projected that the status quo will continue. Accordingly, Scenario 1 (maintenance of status quo) is set as the baseline scenario.

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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Additionality is demonstrated according to the *"Tool for the demonstration and assessment of additionality."*

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

sub-step 1a Define alternatives to the project activity

As was indicated in Section B.4, the alternatives to the project activity are as indicated below.

Scenario	Baseline			Description of situation
	LFG	electricity	Heat	
1	LFG2	-	-	Atmospheric release of LFG, no capture based on legislation, etc. (Maintenance of status quo)
2	LFG1	-	-	In the case where the proposed project activity is undertaken without being registered as a CDM project activity, capture the LFG and combust by flaring.
3	LFG1	P1	-	Power generated from landfill gas undertaken without being registered as CDM project activity.

sub-step 1b Consistency with mandatory laws and regulations

This is the same as indicated in STEP 1 in Section B.4.

Step 2 Investment Analysis

This is the same as indicated in STEP 3 in Section B.4.

Step 3 Barrier Analysis

This is the same as indicated in STEP 3 in Section B.4.

Step 4 Common Practice Analysis

There is no fact to suggest that a similar project has been, is being, or will be implemented in Indonesia outside of the CDM. In other words, the project may be described as the first-of-its-kind.

As was indicated in Section B.4, the baseline scenario is Scenario 1 (maintenance of the status quo). Moreover, the project activity, which is Scenario 2, cannot be the baseline, and since the cumulative reduction in emissions resulting from the project activity over 10 years is 499,901 ton-CO_2, the project can be described as additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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Based on *ACM0001*, the baseline emissions, project emissions and emission reductions in the Project are as follows. Incidentally, the expressions have been consolidated in consideration of the fact that there will be no electricity and thermal energy generation from the collected LFG, nor any supply to the natural gas pipeline.

Baseline emissions

$$BE_y = (MD_{project,y} - MD_{BL,y}) \times GWP_{CH4} \quad (1)$$

BE_y	Baseline emissions in year y (tCO_2e)
$MD_{project,y}$	The amount of methane that would have been destroyed/combusted during the year in project scenario (tCH_4).
$MD_{BL,y}$	The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tonnes of methane (tCH_4)
GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4

Here, each item is defined as follows:

$$MD_{BL,y} = MD_{project,y} \times AF \quad (2)$$

AF	Adjustment Factor

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

$MD_{flared,y}$	Quantity of methane destroyed by flaring (tCH_4)

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

$LFG_{flare,y}$	The quantity of landfill gas fed to the flare(s) during the year (m^3)
$w_{CH4,\,y}$	The average methane fraction of the landfill gas as measured during the year (m^3CH_4/m^3LFG)
D_{CH4}	The methane density (tCH_4/m^3CH_4)
$PE_{flare,y}$	The project emissions from flaring of the residual gas stream in year y (tCO_2e) determined following the procedure described in the *“Tool to determine project emissions from flaring gases containing methane”*.

Here, the project emissions from flaring ($PE_{flare,y}$) are calculated by the following expression based on the *“Tool to determine project emissions from flaring gases containing methane”* .

In the project, a closed flare is adopted. In the Tool, the following two options are proposed in order to determine flare efficiency $\eta_{flare,h}$ in a closed flare:

(a) Use a 90% default value. Continuous monitoring of compliance with manufacturer’s specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of parameters are out of the limit of manufacturer’s specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.
(b) Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).

In the project, since flare efficiency is subject to continuous monitoring, project emissions from the flare are calculated according to the Tool procedure (STEP 1 ~ STEP 7). In cases where monitoring is not carried out properly, the default value is adopted for flare efficiency and project emissions from the flare are calculated according to the Tool procedure (STEP 5 ~ STEP 7).

Moreover, in the Tool, it is required to measure the temperature of the exhaust gas of the flare in order to determine whether or not the flare is being operated. The following conditions exist regarding the flare exhaust gas temperature.

In both cases, if there is no record of the temperature of the exhaust gas of the flare or if the recorded temperature is less than 500 °C for any particular hour, it shall be assumed that during that hour the flare efficiency is zero.

The Tool procedure is as follows:
STEP 1: Determination of the mass flow rate of the residual gas that is flared
STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis
STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency
STEP 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiencies

The calculation procedure in this tool determines the flow rate of methane before and after the destruction in the flare, taking into account the amount of air supplied to the combustion reaction and the exhaust gas composition (oxygen and methane). The flare efficiency is calculated for each hour of a year based either on measurements or default values plus operational parameters. Project emissions are determined by multiplying the methane flow rate in the residual gas with the flare efficiency for each hour of the year.

STEP 1: Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour h, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h} \qquad (5\text{-}1)$$

$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour h
$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h

$$\rho_{RG,n,h} = P_n / (R_u / MM_{RG,h} \times T_n) \qquad (5\text{-}2)$$

$\rho_{RG,n,h}$	kg/m^3	Density of the residual gas at normal conditions in hour h
P_n	Pa	Atmospheric pressure at normal conditions (101,325)
R_u	Pa.m^3/kmol.K	Universal ideal gas constant (8,314)
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
T_n	K	Temperature at normal conditions (273.15)

$$MM_{RG,h} = \sum_i (fv_{i,RG,h} \times MM_i) \qquad (5\text{-}3)$$

$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
$fv_{i,RG,h}$	-	Volumetric fraction of component i in the residual gas in the hour h
MM_i	kg/kmol	Molecular mass of residual gas component i
i	-	The components CH_4, CO, CO_2, O_2,H_2, N_2

The following is stated in the Tool: *"As a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2)."* Landfill gas is the product of anaerobic decomposition, which does not produce hydrogen or carbon monoxide, so these two gases can be eliminated from the calculations, without any assumptions.
The simplification proposed in the tool involves considering CO_2 and O_2 as N_2. Project participants use this simplified approach, since it greatly simplifies measurements and does not significantly affect the estimate of flare efficiency.

