Project Design Document

CDM PROJECT ACTIVITY

LANDFILL GAS RECOVERY IN INDONESIA

JUNE 2007

FINAL VERSION

EXECUTIVE SUMMARY

The objective of the Project is to collect and utilize, where economically possible, the landfill gas (LFG) generated at the landfills. This will involve investing in a highly efficient gas collection system, flaring equipment, and, where economically viable, a modular electricity generation plant. Excess LFG, and all gas collected during periods when electricity is not produced, will be flared.

The project activity consists of several sub-projects:

- Landfill Telaga Punggur in Batam
- Landfill TPA 1 Sukawinatan in Pelembang
- Landfill Pinang in Samarinda
- Landfill Kebun Kongok in Mataram
- Landfill Sumur Batu in Bekasi
- Landfill Supit Urang in Malang
- Landfill Air Dinging in Padang
- Landfill Talang Gulo in Jambi
- Landfill Manggar in Balikpapan
- Landfill Kawatuna in Palu

The projected emission reductions are shown in the table below.

Table I. Annual estimation of emission reductions

Years	**Annual estimation of emission reductions in tonnes of CO_2 e**
2008	143.611
2009	328.153
2010	360.718
2011	389.096
2012	405.273
2013	421.741
2014	438.514
2015	442.904
2016	431.430
2017	429.099
2018	199.928
Total estimated reductions (tonnes of CO_2 e)	3.990.468
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	399.047

The project is able to contribute significantly to the reduction of Green House Gas emissions in the Host Country and to its goals of promoting sustainable development. Specifically the project contributes to:

Emission reduction through CDM

- By collecting the LFG, generated by the landfills, methane is destroyed, thereby reducing emissions from landfills. Methane has a high Global Warming Potential (21 times the potential of CO_2), which makes the project adding considerably to effort to fight global warming. These emission reductions can serve as CER's (Certified Emission Reduction) in the CDM mechanism of the Kyoto Protocol.

Technology Transfer

- The project will use clean and efficient, modern technologies for collecting the landfill gas, flaring and generation of electricity.
- Local people will be trained to maintain and operate the technologies.
- The project will act as a clean technology demonstration project, encouraging development of modern and more efficient generation of electricity using landfill gas throughout the country;
- The project will provide a model for managing LFG, a key element in improving landfill management practices throughout the host country.

Community development

- The project will provide for both short- and long-term employment opportunities for local people. Local contractors and labourers will be required for construction and long-term staff will be used to operate and maintain the system.
- Through the project, general waste management practices are changed. A capacity building programme is designed for this issue.
- Properly collecting and destroying flammable LFG will reduce the risks associated with explosions in and around the landfill. This is particularly important as in one of the landfills in the project an explosion occurred which killed some 140 persons.
- The project will provide a model for managing LFG, a key element in improving landfill management practices throughout the host country.
- The project will act as a clean technology demonstration project, encouraging less dependency on grid-supplied electricity, and will represent a technology transfer from to the host country.
- Improves the overall management practices of the landfills and provides an incentive to improve the community garbage management techniques.

National Financial benefits

- The projects diversifies the sources of electricity generation.
- Electricity generated by the project will be the asset of the operators of the landfills. They can supply the electricity to the national grid.
- Improves the safety situation of the landfills.

Environmental benefits

- The destruction of the LFG will improve the local environment by reducing the amount of noxious air pollution arising from the landfill, resulting in a considerable reduction of nuisance caused by the odours and also health risks associated to these emissions, especially for the surrounding population located nearby the landfill.
- The project uses clean and efficient technologies and conserves natural resources;

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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

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Bundled Landfill gas recovery project Indonesia
Version 07 – final version
June 21st 2007

A.2. Description of the project activity:

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The project activity includes the capture and utilization of landfill gas from landfills in Indonesia. The landfill gas will, if economically viable, be used for generation of electricity, otherwise it will be flared. The project activity consists of several sub-projects, the sub-projects share the same characteristics and are all managed by Global Eco Rescue Foundation, and therefore bundled into one. The different sub-projects are:

- Landfill Telaga Punggur in Batam
- Landfill TPA 1 Sukawinatan in Pelembang
- Landfill Pinang in Samarinda
- Landfill Kebun Kongok in Mataram
- Landfill Sumur Batu in Bekasi
- Landfill Supit Urang in Malang
- Landfill Air Dinging in Padang
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- Landfill Manggar in Balikpapan
- Landfill Kawatuna in Palu

All landfills are owned by the different city councils, which are operating the landfills as well. The following table shows the locations, owners and other characteristics of the included landfills.

Table 1: Characteristics of sub-projects

#	Name	Nearby town	Island	Owner	Operator	People served
1	Telaga Punggur	Batam	Sumatera	Batam Industrial Development Authority. The ownership will be transferred to the City Government, Department of Markets and City Cleaning. Further to the City's intent and efforts the ownership may be transferred to a Consortium winning the tender by mid 2007.	Batam City Government, Department of Markets and City Cleaning.	820.000
2	TPA 1 Sukawinatan	Palembang	Sumatera	City of Palembang	City of Palembang, Waste Management Division	1.275.000

3	Pinang	Samarinda	Kalimantan	City of Samarinda	City of Samarinda, Department of City Cleaning	500.000
4	Kebun Kongok	Mataram	Lombok	Regency of Lombok Barat	City of Mataram	480.000
5	Sumur Batu	Bekasi	West-Java	City of Bekasi	City of Bekasi, Department of City Cleaning	2.000.000
6	Supit Urang	Malang	Java	City of Malang	City of Malang	900.000-1000.000
7	Air Dinging	Padang	Sumatera	City of Padang (except 4 ha which is owned by a community)	City of Padang, Cleaning Department	163.600
8	Talang Gulo	Jambi	Sumatera	City of Jambi	City of Jambi, Department of City Cleaning and Cemeteries	500.000
9	Manggar	Balikpapan	Kalimantan	City of Balikpapan	City of Balikpapan, Department of City Cleaning	380.000
10	Kawatuna	Palu	Sulawesi	Regency of Palu	City of Palu	300.000

The objective of the Project is to collect and utilize, where economically possible, the LFG generated at the landfills. This will involve investing in a highly efficient gas collection system, (enclosed) flaring equipment, and, where economically viable, a modular electricity generation plant. Excess LFG, and all gas collected during periods when electricity is not produced, will be flared.

The Project is being developed through GER, Global Eco Rescue Foundation Ltd. GER is responding to the challenge of climate change, and is helping companies and institutional investors to realize the related opportunities. GER is an environmental finance company formed to promote environmentally sustainable development by accelerating the securitization of emerging markets for environmental assets through a high impact program to develop project-based greenhouse gas emission reductions, and to realize other environmentally beneficial projects and technologies.
GER works with BGP Engineers B.V. for the engineering, procurement and overall implementation of the project as well as for the development of the project under the Clean Development Mechanism under the Kyoto Protocol.

The project can be a significant contribution to the reduction of Green House Gases in the Host Country and its goals of promoting sustainable development. Specifically the project contributes to:

Emission reduction through CDM

- By collecting the LFG, generated by the landfills, methane is destroyed, thereby reducing emissions from landfills. Methane has a high Global Warming Potential (21 times the potential of CO_2), which makes the project adding considerably to effort to fight global warming. These emission reductions can serve as CER’s (Certified Emission Reduction) in the CDM mechanism of the Kyoto Protocol.