When simplified, the expression is as follows:
$$MM_{RG,h} = \sum_i (fv_{i,RG,h} \times MM_i) \qquad (5\text{-}3')$$

$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
$fv_{i,RG,h}$	-	Volumetric fraction of component i in the residual gas in the hour h
MM_i	kg/kmol	Molecular mass of residual gas component i

Note that elemental hydrogen is a part of methane and therefore the hydrogen content of the residual gas affects its stoichiometry.

STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

This step determines the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, calculated from the volumetric fraction of each component i in the residual gas, as follows:

$$fm_{j,h} = (\Sigma_i fv_{i,RG,h} \times AM_j \times NA_{j,i}) / MM_{RG,h} \qquad (5\text{-}4)$$

$fm_{j,h}$	-	Mass fraction of element j in the residual gas in hour h
$fv_{i,RG,h}$	-	Volumetric fraction of component i in the residual gas in the hour h
AM_j	kg/kmol	Atomic mass of element j
$NA_{j,i}$	-	Number of atoms of element j in component i
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
j	-	The elements carbon, hydrogen, oxygen and nitrogen
i	-	The components CH_4, CO, CO_2, O_2,H_2, N_2

As a simplified approach, only methane content of the residual gas should be measured and the remaining part will be considered as N_2. By the reason of applying the simplified approach in this project, this formula becomes the following.

$$fm_{j,h} = (\Sigma_i fv_{i,RG,h} \times AM_j \times NA_{j,i}) / MM_{RG,h} \qquad (5\text{-}4')$$

$fm_{j,h}$	-	Mass fraction of element j in the residual gas in hour h
$fv_{i,RG,h}$	-	Volumetric fraction of component i in the residual gas in the hour h

AM_j	kg/kmol	Atomic mass of element j
$NA_{j,i}$	-	Number of atoms of element j in component i
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour h
j	-	The elements carbon, hydrogen and nitrogen

STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis

This step determines the average volumetric flow rate of the exhaust gas in each hour h based on a stoichiometric calculation of the combustion process, which depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas, as follows:

$$TV_{n,FG,h} = V_{n,FG,h} \times FM_{RG,h} \qquad (5\text{-}5)$$

$TV_{n,FG,h}$	m^3/h	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour h
$V_{n,FG,h}$	m^3/kgRG	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour h
$FM_{RG,h}$	kgRG/h	Mass flow rate of the residual gas in the hour h

$$V_{n,FG,h} = V_{n,CO2,h} + V_{n,O2,h} + V_{n,N2,h} \qquad (5\text{-}6)$$

$V_{n,FG,h}$	m^3/kgRG	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour h
$V_{n,CO2,h}$	m^3/kgRG	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$V_{n,O2,h}$	m^3/kgRG	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$V_{n,N2,h}$	m^3/kgRG	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h

$$V_{n,CO2,h} = fm_{C,h} / AM_C \times MV_n \qquad (5\text{-}7)$$

$V_{n,CO2,h}$	m^3/kgRG	Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
$fm_{C,h}$	-	Mass fraction of carbon in the residual gas in the hour h
AM_C	kg/kmol	Atomic mass of carbon
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/Kmol)

$$V_{n,O2,h} = n_{O2,h} \times MV_n \qquad (5\text{-}8)$$

$V_{n,O2,h}$	m^3/kgRG	Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h

$n_{O2,h}$	kmol/kgRG	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

$$V_{n,N2,h} = MV_n \times (fm_{N,h} / (2 \times AM_N) + (1 - MF_{O2}) / MF_{O2} \times (F_h + n_{O2,h})) \quad (5\text{-}9)$$

$V_{n,N2,h}$	m^3/kgRG	Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 m^3/Kmol)
$fm_{N,h}$	-	Mass fraction of nitrogen in the residual gas in the hour h
AM_N	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air
F_h	kmol/kgRG	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h
$n_{O2,h}$	kmol/kgRG	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h

$$n_{O2,h} = t_{O2,h} / (1 - (t_{O2,h} / MF_{O2})) \times (fm_{C,h} / AM_C + fm_{N,h} / (2 \times AM_N) + (1 - MF_{O2}) / MF_{O2} \times F_h) \quad (5\text{-}10)$$

$n_{O2,h}$	kmol/kgRG	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h
$t_{O2,h}$	-	Volumetric fraction of O_2 in the exhaust gas in the hour h
MF_{O2}	-	Volumetric fraction of O_2 in the air (0.21)
F_h	kmol/kgRG	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h
$fm_{j,h}$	-	Mass fraction of element j in the residual gas in hour h
AM_j	kg/kmol	Atomic mass of element j
j	-	The elements carbon (index C) and nitrogen (index N)

$$F_h = fm_{C,h} / AM_C + fm_{H,h} / (4 \times AM_H) - fm_{O,h} / (2 \times AM_O) \quad (5\text{-}11)$$

F_h	kmol/kgRG	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h
$fm_{j,h}$	-	Mass fraction of element j in the residual gas in hour h
AM_j	kg/kmol	Atomic mass of element j
j	-	The elements carbon (index C), hydrogen (index H) and oxygen (index O)

STEP 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$TM_{FG,h} = TV_{n,FG,h} \times fv_{CH4,FG,h} / 1000000 \quad (5\text{-}12)$$

$TM_{FG,h}$	kg/h	Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
$TV_{n,FG,h}$	m^3FG/h	Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour h
$fv_{CH4,FG,h}$	mg/m^3	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour h

STEP 5: Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).
It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis).