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Environmental benefits

- The destruction of the LFG will improve the local environment by reducing the amount of noxious air pollution arising from the landfill, resulting in a considerable reduction of nuisance caused by the odours and also health risks associated to these emissions, especially for the surrounding population located nearby the landfill.
- The project uses clean and efficient technologies and conserves natural resources;

Figure 1: Current situation at a landfill

A.3. Project participants

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Table 2: Project participants

Name of party involved	Private and/or public project participant	Does the Party involved wish to be considered as project participant?
Indonesia (host)	Ministry of Environment	No
	Batam City Government	No
	City of Palembang	No
	City of Samarinda	No
	Regency of Lombok Barat	No
	City of Bekasi	No
	City of Malang	No
	City of Padang	No
	City of Jambi	No
	City of Balikpapan	No
	Regency of Palu	No
	PT GER Ltd.	No
Commonwealth of the Bahamas	GER Foundation Ltd.	Yes
Switzerland / Indonesia	Borneo Tropical Rainforest Foundation	No
The Netherlands	BGP Engineers B.V.	Yes
	Ministry of VROM	Yes

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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Figure 2: Locations of the landfills in the project

A.4.1.1. Host Party(ies):

>>
Indonesia (Host Country)

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

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Table 3: Location of project activities - provinces

Landfill number	**Name**	**Island**	**Province**
1	Telaga Punggur	Sumatera	Riau
2	TPA 1 Sukawinatan	Sumatera	Lampung
3	Pinang	Kalimantan	South-Kalimantan
4	Kebun Kongok	Lombok	West Nusa-Tenggara
5	Sumur Batu	Java	West Java
6	Supit Urang	Java	East Java
7	Air Dinging	Sumatera	West-Sumatra
8	Talang Gulo	Sumatera	Jambi
9	Manggar	Kalimantan	East Kalimantan

10	Kawatuna	Sulawesi	Central Sulawesi

A.4.1.3. City/Town/Community etc:

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Table 4: Location of project activities - towns

Landfill number	Name	Nearby Town
1	Telaga Punggur	Batam
2	TPA 1 Sukawinatan	Pelembang
3	Pinang	Samarinda
4	Kebun Kongok	Mataram
5	Sumur Batu	Bekasi
6	Supit Urang	Malang
7	Air Dinging	Padang
8	Talang Gulo	Jambi
9	Manggar	Balikpapan
10	Kawatuna	Palu

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

>>

The exact locations of the landfills in the project are shown in the table.

Table 5: Location of project activities – physical locations

#	Name	Nearby town	Location
1	Telaga Punggur	Batam	In the neighbourhood of Punggur, east of Batam Centre and northeast of the international airport, at a distance of 800 m from the sea
2	TPA 1 Sukawinatan	Palembang	6 Km west of the centre of Palembang
3	Pinang	Samarinda	At a distance of 10 km to the north of the city, on the road to the City of Tenggarong
4	Kebun Kongok	Mataram	Near the village of Sukamakmur in the district of Labuapi in the Regency Lombok Barat, about 17 km south of Mataram
5	Sumur Batu	Bekasi	Some 10 km south of the DINAS office on the road to Bantang Gebang; the landfill is another 2 km off this road
6	Supit Urang	Malang	Supiturang, Sukun subdistrict
7	Air Dinging	Padang	17 km to the north of the city centre, on the road to Bukkittingi
8	Talang Gulo	Jambi	14 km south of Jambi town centre, located in the subvillage of Kenali Asam Bawah.
9	Manggar	Balikpapan	Some 20 km to the east of the center of Balikpapan (17 km along the coast, 3 km land inwards)
10	Kawatuna	Palu	North East of City of Palu

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

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According to Annex A of the Kyoto Protocol, the project activity can be categorized as Sectoral Category 13, Waste handling and Disposal.

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

>>
Landfill gas collection system

The project activity involves the installation of state of the art LFG collection technology at every landfill in the project. This includes:

- Vertical gas wells drilled into waste to extract the LFG. The gas wells cover the area of the landfill available for gas extraction.
- The gas collection pipe work consists of pipes connecting groups of gas wells to the manifolds. Manifolds connect into a main pipe and then into the main header pipe delivering the gas to the extraction plan and the flare. The system is modular, so it is relatively easy to extend it on parts of the landfills available for gas extraction in the future.
- The gas collection system pipe work allows for effective condensate management by employing dewatering points at strategic low points and returning the condensate back to the landfill.
- The system operates at pressure slightly lower than atmospheric. A blower draws the gas from the wells through the collection system and delivers it to the flare or gas fuelled internal combustion engine powering electricity generator. The system is optimised to address issues related to pressure losses.
- For efficient operation of the gas collection system, each landfill cell, where the gas is collected from, is covered by an impermeable material (high density polyethylene membrane or mineral material) to provide sufficient containment and prevent air ingress into landfill body.

Electricity generation system

At the landfills an electricity generation system will possibly be put in place, whenever it appears to be economically viable. It will consist of a gas engine/generator of appropriate size.

Installation

The gas collection and electricity generation field installation are closely managed and monitored by experienced project managers. Experienced key workers are employed to ensure that the gas collection system and the electricity generation system are installed correctly, and a large portion of the plants and labour is sourced locally.

Operation

The gas collection system will be set up for optimal long-term operation. Engineers and technicians are involved in balancing the gas collection system on a regular basis in accordance with the monitoring plan.

Sophisticated gas and electricity monitoring equipment, fitted with in-built data logging facility and data retrieval to a PC is used in the day-to-day operation of each landfill.

Flaring technology

The project activity involves the installation of a modular enclosed gas flare consisting of pipe work, valves, blower, stack with burners, instrumentation and control panel.

The flaring system includes the following instrumentation:

- Flow meter to measure accurately the flow of the gas throughout the system;
- Gas analyser that measures the quality of the gas;
- Sampling points for taking gas samples with portable instrumentation and for laboratory analysis;
- Thermocouple that monitors the temperature of the flame in the stack
- Data logging system.

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

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Table 6: Estimated amount of emission reductions

Years	**Annual estimation of emission reductions in tonnes of CO_2 e**
2008	143.611
2009	328.153
2010	360.718
2011	389.096
2012	405.273
2013	421.741
2014	438.514
2015	442.904
2016	431.430
2017	429.099
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Total estimated reductions (tonnes of CO_2 e)	3.990.468
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	399.047

A.4.5. Public funding of the project activity:

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The project will not receive any public funding.

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

>>
For the project, the version 05 of the 'Consolidated baseline methodology for landfill gas project activities ACM0001' will be used, together with the 'Tool for the demonstration and assessment of additionality' version 03 and the 'Tool to determine project emissions from flaring gases containing methane'.

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

>>
The methodology ACM0001 is applicable to landfill gas capture project activities where:

1. The baseline scenario is the partial or total atmospheric release of the gas
2. The project activities includes situations as:
    a) The captured gas is flared; or
    b) The captured gas is used to produce energy, but no emissions reduction are claimed for displacing or avoiding energy for other sources; or
    c) The captured gas is used to produce energy and emission reductions are claimed for displacing or avoiding energy generation form other sources.

This methodology is applicable because in most landfills the gas will be flared (option a) and in the remaining landfills where electricity will be generated, no reductions will be claimed for this (option b).

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

>>
According to ACM0001 baseline methodology, the project boundary is the site of the project activity where the gas will be captured and destroyed/used.

The following project activities and emission sources are considered within the project boundaries:

- CH4 emissions from the un-recovered LFG liberated from the landfill sites. It is estimated that only 60-70% of LFG generated at the landfills will be captured, which means that the remaining 30-40%, will be released as fugitive emissions.
- CO2 from the combustion of landfill gas in the flares and electricity generator. When combusted, methane is converted into CO2. As the methane is organic in nature these emissions are not counted as project emissions. The CO2 released during the combustion process was originally fixed via biomass so that the life cycle CO2 emissions of LFG are zero. The CO2 released is carbon neutral in the carbon cycle.
- Electricity required for the operation of the project activity should be accounted for in the project emissions and they need to be monitored. However, as the project activity may involve electricity generation and therefore use electricity generated from LFG, only the net quantity of electricity drawn from the grid should be used to account for emissions from electricity use.

Table 7: Sources and gases included in project boundary

	Source	Gas	Included?	Justification/explanation
Baseline	Landfill gas emitted to the air	CO_2	No	Negligible
		CH_4	Yes	
		N_2O	No	Negligible
Project activity	Unrecovered landfill gas emitted to the air	CO_2	No	Negligible
		CH_4	Yes	
		N_2O	No	Negligible
	Combustion of landfill gas in flares or electricity generator	CO_2	No	Life-cycle CO_2 emissions of LFG are set to zero
		CH_4	Yes	
		N_2O	No	Negligible
	Electricity required for operations of the project activity	CO_2	Yes	
		CH_4	No	Negligible
		N_2O	No	Negligible

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

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Identification of baseline scenario

According to methodology ACM0001 the baseline is the atmospheric release of the gas and the baseline methodology considers that some of the methane generated by the landfill may be captured and destroyed to comply with regulations or contractual requirements, or to address safety and odour concerns.

Indonesian regulation concerning landfills

There is no regulation requesting recovery and flaring of any LFG portion in the landfills in Indonesia.