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,h} \quad (5\text{-}13)$$

$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour h
$\rho_{CH4,h}$	kg/m^3	Density of methane at normal conditions (0.716)

Note that Tool denominates density by "ρ", while ACM0001 uses "D". Moreover, density is expressed in kg/m^3 in the Tool and $tonne/m^3$ in ACM0001. Care should be taken with the units to avoid errors.

STEP 6: Determination of the hourly flare efficiency

In case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is

- *0%, if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour h.*
- *determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour h :*

$$\eta_{flare,h} = 1 - TM_{FG,h} / TM_{RG,h} \quad (5\text{-}14)$$

$\eta_{flare,h}$	-	Flare efficiency in the hour h
$TM_{FG,h}$	kg/h	Methane mass flow rate in exhaust gas averaged in a period of time t (hour, two months or year)
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h

STEP 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiencies

Project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas ($TM_{RG,h}$) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{(h=1\sim8760)} TM_{RG,h} \times (1 - \eta_{flare,h}) \times GWP_{CH4} / 1000 \quad (5\text{-}15)$$

$PE_{flare,y}$	tCO_2e	Project emissions from flaring of the residual gas stream in year y
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour h
$\eta_{flare,h}$	-	Flare efficiency in the hour h
GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment period

Project emissions

$$PE_y = PE_{EC,y} \quad (6)$$

$PE_{EC,y}$	Emissions from consumption of electricity in the project case calculated following the latest version of *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*

Here, since power consumed in the project is obtained from the grid, Scenario A: Electricity consumption from the grid of the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* is applied. $PE_{EC,y}$ is calculated based on the following expression.

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y}) \quad (7)$$

$EC_{PJ,j,y}$	The quantity of electricity consumed by the project activity during the year y (MWh)
$EF_{EL,j,y}$	The emission factor for the grid in year y (tCO_2/MWh)
$TDL_{j,y}$	The average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site
j	Source of electricity consumption in the project

In $EF_{EL,j,y}$, Option A2 from the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" is applied, and a default value of 1.3 is used.
In $TDL_{j,y}$, the default value of 20% (=0.2) from the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* is used.

Leakage

According to ACM0001, there is no need to consider the effects of leakage.

Emission Reductions

Emission reductions are calculated by the following expression:

$$ER_y = BE_y - PE_y \quad (8)$$

ER_y	Emission reductions in year y (tCO_2e/yr)
BE_y	Baseline emissions in year y (tCO_2e/yr)
PE_y	Project emissions in year y (tCO_2e/yr)

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

(Copy this table for each data and parameter)

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	--
Description:	Regulatory requirements relating to landfill gas projects
Source of data used:	The DNA shall be contacted to provide information regarding host country regulation.
Value applied:	AF = 0
Justification of the choice of data or description of measurement methods and procedures actually applied:	Based on information obtained from the host country DNA, it has been confirmed that the host country has no legislation concerning capture of methane from landfill gas. Moreover, in the event where regulations newly arise, calculate based on ACM0001.
Any comment:	Record information on renewal of legislation, etc. every year.

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of CH_4
Source of data used:	IPCC
Value applied:	21
Justification of the choice of data or description of measurement methods	21 for the first commitment period.

and procedures actually applied:	
Any comment:	Confirm the latest information in monitoring.

Data / Parameter:	**D_{CH4}**
Data unit:	tCH_4/Nm^3CH_4
Description:	Methane density
Source of data used:	-
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied :	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4
Any comment:	

Data / Parameter:	**$BE_{CH4,SWDS,y}$**
Data unit:	tCO_2e
Description:	Methane generation from the landfill in the absence of the project activity in year y
Source of data used:	Calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Value applied:	Indicated in Section B.6.3.
Justification of the choice of data or description of measurement methods and procedures actually applied :	Calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Any comment:	Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during a year

Data / Parameter:	**φ**
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	Oonk et el. (1994) have validated several landfill gas models based on 17 realized landfill gas projects. The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during a year

Data / Parameter:	OX
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data used:	IPCC
Value applied:	0.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	Project site is an unmanaged SWDS.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year

Data / Parameter:	F
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	IPCC
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	A default value of 0.5 is recommended by IPCC.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year

Data / Parameter:	DOC_f
Data unit:	-
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data used:	IPCC
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	A default value of 0.5 is recommended by the IPCC.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year

Data / Parameter:	MCF

Data unit:	-
Description:	Methane correction factor
Source of data used:	IPCC
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	Project site is an unmanaged SWDS with the depth of 25~30 m.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year

Data / Parameter:	DOC_j
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type j
Source of data used:	IPCC
Value applied:	(see table below)
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with the state of waste on the project sites, the "wet waste" values are adopted.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year.

Waste type j	DOC_j (Wet waste)
Wood and wood products	0.43
Pulp, paper and cardboard (other than sludge)	0.40
Food, food waste, beverages and tobacco	0.15
Textiles	0.24
Garden, yard, and park waste	0.20
Glass, plastic, metal, other inert waste	0.00

Data / Parameter:	k_j
Data unit:	-
Description:	Decay rate for the waste type j
Source of data used:	IPCC
Value applied:	(see table below)

Waste type j	k_j (Tropical)

	(Wet)
Pulp, paper, cardboard, textiles	0.070
Wood, wood products and straw	0.035
Other (non-food) organic putrescible garden and park waste	0.170
Food, food waste, beverages and tobacco	0.400

Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with the climate in the host country, the "Tropical" and "Wet" values were adopted.
Any comment:	This parameter is based on the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year

Data / Parameter:	**f**
Data unit:	-
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another matter
Source of data to be used:	ACM0001
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	According to ACM0001, as fraction of methane captured at the SWDS is already accounted for in equation (2), "f" shall be assigned a value 0.
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year. In this project, this parameter is not monitored.