Contractual requirements

As all landfills are operated and owned by state-bodies, no special contractual requirements exists concerning methane capturing apart from law.

Safety and odour concerns

From site-visits to all landfills it became clear that no measures are taken at the moment for safety and odour reduction. This is particularly evident as in one of the landfills in the project an explosion occurred recently which killed some 140 persons.
During the visits to a total of 36 landfills, no flaring activities were observed. In some cases methane was vented in order the decrease the risk of explosion of the landfill.

Figure 3: Current practice for methane release

Summarising, the baseline scenario will not consider any destruction of methane, and all the CH_4 potential of the landfills will be emitted into the atmosphere.

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

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The determination of the projects additionality is done using the CDM consolidated tool for demonstration of additionality version 03, which follows the following steps:

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

Substep 1a. Define alternatives to the project activity.

Alternative 1: The landfill operator could continue the current business as usual practice of passive venting (i.e., not collecting and flaring) LFG from the waste management operations directly to the atmosphere.

Alternative 2: The landfill operator could invest in a LFG collection system of high effectiveness, as well as a high efficiency flaring system. In the case of landfills where electricity will be generated, the landfill operator would also invest in LFG power generation equipment. The operation would reduce GHG emissions and the generation of power from fossil-fired grid-connected sources. Alternative 2 represents the proposed project activity.

Sub-step 1b. Enforcement of applicable laws and regulations:

As mentioned, there is no mandatory law or regulation, or any contractual arrangement that force landfill operators to collect and flare methane or to use it for electricity generation. Therefore, the two alternatives considered above are in compliance with all applicable legal and regulatory requirements.

In addition, in the foreseeable future, it is unlikely that new regulations or laws that may bring one of the sub-projects to non-compliance would be issued. Moreover, and according to the monitoring plan ACM0001, relevant regulations for LFG extraction or combustion (even if these laws and regulations have objectives other than GHG reductions) will be monitored yearly, and any implication on emissions will be taken into account when calculating actual emissions of the project activity.

Step 2. Investment Analysis

Sub-step 2a: Determine appropriate analysis method

According to the tool for the demonstration and assessment of additionality, one of three options must be applied for this step: (1) simple cost analysis (where no benefits other than CDM income exist for the project), (2) investment comparison analysis (where comparable alternatives to the project exist), or (3) benchmark analysis.

In the case of the landfills where the project activity involves only collection and flaring of the LFG and the only income of the project would come from the carbon revenues. Therefore option (1) simple cost analysis will be applied.

In the case of the landfills where the project activity involves collection and utilization of the LFG for electricity generation, the most likely alternative to the project is to simply not install flaring and generation equipment at the site, i.e., the alternative does not involve investments of a similar scale to the project. Therefore, option (3) benchmark analysis will be applied for these landfills.

Substep 2b Option I. Apply simple cost analysis –landfills without electricity generation

The costs of the project activity for landfills without electricity generation are documented in the table below. Since there are no revenues other than CDM revenues, the project is demonstrably additional. By investing in a landfill gas collection and flaring systems, the Project would not generate any revenues in the absence of the CDM. Therefore, the project activity is not economically attractive and not a realistic baseline scenario for the landfills where no electricity is generated.

Table 8: Costs related to project activity

Landfill	Cost	Amount (EURO)	Frequency
1	Capital costs	898.066	Once
	Operational costs	38.000	Annually
2	Capital costs	286.035	Once
	Operational costs	21.000	Annually
3	Capital costs	605.260	Once
	Operational costs	30.000	Annually
4	Capital costs	278.218	Once
	Operational costs	30.000	Annually
5	Capital costs	488.645	Once
	Operational costs	26.000	Annually
6	Capital costs	1.105.809	Once

	Operational costs	38.000	Annually
7	Capital costs	763.607	Once
	Operational costs	40.000	Annually
8	Capital costs	519.948	Once
	Operational costs	32.000	Annually
9	Capital costs	381.436	Once
	Operational costs	23.000	Annually
10	Capital costs	422.248	Once
	Operational costs	24.000	Annually
TOTAL	**Capital costs**	**5.749.272**	**Once**
	Operational costs	**302.000**	**Annually**

Sub-step 2b: Option III - Apply benchmark analysis – landfills with electricity generation

The likelihood of development of this project, as opposed to the continuation of current activities (i.e., no collection and combustion of landfill gas), will be determined by comparing its IRR with the benchmark of interest rates available to a local investor, In December 2006, interest rates at the central banks in Indonesia is 10% and yields on government bonds were 8,15% in October 2006. The benchmark rate of return on construction or projects with similar risks involved is commonly set at least at 15%.

It is pertinent to note that project developers or equity investors face a number of risks in implementing the project, which demands additional premium to be added to the return of investment. The first kind of risk is that for commercial projects in general as opposed to government financed projects. The second type of risk is that for projects that are one of, if not the first of its kind in the country. The third type of risk is the use in the project of a technology that is new to the country.
Once all of these risks are taken into account, the benchmark IRR will be significantly higher than the inter-bank interest rate. It is not uncommon for investors in first-of-the-kind projects in developing countries to demand an IRR of well over 25%. Here, for the purpose of simplicity and conservatism, no further risk premium is added. Therefore, 10% is the benchmark.

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

The Table below shows the financial analysis for the sub-project activities for each landfill where possibly electricity will be generated. The electricity price is assumed to be EUR 38 / MWH, consistent with current prices, which are not expected to change substantially. As shown, the project IRR (without carbon revenues) at the most viable case is 3 %, lower than the interest rates provided by banks or government bonds in the Host Country. Here the connection to the grid is stated to be an investment of EUR. 1500. This is the minimum investment needed, but can range to over 100.000 EUR depending on technical factors and the distance to the grid. This will make the IRR even lower for projects without carbon revenues.

Table 9: Financial results of the project (Alternative 2) with and without carbon finance

Landfill	IRR with carbon credits	IRR without carbon credits
1	13%	-5%
2	16%	-5%
3	17%	3%
4	30%	1%
5	20%	-4%
6	8%	-10%
7	22%	0%
8	15%	-2%
9	9%	-10%
10	12%	-11%

Sub-step 2d: Sensitivity analysis

A sensitivity analysis was conducted by altering the following parameters:

• Increase in project revenue (price of electricity sold to the grid);
• Reduction in project capital and running costs (Investment and Operational and Maintenance costs).

Those parameters were selected as being the most likely to fluctuate over time. Financial analyses were performed altering each of these parameters by 10%, and assessing what the impact on the project IRR would be (see Table below). As it can be seen, the project IRR remains lower than its alternative even in the case where these parameters change in favour of the project.

Table 10: Sensitivity analysis

Scenario	% change	IRR (%)									
		Landfill									
		1	2	3	4	5	6	7	8	9	10
Original		-5%	-5%	3%	1%	-4%	-10%	0%	-2%	-10%	-11%
Increase in project revenue	**10%**	-3%	-2%	5%	5%	-3%	-7%	2%	1%	-6%	-7%
Reduction in project costs	**10%**	-2%	-1%	6%	5%	-1%	-7%	3%	1%	-6%	-7%

In conclusion, the project IRR remains too low even in the case where these parameters change in favour of the Project. Even though these numbers are similar to the risk free returns of government bonds, these are still too low for a risky enterprise such as the construction and operation of a landfill gas-to-energy project, and fairly lower than private equity investments such as 15%. Consequently, the Project cannot be considered as financially attractive.

Step 4. Common Practice Analysis

Sub-step 4a. Analyze other activities similar to the proposed project activity

According to a presentation on municipal waste management in Indonesia by Mrs. Hilman, the Deputy Minister for Nature Conservation Enhancement and Environmental Destruction Control, the situation of waste management in Indonesia can be summarised as:

“Last identified by MoE in year 2004, there are 62 TPA classified as Open Dumping and only 1 is Control Landfill (Bantar Gebang)”

This one controlled landfill in Bekasi (Bantar Gebang) mentioned as a CDM activity. Since this investigation, outside CDM activities there are no further projects of this kind started. Furthermore, there are no regulations that require landfill gas to be collected and destroyed, so that even the more simple and less expensive technology of landfill gas recovery and utilization is yet to be carried out commercially.

Sub-step 4b. Discuss any similar options that are occurring

As there are no similar activities to the Project Activity, this step is not relevant.

The investment analysis in Step 2 demonstrated that the Project is not financially viable without the CDM, and that CDM designation of the Project will enable it to generate additional revenue from the sale of CER’s, which will increase the IRR of the Project significantly to an acceptable level. Step 4 showed that there are currently no other activities similar to this CDM activity in the country.
Thus, the CDM registration directly impacts on both management and investors’ decisions to proceed with the Project.
It therefore can be concluded that the project is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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The methodology ACM0001 requires that ‘Project proponents should provide an ex ante estimate of emissions reductions, by projecting the future GHG emissions of the landfill. In doing so, verifiable methods should be used’. In the case of this project, a proprietary first order decay model is used to determine estimated emissions reductions ex ante. This ex ante estimate is for illustrative purposes, as emissions reductions will be monitored ex-post, according to the methodology.
The methodology will be applied using option a) and b) of the Consolidated Methodology, where the gas captured is either flared or the captured gas is used for electricity generation but no emission reductions are claimed for displacing or avoiding energy from other sources.

The development of equations specified in Methodology ACM0001 are included under section B.6 hereunder.

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

Data / Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential value for methane
Source of data used:	Revised 1996 IPCC guidelines
Value applied:	21 tCO_2e/tCH_4
Justification of the choice of data or description of measurement methods and procedures actually applied:	Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4
Any comment:	

Data / Parameter:	$MD_{reg,y}$
Data unit:	tonnes of methane (tCH_4)
Description:	The amount of methane that would have been destroyed/combusted during the year in the absence of the project.
Source of data used:	-
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied :	There is no regulation requesting recovery and flaring of any LFG portion in the landfills in Indonesia. Therefore, the baseline will not consider any destruction of methane (MDreg = 0), and all the CH4 potential of the landfills will be emitted into the atmosphere, based on the IPCC methodology for estimating these emissions.
Any comment:	-

Data / Parameter:	k_l
Data unit:	(1/yr)
Description:	decay rate constant (1/yr) relates to the time taken for the Degradable Organic Carbon (DOC) in waste to decay to half its initial mass.
Source of data used:	Estimate based on Revised 1996 IPCC guidelines and expert consultation
Value applied:	0.113
Justification of the choice of data or description of measurement methods and procedures actually applied :	Indonesian conditions are quite favourable to biodegradation kinetic because of the high temperature, moisture content and humidity conditions and the high composition in rapidly degradable materials such as food waste. Therefore the methane generation rate is set 20 % above the default value of 0.094
Any comment:	-

Data / Parameter:	ζ
Data unit:	t CH_4 / t Waste
Description:	dissimilation factor
Source of data used:	Empirical data, expert consultation
Value applied:	0,58

Justification of the choice of data or description of measurement methods and procedures actually applied :	Empirically determined to be 0,58 as a result of the heterogeneity of the waste, meaning there are places within the waste that never have good conditions for anaerobic decay (too much oxygen, too little moisture)
Any comment:	

Data / Parameter:	C_0
Data unit:	kgC.ton waste^{-1}
Description:	Amount of organic carbon in the waste
Source of data used:	Estimates
Value applied:	105.3
Justification of the choice of data or description of measurement methods and procedures actually applied :	The estimated content of the waste is 60% municipal solid waste, 15% commercial waste, 10% construction and demolition waste, 5% city cleansing waste,, 5% sewage sludge and 5% contaminated soil.
Any comment:	-

Data / Parameter:	A
Data unit:	Tonnes waste /year
Description:	Amount of waste in place
Source of data used:	Contractors data
Value applied:	See Annex 3 – Baseline information
Justification of the choice of data or description of measurement methods and procedures actually applied :	-
Any comment:	-

Data / Parameter:	F
Data unit:	-
Description:	the fraction by volume of CH4 in the landfill gas
Source of data used:	Revised 1996 IPCC guidelines
Value applied:	50%
Justification of the choice of data or description of measurement methods and procedures actually applied :	The default value for the fraction of methane in landfill gas is 0.5 as recommended by IPCC.
Any comment:	-

Data / Parameter:	m_v
Data unit:	$gCH_4.m^{-3}$
Description:	volumetric mass
Source of data used:	International Standard
Value applied:	0.174
Justification of the choice of data or description of measurement methods	-

measurement methods and procedures actually applied :	
Any comment:	-

Data / Parameter:	EE
Data unit:	-
Description:	Extraction Efficiency
Source of data used:	Estimate
Value applied:	70%
Justification of the choice of data or description of measurement methods and procedures actually applied :	This is generally between 60% and 90%, depending on waste characteristics, coverage and extraction equipment quality. To be conservative, a value of 70% is used for calculations.
Any comment:	-

Data / Parameter:	FE
Data unit:	-
Description:	Flaring Efficiency
Source of data used:	Estimate
Value applied:	100%
Justification of the choice of data or description of measurement methods and procedures actually applied :	The destruction efficiency of enclosed flares at 1000 ºC or greater which are combusting CH4 is typically >99%. Therefore, 100% was assumed.
Any comment:	-

B.6.3 Ex-ante calculation of emission reductions:

>>

Baseline emissions

According to the Consolidated Baseline Methodology ACM0001, the greenhouse gas emission reduction achieved by the project activity during a given year "y" (ER_y) is the difference between the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$), times the approved Global Warming Potential value for methane (GWP_{CH4}), plus the net quantity of electricity displaced during the year (EG_y) multiplied by the CO_2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$), plus the quantity of thermal energy displaced during the year (ET_y) multiplied by the CO_2 emissions intensity of the thermal energy displaced ($CEF_{thermal,y}$).

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y \cdot CEF_{electricity,y} - ET_y * CEF_{thermal,y}$$ eq. 1

Where

ER_y	is 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)
$MD_{reg,y}$ [3]	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 21 tCO_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. This can be estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced, or AMS-I.A if captive electricity is used or displaced.
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

In the case of the landfills of this bundled project, no reductions are claimed for displacement of electricity and thermal energy. Therefore, the emission reduction will be calculated as follows:

$ER_y = (MD_{project,y} – MD_{reg,y})*GWP_{CH4}$ eq. 2

There is no regulation requesting recovery and flaring of any LFG portion in the landfills in Indonesia. Therefore, the baseline will not consider any destruction of methane (MDreg = 0), and all the CH4 potential of the landfills will be emitted into the atmosphere.

The first step in applying the methodology to find the amount of methane actually destroyed/combusted during the year (MDproject,y), is to estimate the volume of methane that is expected to be generated from the landfills during the project lifetime. This estimated quantity of methane is based on the projected quantities of wastes to be disposed of the respective landfills.

The first order decay model1 by TNO (Dutch institute for Applied Sciences)1 was used. The model originates with the depletion of carbon in the landfill waste through time, to be sole responsible for the formation of methane in the landfill.
It represents that landfill gas (LFG) formation from a certain amount of waste is assumed to decay exponentially in time, mathematically[3]:

$$\alpha_t = \varsigma 1.87 A C_0 k_1 e^{-k_1 t} \quad . \qquad \text{eq. 3}$$

Where:

α_t	= LFG production at a given time	$[m^3 LFG.yr^{-1}]$
ζ	= dissimilation factor	[-]
1,87	= conversion factor	$[m^3 LFG.kgCdegraded^{-1}]$
A	= amount of waste in place	[ton]
C_0	= amount of organic carbon in the waste	$[kgC.ton\ waste^{-1}]$
k_l	= decay rate constant	$[yr^{-1}]$
t	= time elapsed since depositing	[yr]

Applying the model and using the estimated parameters, the total quantity of methane generated in the baseline situation by the landfills can be estimated by

$$MD_{baseline,y} = \sum \alpha_t * F * m_v \qquad \text{eq. 4}$$

Where

$MD_{baseline,y}$	= the amount of methane generated during the year	$[tCH_4.yr^{-1}]$
α_t	= LFG production at a given time	$[m^3 LFG.yr^{-1}]$
F	= the fraction by volume of CH4 in the landfill gas	[-]
m_v	= volumetric mass	$[gCH_4.m^{-3}]$

When applying all the equations together with the parameters as described in chapter B6.2 the generated amount of methane in the landfills in the baseline situation can be calculated as presented in the figure below. The amounts of waste deposited and expected to be deposited are presented in Annex 3 Baseline Information.