Data / Parameter:	$\mathbf{GWP_{CH4}}$
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
Source of data to be used:	IPCC
Value of data applied for the purpose of calculating expected emission reductions in section B.5	21
Description of measurement methods and procedures to be	A value of 21 is to be applied for the first commitment period of the Kyoto Protocol

applied:	
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Used for ex-ante estimation of the amount of the methane that would have been destroyed/combusted during the year. In this project, this parameter is not monitored.

B.6.3. Ex-ante calculation of emission reductions:

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Baseline emissions

As was indicated in Section B.6.1., expression (1) is used to make the calculation.

$$BE_y = (MD_{project,y} - MD_{BL,y}) \times GWP_{CH4} \quad (1)$$

According to *ACM0001*, $MD_{project,y}$ is calculated using the expression below in the ex-ante estimation.

$$MD_{project,y} = BE_{CH4,SWDS,y} / GWP_{CH4} \quad (9)$$

$BE_{CH4,SWDS,y}$	The methane generation from the landfill in the absence of the project activity at year y (tCO_2e)

According to the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site", $BE_{CH4,SWDS,y}$* can be calculated using the following expression.

$$BE_{CH4,SWDS,y} = 0.9 \times (1 - f) \times GWP_{CH4} \times (1 - OX) \times 16/12 \times F \times DOC_f \times MCF \times \sum_{(x=1\sim y)}\sum_j W_{j,x} \times DOC_j \times e^{-k(y-x)} \times (1 - e^{-kj}) \quad (10)$$

f	Fraction of methane captured at the landfill site (SWDS)
OX	Oxidation factor
F	Fraction of methane in the LFG (SWDS gas)
DOC_f	Fraction of DOC that can decompose
MCF	Methane correction factor
$W_{j,x}$	Mass of waste type *j* deposited in year x (t)
DOC_j	Fraction of DOC in the waste type *j*
k_j	Decay rate for the waste type *j*
j	Waste type category

According to ACM0001, "Sampling to determine the different waste types is not necessary; the waste composition can be obtained from previous studies".

Mass of waste type j deposited in year *x* ($W_{j,x}$) is calculated from the product of the amount of organic waste deposited in year *x* and the composition ratio.

Concerning the amount of waste, site survey was implemented on the amount carried into the site from June 2007 to March 2008, and judging from the data for the period from June to December 2007, the amount of waste in 2007 was set as 142,000 tons. Assuming the amount in 2007 to be the reference level, the past and future amounts of waste were set in line with the population increase rate in Yogyakarta of 1.3% estimated by the Indonesian Department of Statistics.

The amount of organic waste deposited in year *x* from 1995 to 2009

year *x*	amount of waste (tons/year)	year *x*	amount of waste (tons/year)
1995	98,526	2003	125,712
1996	101,573	2004	129,600
1997	104,714	2005	133,608
1998	107,953	2006	137,740
1999	111,292	2007	142,000
2000	114,734	2008	146,260
2001	118,282	2009	150,648
2002	121,940		

Concerning the composition of waste, using data obtained in the survey conducted in 2006 at Pulti Cempo disposal site in Solo City (Surakarta), which is situated close to Yogyakarta and is in the same living area, this was classified according to the IPCC waste types to give the following composition.

The waste composition

Waste type *j*	waste composition
Wood and wood products	6.11 %
Pulp, paper and cardboard	10.24 %
Food, food waste, beverages and tobacco	27.41 %
Textiles	3.94 %
Garden, yard and park waste	41.11 %
Glass, plastic, metal, other inert waste	11.19 %
Total	100.0 %

Project emissions

As was indicated in Section B.6.1, project emissions are calculated from the project power consumption using expression (6).

$$PE_y = PE_{EC,y} \quad (6)$$

In addition, since the disposal of waste will continue in parallel with the project activity in 2009, the "not collected LFG" will be included in the project emissions.

Leakage

As was indicated in Section B.6.1, according to *ACM0001* there is no need to consider the effects of leakage.

Emission Reductions

As was indicated in Section B.6.1, emission reductions are calculated using expression (8).

$$ER_y = BE_y - PE_y \quad (8)$$

Details on the above calculation conditions and calculation results are as shown in the following table.

		2009.07~	2010	2011	2012	2013	2014
$BE_{CH4,SWDS,y}$	tCO_2e	42,554	89,084	74,285	62,781	53,694	46,405
collected LFG	tCO_2e	42,554	80,176	74,285	62,781	53,694	46,405
BE_y	tCO_2e	42,554	89,084	74,285	62,781	53,694	46,405
$MD_{project,y}$	tCH_4	2,026	4,242	3,537	2,990	2,557	2,210
$MD_{reg,y}$	tCH_4	0	0	0	0	0	0
AF	-	0.0	0.0	0.0	0.0	0.0	0.0
PE_y	tCO_2e	410	9,728	820	820	820	820
$PE_{EC,y}$	tCO_2e	410	820	820	820	820	820
$EC_{PJ,y}$	MWh	263	526	526	526	526	526
$EF_{grid,y}$	tCO_2e/MWh	1.3	1.3	1.3	1.3	1.3	1.3
TDL_y	-	0.2	0.2	0.2	0.2	0.2	0.2
not collected LFG	tCO_2e	0	8,908	0	0	0	0
ER_y	tCO_2e	42,144	79,356	73,465	61,961	52,874	45,585

		2015	2016	2017	2018	~2019.06	TOTAL
$BE_{CH4,SWDS,y}$	tCO_2e	40,474	35,585	31,507	28,068	12,571	517,009
collected LFG	tCO_2e	40,474	35,585	31,507	28,068	12,571	508,100
BE_y	tCO_2e	40,474	35,585	31,507	28,068	12,571	517,009
$MD_{project,y}$	tCH_4	1,927	1,695	1,500	1,337	599	24,619
$MD_{reg,y}$	tCH_4	0	0	0	0	0	0
AF	-	0.0	0.0	0.0	0.0	0.0	
PE_y	tCO_2e	820	820	820	820	410	17,108
$PE_{EC,y}$	tCO_2e	820	820	820	820	410	8,199
$EC_{PJ,y}$	MWh	526	526	526	526	263	5,256
$EF_{grid,y}$	tCO_2e/MWh	1.3	1.3	1.3	1.3	1.3	
TDL_y	-	0.2	0.2	0.2	0.2	0.2	
not collected LFG	tCO_2e	0	0	0	0	0	8,908
ER_y	tCO_2e	39,654	34,765	30,687	27,248	12,161	499,901

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

The following table gives a summary of the ex-ante estimation of emission reductions caused by the project.

Year	Estimation of project activity emission (tCO_2e)	Estimation of baseline emission (tCO_2e)	Estimation of leakage (tCO_2e)	Estimation of emission reductions (tCO_2e)
2009	410	42,554	0	42,144
2010	9,728	89,084	0	79,356
2011	820	74,285	0	73,465
2012	820	62,781	0	61,961
2013	820	53,694	0	52,874
2014	820	46,405	0	45,585
2015	820	40,474	0	39,654
2016	820	35,585	0	34,765
2017	820	31,507	0	30,687
2018	820	28,068	0	27,248
2019	410	12,571	0	12,161
Total	17,108	517,009	0	499,901

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

B.7.1. Data and parameters monitored:

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(Copy this table for each data and parameter)

Data / Parameter:	**$LFG_{total,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas captured at normal temperature and pressure
Source of data to be used:	Calculated by using the data $LFG_{flare,y}$
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:	Calculated by using the data $LFG_{flare,y}$.
QA/QC procedures to be applied:	-
Any comment:	In this project, the captured landfill gas is supplied only to the flare, so $LFG_{total,y} = LFG_{flare,y}$. Therefore, this parameter is not monitored in this project.

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	m^3
Description:	Amount of landfill gas flared at normal temperature and pressure
Source of data to be used:	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 by a flow meter. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	

Data / Parameter:	**$PE_{flare,y}$**
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year y
Source of data to be used:	Calculated as per the *"Tool to determine project emissions from flaring gases containing Methane"*.
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:	Calculated as per the "Tool to determine project emissions from flaring gases containing Methane".
QA/QC procedures to be applied:	As per the "Tool to determine project emissions from flaring gases containing Methane".
Any comment:	

Data / Parameter:	**$w_{CH4,y}$**
Data unit:	m^3CH_4/m^3LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	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 by a gas analyser. Measured on wet basis.
QA/QC procedures to be applied:	Gas analysers should be subject to a regular maintenance and testing regime to ensure accuracy.

Any comment:	

Data / Parameter:	**T**
Data unit:	K
Description:	Temperature of the landfill gas
Source of data to be used:	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 by thermometer.
QA/QC procedures to be applied:	Thermometer should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.

Data / Parameter:	**P**
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data to be used:	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 by pressure gauge.
QA/QC procedures to be applied:	Pressure gauge should be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards.
Any comment:	Measured to determine the density of methane D_{CH4}. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.

Data / Parameter:	$\mathbf{PE_{EC,y}}$
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year y
Source of data to be used:	Calculated as per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.
Value of data applied for	Indicated in Section B.6.3.

the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
QA/QC procedures to be applied:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
Any comment:	

Data / Parameter:	$\mathbf{fv_{CH4,RG,h}}$
Data unit:	-
Description:	Volumetric fraction of component CH_4 in the residual gas in the hour h
Source of data to be used:	Calculated by using the data $w_{CH4,y}$
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:	Using the data $w_{CH4,y}$ measured continuously, values to be averaged hourly.
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on the "Tool to determine project emissions from flaring gases containing Methane".

Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h
Source of data to be used:	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 by flow meters. Values to be averaged hourly. The same basis (dry or wet) is considered for this measurement and the measurement of the volumetric fraction of all components in the residual gas ($fv_{i,RG,h}$) when the residual gas temperature exceeds 60 °C.
QA/QC procedures to be applied:	Flow meters should be periodically calibrated according to the manufacturer's recommendation.
Any comment:	This parameter is based on the "Tool to determine project emissions from flaring gases containing Methane".