[1] Oonk H., Weenk A., Coops O., Luning L.; Validation of landfill gas formation models (1994); NOVEM Programme Energy Generation from Waste and Biomass (EWAB), TNO report 94-315, Apeldoorn, Netherlands

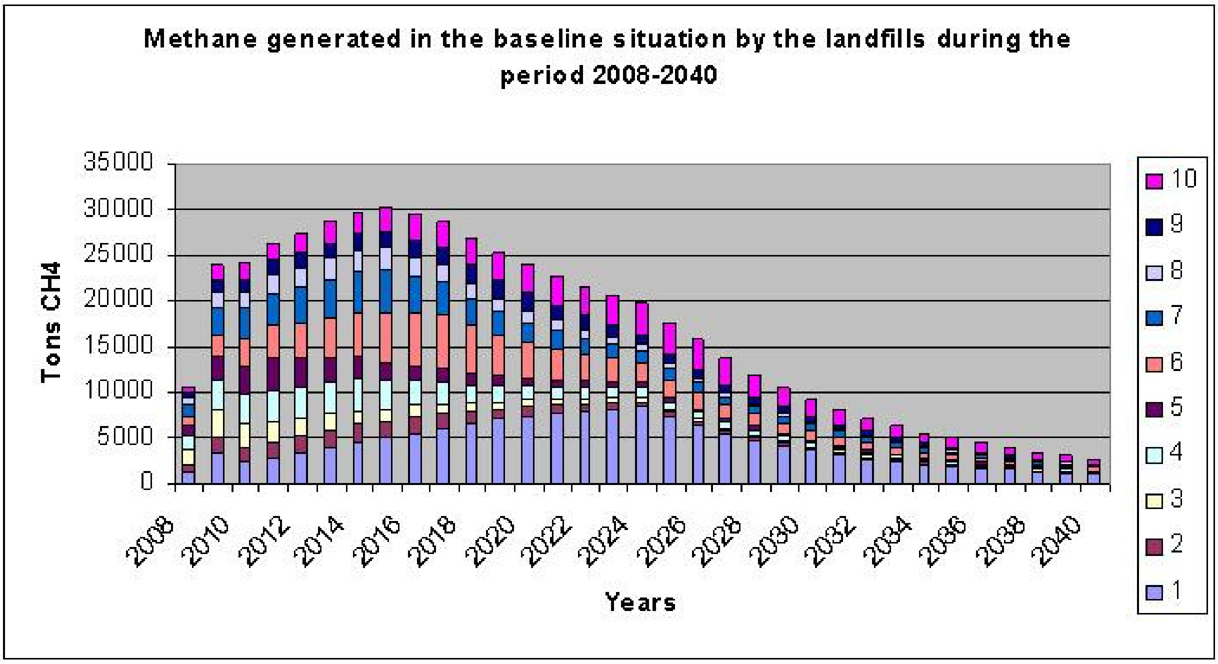

Figure 4: Projected methane generation in the baseline situation

Project emissions

In principal, emissions in the landfills during project activity occur within the same boundaries as the one related to the baseline. However the LFG collection and flaring system will also imply a consumption of some quantities of electricity from the grid.
Such emissions are not that significant, but for completeness purposes they have been estimated and reflected in the emissions related to project activity.
Electrical consumption for the LFG system is based on an aggregated 150 kW nominal capacity for flaring, which meet the aggregated peek flow of LFG in the ten landfills, taking the requirement of existing technologies into account, plus a 30% overestimation of capacity which will reflect some conservativeness expressed in terms of m3/hr. A full time functioning; e.g. 8760 hours are also assumed, which is overestimated.
In estimating emissions, the electricity generation on the island of Java is taken as an example. The Carbon Emission Factor for this grid is published by the Directorate General of Electricity and Energy Utilisation (DGLPE), a governmental agency in charge of electricity. They calculated the CEF for Java island as 0.754 tCO2/MWh.

Thus the project emissions due to electricity consumption are 991 ton CO2 per year for the landfills together, when electricity generation by the Project is not considered. This source can be regarded as negligible (the source is only 0.2 % of the baseline emissions), even if the CEF of the islands outside Java happens to be higher (two times higher CEF is 0.4% of the baseline emissions, which is still negligible).

Another source of project emissions is the CH4 emission from the un-recovered LFG liberated from the landfill sites. It is estimated that, depending on the design of the landfill, only 60-70% of LFG generated at the landfills will be captured, which means that the remaining 30-40%, will be released as fugitive emissions.

A final source of project emission is the methane fraction that will be released into the atmosphere as a consequence of the flare efficiency (FE). The destruction efficiency of enclosed flares at 1000 ºC or greater which are combusting CH4 is typically >99%. Therefore, 100% was assumed.

This means:

$MD_{project,y} = MD_{baseline,y} * (EE + FE)$ eq. 5

Where

$MD_{project,y}$	= the amount of methane combusted / flared during the year	$[tCH_4.yr^{-1}]$
$MD_{baseline,y}$	= the amount of methane generated during the year	$[tCH_4.yr^{-1}]$
EE	= Extraction Efficiency	[%]
FE	= Flaring Efficiency	[%]

Leakage

Not applicable

Total emission reduction

The total emission reductions through the project activity can be calculated as:

$ER_y = (MD_{project,y}) * GWP_{CH4}$ eq. 6

Where

ER_y	= the greenhouse gas emission reduction achieved by the project activity during a given year "y"	$[tCO_2eq.yr^{-1}]$
$MD_{project,y}$	= the amount of methane combusted / flared during the year	$[tCH_4.yr^{-1}]$
GWP_{CH4}	= the approved Global Warming Potential value for methane	[-]

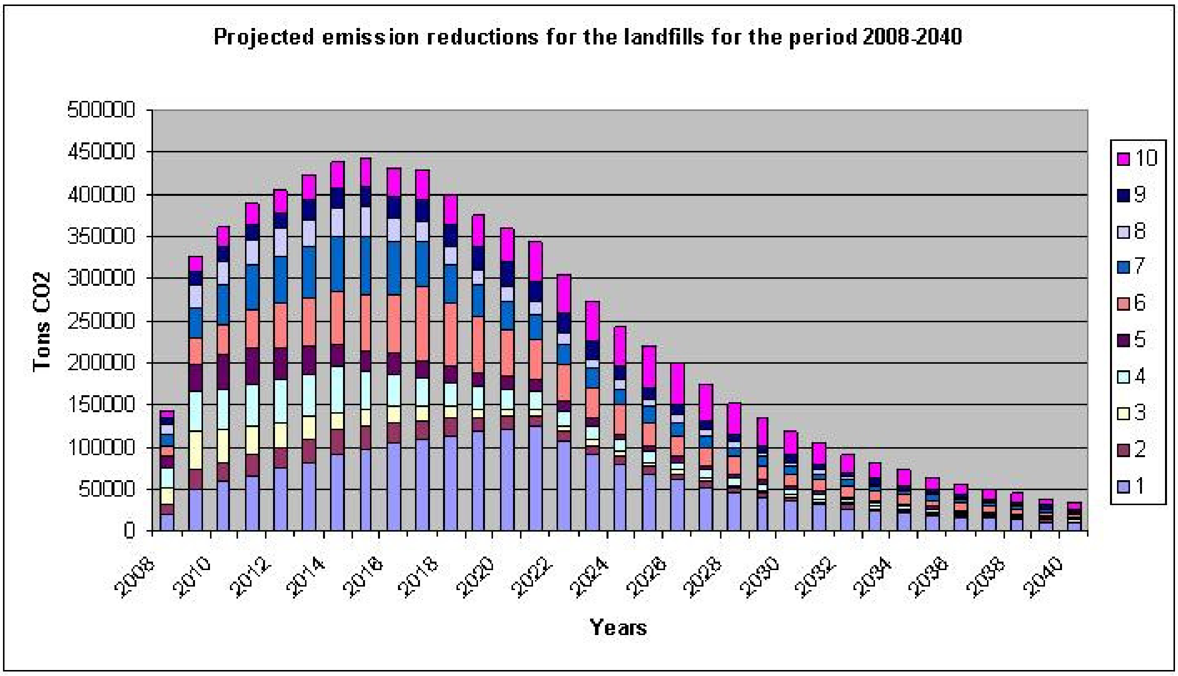

Figure 5: Projected emission reductions

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

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Table 11: Summary of emission reductions