Data / Parameter:	**$t_{O2,h}$**
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h
Source of data to be used:	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 by a gas analyser with water and particulates removal devices or in situ analysers for wet basis determination. Values to be averaged hourly. Sampling should be conducted with appropriate sampling probes adequate to high temperatures level in the upper section of the flare (80% of total flare height).
QA/QC procedures to be applied:	Analysers should be periodically calibrated according to the manufacturer's recommendation. A zero check should be performed by comparison with a standard gas.
Any comment:	This parameter is based on the "Tool to determine project emissions from flaring gases containing Methane". Only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data / Parameter:	**$fv_{CH4,FG,h}$**
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
Source of data to be used:	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 by a gas analyser with water and particulates removal devices or in situ analysers for wet basis determination. Values to be averaged hourly. Sampling should be conducted with appropriate sampling probes adequate to high temperatures level in the upper section of the flare (80% of total flare height).
QA/QC procedures to be applied:	Analysers should be periodically calibrated according to the manufacturer's recommendation. A zero check should be performed by comparison with a standard gas.
Any comment:	This parameter is based on the "Tool to determine project emissions from flaring gases containing Methane". Only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data / Parameter:	**T_{flare}**
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare

Source of data to be used:	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 by a Type N thermocouple.
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	This parameter is based on the “Tool to determine project emissions from flaring gases containing Methane”.

Data / Parameter:	**Other flare operation parameters**
Data unit:	-
Description:	All data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to the manufacturer’s specifications
Source of data to be used:	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:	According to the maker, the only required operating condition is “temperature of no less than 500°C.” In order to monitor T_{flare}, parameters are not particularly added here.
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on the “Tool to determine project emissions from flaring gases containing Methane”. Only applicable in case of use of a default value

Data / Parameter:	$\mathbf{EC_{PJ,j,y}}$
Data unit:	MWh
Description:	Electricity consumption by the project activity during the year y
Source of data to be used:	Measured on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Indicated in Section B.6.3.
Description of measurement methods and procedures to be applied:	Measured continuously by electricity meter. Data to be aggregated at least annually.
QA/QC procedures to be applied:	Electricity meters should be subject to a regular maintenance and testing regime to ensure accuracy. Cross check measurement results with invoices

	for purchased electricity.
Any comment:	This parameter is based on the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

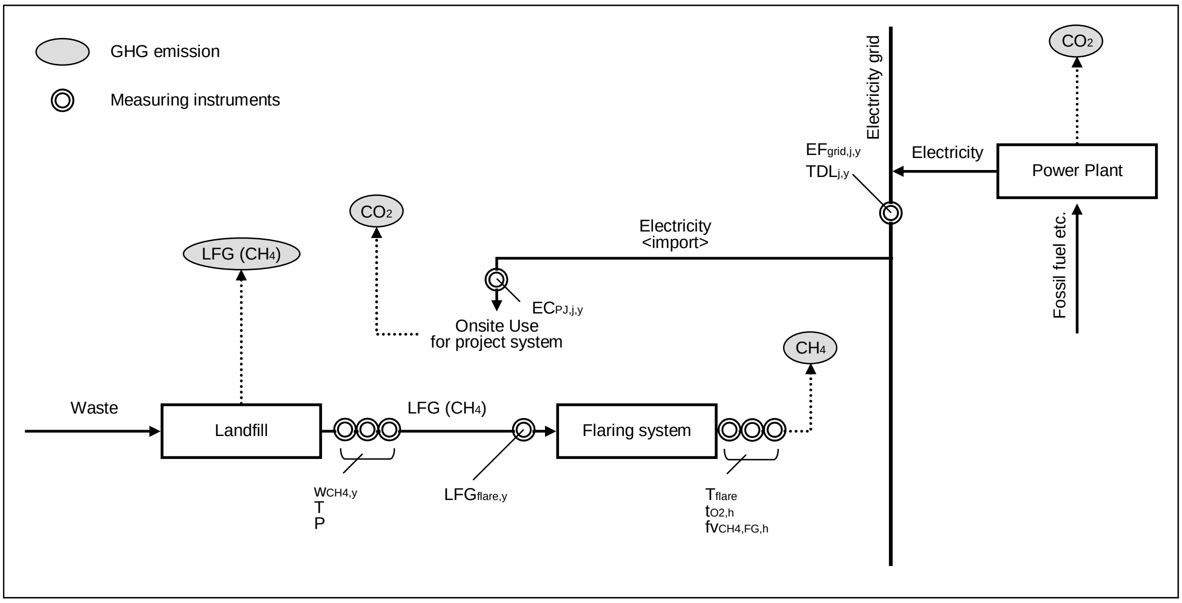
Data / Parameter:	$\mathbf{EF_{grid,j,y}}$
Data unit:	tCO_2/Mwh
Description:	Combined margin emission factor for the grid in year y
Source of data to be used:	As per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1.3
Description of measurement methods and procedures to be applied:	-
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

Data / Parameter:	$\mathbf{TDL_{j,y}}$
Data unit:	-
Description:	Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site
Source of data to be used:	As per the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Value of data applied for the purpose of calculating expected emission reductions in section B.5	20% (= 0.2)
Description of measurement methods and procedures to be applied:	-
QA/QC procedures to be applied:	-
Any comment:	This parameter is based on the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

B.7.2. Description of the monitoring plan:

>>

Figure 6 shows the monitoring plan in the project.



Note : The power consumed in the project $EC_{PJ,y}$ is the electric power consumed in the facilities that are newly installed in the project.

Figure 6 Flow chart of monitoring plan

Project operation and management (monitoring, facilities operation and maintenance, accounting, subcontracting, personnel affairs, reporting, etc.) will be born full responsibility for working under the assigned authority of the three municipalities stated in A.2, . In the project, quality control and quality assurance will 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 manufacturer’s recommendation”.
- ○ 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.

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: 18/08/2008

General Manager: Kurita Hiroyuki,
Manager: Maruyama Kazuhide, and
Manager: Mori Sueo
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(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:

>>

01/03/2009 (The day ordering of equipment is commenced)

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

>>

10 years

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:

>>

01/07/2009

C.2.2.2. Length:

>>

10 years

SECTION D. Environmental impacts

>>

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

>>

Legal basis which the environmental management effort (UKL) and environmental monitoring effort (UPL) were applied, is listed as follows.

1) Article 15 of Law of the Republic of Indonesia, No.23/1997, regarding environmental management
2) Elucidation of the Governmental Regulation (PP) No.27/1999, regarding analysis of environmental impact (Analisis Mengenai Dampak Lingkungan: AMDAL)
3) the Regulation of the State Minister of Environment, No.11/2006, regarding line of business or activity plan required an AMDAL
4) Decree of the State Minister of Environment, No.86/2002, regarding guidelines on implementation of program manual of Environmental Management Effort (UKL) and Environmental Monitoring Effort (UPL)

Based on 3), more than 10 MW for biomass power generation, more than 10 Ha for new construction of waste dumping site, and others are the defined magnitude for proceeding the environmental impact analysis: AMDAL. The Project activities and its magnitude are not exeed the scale of magnitude that are required to be completed with the environmental impact analysis.

Since the increase of noise level and or the decrease of ambient air quality in the construction stage of the Project activities, and negative component of noise and air vibration caused by blower and flare stack operation and also positive component of decrease of leachate volume and odor level in the operational stage are identified, UKL-UPL procedure are implemented based on the above 4).

Study and analysis are compiled as bellows.

Chapter 1 Introduction
Chapter 2 Activity Plan
Chapter 3 Environmental Setting
Chapter 4 Environmental Impact that will be generated
Chapter 5 Environmental Management Effort (UKL)
Chapter 6 Environmental Monitoring Effort (UPL)

UKL-UPL procedure is not for judgment of stop or go to the said project activities, but for the integrated approach to induce the project activities into being for environmental improvement between the project developer for the efforts and environmental management authorities for guidance and management, by means of identification of environmental management and monitoring effort for environmental components impacted which is contained socio-economic and cultural aspects.

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:

>>

On the results of the study and analysis for the Project Activities, environmental component impacted to be treated through the environmental management effort (UKL) and the environmental monitoring effort (UPL) are identified as follows;

Stage	Environmental Component Impacted	Present Prediction
Construction activities	Decrease in ambient air quality	Negative
	Disturbance of land biota which is cow population	Negative
	Increaseof Job opportunity	Positive
	Community’s Restlessness	Negative
Operational activities	Decrease in ambient air quality	Negative/Positive
	Increase of Noise	Negative/Positive
	Environmental Sanitation	Negative/Positive
	Community’s Perception	Positive

SECTION E. Stakeholders’ comments

>>

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

>>

Local stakeholders were assembled for a meeting to hear the project explanation and to discuss the contents. Invitations were sent to the stakeholders in advance (June 10, 2008). An outline of the meeting is as follows.

Day, Date : Saturday, June 14th 2008
Time : 09.00-12.00 am
Location : TPA Piyungan Bantul
Activity : Socialization of Methane Gas Capture in TPA Piyungan, Bantul, Yogyakarta
Participant : 52 persons

Figure 7 Meeting of Stakeholders

E.2. Summary of the comments received:

>>

The following stakeholders attended the meeting:

- Scavenger group
- Cattleman group
- Society
- Division Head of governance Sitimulyo Village
- Pleret Sub-district
- Piyungan Sub-district
- LESTARI NGO
- Government staff
- BPPT
- Shimizu Corporation

Basically, the project plan of methane gas capture has been agreed by village society and sub-district society in several sub-districts (kecamatan) with the annotation as below:

- The society intends a new land or enlargement of TPA that the government should provide.
- Every thing which involved in this project will always be handled by discussing and finding a "win-win solution" either for central government, regional government, Japan participants and society around the location.
- In the need for enlarging the land, the society expected to support the enlarging land planning with giving an easiness for government in providing a new land

Regarding the project itself, there was some opposition from those benefiting from the current landfill practice, most notably scavengers, who feared income loss by closing and management of landfill site.

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

>>

According to the comments that have been provided, almost stakeholders are positive about this project and it is believed that no particular measures are necessary with respect to the comments that have been received.

Every thing which involved in this project will always be handled by discussing and find a "win-win solution" either for central government, regional government, Japan participants and society around the location.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The project will not utilize any official funding from Annex I countries.

Annex 3

BASELINE INFORMATION

Indonesia***Financial Indicators***

Details of the sensitivity analysis conducted for the baseline scenarios in Section B.4 are given.
In Scenario 2, which is the Project case, since there is investment but no returns, this clearly cannot become the baseline scenario. Accordingly, sensitivity analysis is only carried out on Scenario 3.
In Scenario 3, it is assumed that a 620 kW gas engine is introduced. Table A3-6 shows the costs and parameters used in calculating the project IRR in Scenario 3. Moreover, Table A3-7 shows the results of Project IRR sensitivity analysis in the case where CERs are not taken into account.

Incidentally, the project implementation period will be 11 years from 2009 to 2019 (the credit period will be 10 years from July 2009 to June 2019).

In the calculation of IRR, two cases are tried; namely the first is for 11 years by the above-mentioned basis and the second is for 15 years by the basis of the life of gas engine generator (which equals to legal life in Japan).

Table A3.6 Cost and financial parameters

Item		Unit	Value
Initial cost		US$	3,691,522
Running cost		US$/y	145,000
Rate of inflation in Indonesia		%	8.0
Depreciation rate		%	90.0
Power tariff		US$/kWh	0.037
Exchange rate	Yen⇔US$	105.00	105.0

Table A3-7 Results of Sensitivity Analysis

			Reference		
Construction cost	-10%	-5%	±0%	+5%	+10%
IRR	Minus	Minus	Minus	Minus	Minus

			Reference		
Running cost	-10%	-5%	±0%	+5%	+10%
IRR	Minus	Minus	Minus	Minus	Minus

			Reference		
Electricity sales tariff	-20%	-10%	±0%	+10%	+20%
IRR	Minus	Minus	Minus	Minus	Minus

			Reference		
Generated LFG	-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.