Year	Estimation of project activity emissions (tonnes of CO_2e)	Estimation of baseline emissions (tonnes of CO_2e)	Estimation of leakage (tonnes of CO_2e)	Estimation of overall emission reductions (tonnes of CO_2e)
2008	79315	222927	0	143611
2009	173191	501345	0	328153
2010	146486	507204	0	360718
2011	163609	552705	0	389096
2012	171965	577238	0	405273
2013	179849	601590	0	421741
2014	187399	625913	0	438514
2015	191256	634161	0	442904
2016	185029	616459	0	431430
2017	171713	600812	0	429099
2018	81564	281492	0	199929
TOTAL	1731378	5721845	0	3990468

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

B.7.1	Data and parameters monitored:

Data / Parameter:	ID 1. $LFG_{total,y}$
Data unit:	m^3
Description:	Total amount of landfill gas captured
Source of data to be used:	Electronic measurements
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 by a flow meter. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Maintenance and calibration of meter will be carried out according to international standard that is verifiable by a third party.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 2. $LFG_{flare,y}$
Data unit:	m^3
Description:	Amount of landfill gas flared
Source of data to be used:	Electronic measurements
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 by a flow meter. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Maintenance and calibration of meter will be carried out according to international standard that is verifiable by a third party.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 3. $LFG_{electricity,y}$
Data unit:	m^3
Description:	Amount of landfill gas combusted in power plant
Source of data to be used:	Electronic measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods	Measured by a flow meter. Data to be aggregated monthly and yearly.

and procedures to be applied:	
QA/QC procedures to be applied:	Maintenance and calibration of meter will be carried out according to international standard that is verifiable by a third party.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 4. $W_{CH4,y}$
Data unit:	m^3 CH_4/ m^3 LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Electronic measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	50%
Description of measurement methods and procedures to be applied:	Measured by continuous gas quality analyser.
QA/QC procedures to be applied:	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 5. $fv_{CH4,RG\ h}$
Data unit:	-
Description:	Volumetric fraction of CH_4 in the landfill gas (residual gas)
Source of data to be used:	Electronic measurements
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 by continuous gas quality analyser.
QA/QC procedures to be applied:	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 6. $FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the landfill gas (residual gas) in dry basis at normal conditions
Source of data to be used:	Electronic measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be	Measured by a flow meter. The same basis (dry or wet) is considered for this measurement and the measurement of volumetric fraction of CH_4 in the residual gas when the residual gas temperature

applied:	exceeds 60°C.
QA/QC procedures to be applied:	The flow meter should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 7. $fv_{CH4,FG,h}$
Data unit:	Mg / m^3
Description:	Methane fraction in the exhaust gas of the flare in dry basis at normal conditions
Source of data to be used:	Electronic measurements
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:	Measured by continuous gas analyser.
QA/QC procedures to be applied:	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 8. $T_{O2,h}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare
Source of data to be used:	Electronic measurements
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 by continuous gas analyser.
QA/QC procedures to be applied:	The gas analyser should be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 9. T_{flare}
Data unit:	°C
Description:	Temperature of the exhaust gas of the flare
Source of data to be used:	Electronic measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods	Measures the temperature of the exhaust gas stream in the flare by a Type N thermocouple.

and procedures to be applied:	Measured to determine the operation hours of the flare. A temperature above 500 °C indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be applied:	Thermocouples are replaced or calibrated every year
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 10. T_{LFG}
Data unit:	°C
Description:	Temperature of the landfill gas
Source of data to be used:	Electronic measurements
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 with T sensor in order to determine the CH_4 density in the landfill gas.
QA/QC procedures to be applied:	No specific procedure mentioned in ACM0001 / Version 05
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 11. p
Data unit:	Pa
Description:	Pressure of the landfill gas
Source of data to be used:	Electronic measurements
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 to determine the density of methane
QA/QC procedures to be applied:	No specific procedure mentioned in ACM0001 / Version 05
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 12. EL_{IMP}
Data unit:	MWh
Description:	Total amount of electricity imported to meet project requirements
Source of data to be used:	Electronic measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	The value is calculated at 1314 MWh
Description of	Required to determine CO_2 emissions from use of electricity or other energy carriers to

measurement methods and procedures to be applied:	operate the project activity. Measured with an electricity consumption meter. When the project activity is generating its own electricity, this measure will be zero.
QA/QC procedures to be applied:	Maintenance and calibration of meter will be carried out according to international standard that is verifiable by a third party.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 13. CEF
Data unit:	tCO_2/MWh
Description:	CO_2 emission intensity of the electricity and/or other energy carriers
Source of data to be used:	Calculations based on national statistics
Value of data applied for the purpose of calculating expected emission reductions in section B.5	The value is calculated at 0.754 tCO_2eq / MWh
Description of measurement methods and procedures to be applied:	Measured by the energy suppliers of the electricity grid, and calculated to determine the average.
QA/QC procedures to be applied:	The CEF is calculated ex-ante, according to the monitoring methodology AMS I. D The value is calculated at 0.754 tCO_2eq / MWh
Any comment:	

Data / Parameter:	ID 14. Legal requirements related to LFG projects
Data unit:	-
Description:	Regulatory requirements relating to landfill gas projects
Source of data to be used:	Text, national regulations
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:	Required for any changes to the adjustment factor (AF) or directly $MD_{reg,y}$. This will be investigated yearly.
QA/QC procedures to be applied:	n.a.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

Data / Parameter:	ID 15. Hours of operation of electricity generator
Data unit:	Hours
Description:	Operation of the electrical generators (where applicable)
Source of data to be used:	Electronic measurements
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:	Monitoring of the operation hours of the electrical generator in order to ensure methane reductions be the actual ones.
QA/QC procedures to be applied:	n.a.
Any comment:	Data shall be stored during the crediting period and an additional two-year period

B.7.2 Description of the monitoring plan:

>>

The Monitoring Plan has been developed according to the parameters established by Consolidated Monitoring Methodology ACM0001 / Version 05 "Consolidated monitoring methodology for landfill gas project activities", together with the 'Tool to determine project emissions from flaring gases containing methane'

The monitoring methodology is based on the direct measurement of the landfill gas amounts captured and destroyed through the treatment system and the thermal or electricity energy units generated from biogas.

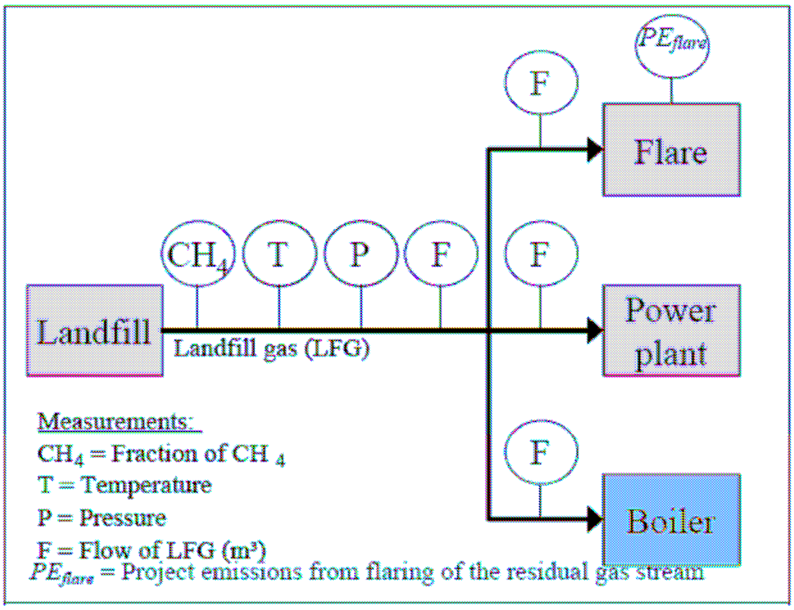

Figure 6: Monitoring plan[23]

[2] ACM0001 / Version 05 – http://cdm.unfccc.int

[3] Note: In the Project, no boiler is used to capture methane. Therefore this parameter is left out of the monitoring plan.

Based on the provisions of monitoring methodology ACM0001 / version 05, the main variables to be determined in this project are: the amount of methane actually captured ($MD_{project,y}$), the amount of methane burned ($MD_{flared,y}$), the amount of methane used for electricity generation ($MD_{electricity,y}$) and the total amount of methane generated ($MD_{total,y}$).

The monitoring methodology establishes the monitoring of the following parameters:

- The amount of biogas generated (in cubic meters) , where the total biogas ($LFG_{total,y}$), as well as the amount meant for flares ($LFG_{flare,y}$) and for the electricity generation facilities ($LFG_{electricity,y}$) must be constantly monitored for each landfill.
- The fraction of methane present in the biogas ($w_{CH4,y}$).
- Project emissions from flaring ($PE_{flare,y}$) due to the flaring efficiency, expressed based on the time the gas remains in the flares' flame. The efficiency is determined by monitoring the hourly methane fraction in the residual gas fed to the flare ($fv_{CH4,RG,h}$), the hourly methane fraction in the exhaust gas ($fv_{CH4,FG,h}$) and the hourly oxygen fraction in the exhaust gas ($t_{O2,h}$).
- Biogas temperature (T_{LFG}) and pressure (p) must be measured in order to determine methane density within the landfill gas.
- The amounts of electricity or fuel needed for the operation of this biogas capture project, including the necessary suction pumps for the capture system must be monitored. The resulting emissions are subtracted from the project's reduction.
- The Indonesian legislation applicable to this project activity in the national, provincial and municipal scope, in order to identify whether there has been any changes in the applicable requirements.
- Hours of operation of the flaring system and electrical generators (if applicable) and the temperature (T_{flare}) of the exhaust gas, in order to determine the proper functioning of the flaring system.

Parameters that will be monitored and the frequency of monitoring are described in section B7.1 and in annex 5 Information on monitoring. In Annex 5 the calculations for the monitoring of parameters to emission reduction calculations are given as well.

The objective of the MP is to set the basis for assessing, on a constant basis, the performance of the CDM project; in addition , the Monitoring Plan will provide developers with the minimum requirements for managing the information that will be assessed by the verification entity, prior to issuance of CER's.

For the purposes of guaranteeing ongoing activity follow-ups, the MP will be used during the life of the project. On the other hand, the MP will be able to be adjusted or changed as necessary.

To assure correct monitoring, at least two persons on every landfill will be trained regarding:

- General knowledge of equipment used in the landfill and for landfill gas extraction and monitoring;
- Specialized training with reading and recording data;
- Specialized training regarding calibration of equipment;
- Environmental safety and health, including emergency situations.

Chosen trainees will have a good understanding of the processes and installation technology of the landfill gas extraction. Verification and training will be initiated in parallel with the first well installations.

An operations and maintenance manual will be developed for the project which is inclusive of environmental safety and health.
This manual will include:

- Detailed information on operations
- As-built drawings
- Maintenance procedures
- Equipment drawings and specifications
- Methodologies for monitoring, maintenance of monitoring equipment, and equipment calibration
- Environmental safety and health guidelines and procedures.

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 of conclusion: June 21st 2007

Responsible Party

BGP Engineers B.V.
Loopkantstraat 45
5405 AC Uden
The Netherlands
Phone: +31 413-243800
E-mail: mj@bgp.nl / wm@bgp.nl

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:

>>
01-10-2007

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

>>
More than 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:

>>
Not applicable

C.2.1.2. Length of the first crediting period:

>>
Not applicable

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01-07-2008

C.2.2.2. Length:

>>
10 years

SECTION D. Environmental impacts

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

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The project will collect and combust LFG, thereby improving overall landfill management and reducing adverse global and local environmental effects of uncontrolled releases of landfill gas. While the main global environmental concern over gaseous emissions of methane is the fact that it is a potent greenhouse gas and thus contributes importantly to global warming, emissions of LFG can also have significant health and safety implications at the local level.

The following positive environmental impacts can be identified with the Project;

a. Reduction of extreme dangerous situations regarding explosions at the landfills.
b. Reduction of waste volume and the elimination of odour from waste piling.
c. Improvement in the quality of water and its ecology in the surroundings by preventing direct leachate release to the water system;
d. Improvement in sanitary and hygiene for surrounding communities. In particular, significant improvement associated with ground water quality; and the reduction of hazardous gas emission;
e. Improvement in the overall waste management approach that should be followed with the improvement in the level of hygiene for surrounding communities .

In addition to the environmental impacts, there are a large number of positive impacts. Some examples are:

f. Increase of work opportunity for unskilled labours during construction period;
g. Improvement in community perception towards waste management, which would have a significant impact to other regions inside Indonesia;

A number of negative impacts were identified such as the lowering of air quality during construction period and possible air emission from the stack gas of the power generators.

However, it can be seen from the above that the positive impacts are overwhelmingly greater than the negative impact.

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:

>>
Not applicable

SECTION E. Stakeholders' comments

>>

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

>>

Stakeholders' comments have been collected on three levels, i.e.:

- on national level, by interviewing the Indonesian authorities competent for matters of waste management and climate change
- on regional level, by interviewing the authorities responsible for regional waste management practices by interviewing stakeholders directly involved in waste management on site
- on international level: by collecting comments from leading NGO's, including the BTRF and Universities

The activities by which the stakeholders' comments were collected comprised a number of extensive undertakings:

(1) All national and regional stakeholders have been invited to the *National Workshop on Waste Management and Clean Development Mechanism*, which took place on 5 December 2006 at the premises of Malang University, Indonesia. More than 45 representatives from the most important regions of Indonesia have participated to the workshop (see Annex 5 Stakeholder consultation - list of participants and the workshop programme). The audience consisted of different groups, including the regional waste managers, municipal representatives, waste management experts, consultants, national and international NGO's, international waste management experts, university professors and students.

(2) During June, August and December 2006 a broad consultation programme was executed on local level. The consultation included a large number of Indonesian Regencies (Municipalities) on Sumatra, West-Java, East-Java, Kalimantan, Sulawesi and other regions. Stakeholders at every site were consulted and their comments and views were registered in the form of Memoranda of Understanding.

(3) International stakeholders consultation took place through publication of the draft Project Design Document on the Internet during a period of 30 days. Besides, comments were actively sought from the most important NGO's which are active in Indonesia. Comments by the Borneo Tropical Rainforest Foundation and the University of Malang have been included.

Figure 7: Stakeholder consultation

E.2. Summary of the comments received:

>>

In general, the project proposal has received broad support from the different groups of stakeholders. In the following, these comments are summarized.

National level

Several representatives from the DNA and the Ministry of Environment were present at the *National Workshop on Waste Management and Clean Development Mechanism*. The Ministry presented the national guidelines and priorities for CDM-projects.

The Indonesian national authorities have indicated that the project should comply with the four policy priorities, i.e.:

1. Economic aspects should be sound
2. The project should have positive environmental impact and contribute to environmental protection
3. The social aspects should be positive, including the promotion of job creation, improvement of social circumstances and growth of income.
4. There should be technology transfer through the project.

In addition, the following issues have to be addressed by the project owner:

- relationships between project owner an local stakeholders; legal structure;
- generation, ownership and transfer of CER's

The programme of the workshops is given in Annex 5 – Stakeholder consultation.

Regional/local level

Very extensive consultations were done on regional level as the landfill owners are basically regional organizations.
Comments are summarized as follows:

- All landfill owners support the implementation of methane mitigation systems and support the vision that all stakeholders will benefit from the project.
- Owners of landfill where gas extraction systems have been installed, see the utilization of biogas as a valuable addition to the existing situation. At present, LFG is discharged into the atmosphere (Samarinda, Palemembang)
- Owners of landfills where no systems are in place at all, wish to facilitate the implementation of LFG extraction and utilization systems (Batam, Materam, Bekasi, Bandung .etc.). The impacts from the project are seen in positive manner. Positive impacts include:
  - Improvement of the environmental situation
  - improvement of the working conditions at the landfill
  - decrease of the hazardous situation: mitigation of explosion risk in particular
  - the project will enhance better landfill management
- All landfill owners confirm that the investments required for implementation of LFG systems cannot be supported by the local stakeholders. The budget required is far beyond the operational budget of the Regencies.
- On the generation of electricity comments were also made. The importance of electricity is recognized. Several local communities, living in the surroundings (1-2 km) of the landfill, are not served by the national network or, frequent power supply problems exist. However, the technical provisions for the utilization of electricity should be such that effective power supply will be created. The supply of electricity to communities is particularly interesting where the public power supply is limited to a maximum (for example: 450 V per household).

International level

- Abatement of global warming (BTRF)
- University of Malang

The statements of the stakeholders on international level are presented in Annex 5 – Stakeholder consultation.