○ **$LFG_{total,y}$ Collected amount of LFG**
○ **$LFG_{flare,,y}$ Flared amount of LFG (= $FV_{RG,h}$, hourly flow rate of RG)**

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, a vortex type flow meter or a turbine 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 turbine type and the vortex type flow meters fulfil these requirements. As is explained below, the flow meter must be capable of outputting to a computing unit.

The turbine type and the vortex type flow meters measure 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 turbine flow meter is characterized by having a moving part, i.e. a turbine, in the flow meter unit. Accordingly, it is necessary to attach a filter to the upstream part of the flow meter to ensure that no foreign objects get caught in the turbine. The vortex type flow meter has no movable parts, however, it does have a vortex generator. Therefore, as with the turbine flow meter, it is essential to attach a filter to the upstream part of the flow meter to ensure that no foreign objects get caught in the vortex generator. Accordingly, it is very important to manage the filter and keep it clean. If the filter is managed and cleaned adequately, there is no need to perform regular calibration of the flow meter unit.

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 collected LFG 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.

The flow rate of gas going to the flare shall be continuously measured and averaged every hour.

○ **T** **Temperature of LFG**

○ **T_{flare}** **Temperature of flare exhaust gas**

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, etc. (i.e. fitting with a terminal). The resistance type thermometer fulfils these requirements if measuring relatively low temperature (80°C~50°C) objects such as LFG, whereas the thermocouple is more appropriate for measuring relatively hot (500°C~1500°C) objects such as flare exhaust gas.

The resistance type thermometer has a platinum temperature sensor with extremely high durability. However, since the thermocouple is used under extremely high temperatures, there is a risk that resistive element degradation will diminish the accuracy of temperature measurements. Therefore, it is necessary to regularly change the thermocouple.

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.

The temperature of flare exhaust gas 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.

○ **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, a pressure transmitter that utilizes a diaphragm is used, however, since this has excellent durability, there is no need especially to carry out calibration on site.

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.

○ **$w_{CH4,y}$** **Methane concentration in LFG (=$fv_{CH4,RG,h}$, hourly methane concentration in RG)**

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 in LFG shall be continuously measured and averaged every hour.

○ **$fv_{CH4,FG,h}$** **Methane concentration in flare exhaust gas**
○ **$t_{O2,h}$** **Oxygen concentration in flare exhaust gas**

Methane Concentration
The non-dispersive infrared absorption method (NDIR method) was used. The gas chromatograph is also available, however, due to problems in securing the safe installation of the FID (flame ionization detector) hydrogen source, and since there is a possibility that interference by co-existing gases such as oxygen will compromise accurate readings, the non-dispersive infrared absorption method is deemed to be the most appropriate. Also, the ratio method (ratio photometry method) has been adopted. The principle of operation in this method is as follows: The infrared light radiated from the light source is guided in pulses by a rotary sector alternately into a sample cell and a reference cell. The infrared light passing through each cell then reaches the detector. The reference cell contains sealed nitrogen to prevent it from absorbing the infrared light. Accordingly, the same intensity of infrared light is always radiated on the detector. In contrast to this, in the sample cell, infrared absorption occurs according to the concentration of the gas targeted for measurement, so the infrared light is attenuated before entering the detector. Since the target gas is sealed inside the detector, out of the infrared light reaching the detector, only the infrared absorption band of the target gas is detected and the difference in pressure between the front chamber and rear chamber of the detector is detected as a signal. The measured concentration is calculated from the ratio of the independently detected comparative signal and the measured signal. At this time, since the comparative signal is constantly monitored, the concentration level can be obtained at a uniform sensitivity even if the strength of the light source and detector sensitivity change. This detector itself has a front and rear chamber structure which minimizes the interference by co-existing gas and leads to stable results.

Oxygen Concentration

The magnetic wind measurement method was used. This method, which measures through utilizing the propensity of oxygen to be attracted to magnetic fields, has been around for a long time. It offers good reproducibility and stability. The zirconia method is also available, however, when combustible gases are included, since there is a possibility that these will burn and consume the oxygen in the high temperature measurement cell, there is a chance that negative error will be imparted.

The methane concentration and oxygen consentration shall be continuously measured and averaged every hour each.

Maintenance

Maintenance comprises the following: replacement of filters, confirmation of dirt on drain separator, replacement of the mist absorber, replacement of the pump diaphragm.

Calibration is implemented automatically, however, it is necessary to exchange the calibration gases.

○ **$EC_{Pj,y}$** **Amount of electricity consumed in the project**

The watt-hour meter shall be installed in order to monitor the amount of electricity consumed in the facilities newly installed in the Project. Incidentally, the site already has power consumption and watt-hour meter to measure the amount of purchased electricity, however, it will be necessary to install a separate watt-hour meter for measuring just the project power. The new watt-hour meter shall be the same type as the existing one. Accordingly, the meter demanded by the grid owner shall be installed, and the calibrations that are required 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.

○ **$EF_{grid,j,y}$** **Grid emission factor**

○ **$TDL_{j,y}$** **Transmission loss factor**

The default values from the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" are used.

○ **AF** **Adjustment factor**

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

In the event where legislation and regulations are changed, calculate the AF based on ACM0001.

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