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

>>
n.a.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Not applicable

Annex 3

BASELINE INFORMATION

Table 3.1: Amount of waste estimated, measured and projected for the landfills

	Landfill										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
2000	73.934	44.671	103.965	116.508	0	40.000	52.958	58.752	0	0	490.788
2001	79.017	49.827	109.586	119.143	0	50.000	57.277	62.208	0	20.000	547.058
2002	87.565	55.167	115.495	120.669	0	50.000	75.775	66.048	40.000	35.000	645.720
2003	97.500	60.699	121.707	123.443	94.604	60.000	92.450	66.432	50.000	50.000	816.835
2004	108.359	66.426	128.235	127.604	142.662	80.000	96.259	74.650	60.000	65.000	949.194
2005	129.846	61.502	135.096	133.152	143.348	80.000	111.259	78.209	65.000	80.000	1.017.412
2006	139.088	66.716	142.306	130.517	157.680	140.000	163.199	79.872	76.000	95.000	1.190.378
2007	223.454	69.683	145.152	131.822	172.187	160.000	170.082	83.067	76.600	100.000	1.332.047
2008	239.752	72.743	148.055	133.140	187.601	180.000	177.174	86.390	76.600	100.000	1.401.455
2009	255.833	75.897	0	134.471	203.974	210.000	184.483	89.845	76.600	100.000	1.331.103
2010	273.742	79.148	0	135.816	221.356	240.000	192.013	93.439	76.600	120.000	1.432.113
2011	292.903	82.499	0	137.174	0	260.000	199.770	97.177	76.600	120.000	1.266.122
2012	313.406	85.952	0	138.546	0	260.000	207.761	101.064	76.600	120.000	1.303.328
2013	335.344	89.510	0	139.932	0	260.000	215.991	105.106	76.600	120.000	1.342.484
2014	335.344	47.654	0	0	0	260.000	224.468	109.310	76.600	120.000	1.173.376
2015	335.344	47.654	0	0	0	280.000	0	0	76.600	120.000	859.598
2016	335.344	0	0	0	0	290.000	0	0	76.600	120.000	821.944
2017	335.344	0	0	0	0	0	0	0	76.600	120.000	531.944
2018	335.344	0	0	0	0	0	0	0	76.600	120.000	531.944
2019	335.344	0	0	0	0	0	0	0	76.600	120.000	531.944
2020	335.344	0	0	0	0	0	0	0	0	120.000	455.344

Table 3.2 Financial sheets (separate document)

Annex 4

MONITORING INFORMATION

The amount of methane will be determined by monitoring the amount of landfill gas, the temperature and pressure of the landfill gas and the percentage methane in the landfill gas and exhaust gas, together with the oxygen content and temperature of the exhaust gas from flaring.

The regulatory framework will be monitored on an annual basis. Other monitoring as required in terms of the EIA authorisation will also be conducted.

Parameters that will be monitored for each landfill and the frequency of monitoring are indicated below:

Table 4.1:Monitoring information

ID	**Parameter**	**ACM0001 name**	**Unit**	**Monitoring frequency**	**Comments**
1	Total LFG captured	LFG_{total}	m^3	Continuous	Measured by a flow meter, data will be aggregated monthly and yearly
2 / 6	Total flared LFG	LFG_{flare} $FV_{RG,h}$	m^3 m^3/h	Continuous	Measured by a flow meter, data will be aggregated monthly and yearly and kept on a hourly basis for determining $FV_{RG,h}$
3	Total LFG combusted in electricity generator	$LFG_{electricity}$	m^3	Continuous	Measured by a flow meter, data will be aggregated monthly and yearly
4 / 5	Volumetric fraction of CH_4 in LFG	$fv_{CH4,RG h}$ $w_{CH4,y}$	-	Continuous	Measured by a gas analyser. Values will be averaged hourly and yearly (for determining $W_{CH4,y}$)
6	Methane fraction in the exhaust gas of the flare	fvCH4,FG,h	Mg / m^3	Continuous	Measured by a gas analyser. Values will be averaged hourly.
7	Volumetric fraction of O2 in the exhaust gas of the flare	$T_{O2,h}$	-	Continuous	Measured by a gas analyser. Values will be averaged hourly.
8	Temperature of the exhaust gas of the flare	T_{flare}	°C	Continuous	Measured by a type N thermocouple.
9	Temperature of LFG	T_{LFG}	°C	Continuous	Measured by a T sensor
10	Pressure of LFG	p	Pa	Continuous	Measured by a pressure meter
11	Total amount of	EL_{IMP}	MWh	Continuous	Measured by electricity use

	electricity imported				meter, analysis of electricity use invoices.
13	Legal requirements related to LFG projects	MD_{REG} AF	-	Yearly	Annual reviews of the regulation applicable to LFG capture projects.
13	Hours of operation of electricity generator	-	h	Continuous	Registration of operating hours. Values will be aggregated monthly and yearly.

The equations to calculate the emission reduction out of the above mentioned parameters are presented below.

The methane recovered and destructed through flaring and power generation together form the direct Emissions reductions.

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_y \cdot CEF_{electricity,y} - ET_y * CEF_{thermal,y}$$ eq. 1

Where

ER_y	is 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)
$MD_{reg,y}$ [3]	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 21 tCO_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. This can be estimated using either ACM0002 or AMSI.D, if the capacity is within the small scale threshold values, when grid electricity is used or displaced, or AMS-I.A if captive electricity is used or displaced.
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

Since no reductions are claimed for electricity and / or thermal energy displacement only $MD_{project,y}$ and $MD_{reg,y}$ have to be monitored.

$$MD_{reg,y} = MD_{project,y} * AF$$ eq. 2

And

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y}$$

In which

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$$ eq. 3

And

$$MD_{flared,y} = \{LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (PE_{flare,y} / \mathrm{GWP}_{CH4})$$ eq. 4

For flaring, an enclosed flare is used and the flaring efficiency is monitored continuously, according to the 'Tool to determine project emissions from flaring gases containing methane'[4].

The Project emissions from flaring ($PE_{flare,y}$) are calculated with the following equations:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH4}}{1000}$$ eq. 5

Where

Variable	SI Unit	Description
$PE_{flare,y}$	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 hour *h*
GWP_{CH4}	tCO_2e/tCH_4	Global Warming Potential of methane valid for the commitment period

In which

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}}$$ eq. 6

Where

[4] UNFCCC, EB 28 report Annex 13.

Variable	SI Unit	Description
$\eta_{flare,h}$	-	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*

In which

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n} \qquad \text{eq. 7}$$

Where

Variable	SI Unit	Description
$TM_{RG,h}$	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* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane).
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (0.716)

And

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH4,FG,h}}{1000000} \qquad \text{eq. 8}$$

Where

Variable	SI Unit	Description
$TM_{FG,h}$	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^3/h exhaust gas	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*

In which

$$TV_{n,FG,h} = V_{n,FG,h} \times FM_{RG,h} \qquad \text{eq. 9}$$

Where

Variable	SI Unit	Description
$TV_{n,FG,h}$	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/kg residual gas	Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour *h*
$FM_{RG,h}$	kg residual gas/h	Mass flow rate of the residual gas in the hour *h*

In which

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h}$$ eq. 10

Where

Variable	SI Unit	Description
$V_{n,FG,h}$	m^3/kg residual gas	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/kg residual gas	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*
$V_{n,N2,h}$	m^3/kg residual gas	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*
$V_{n,O2,h}$	m^3/kg residual gas	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

In which

$$V_{n,O_2,h} = n_{O_2,h} \times MV_n$$ eq. 11

Where

Variable	SI Unit	Description
$V_{n,O2,h}$	m^3/kg residual gas	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/kg residual gas	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)

And

$$V_{n,N_2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}} \right) * \left[F_h + n_{O_2,h} \right] \right\}$$ eq. 12

Where

Variable	SI Unit	Description
$V_{n,N2,h}$	m^3/kg residual gas	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/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour ***h***
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour ***h***

And

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} * MV_n$$

eq. 13

Where

Variable	SI Unit	Description
$V_{n,CO2,h}$	m^3/kg residual gas	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)

In which

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1-(t_{O_2,h}/MF_{O_2})\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1-MF_{O_2}}{MF_{O_2}}\right) \times F_h\right]$$

eq. 14

Where

Variable	SI Unit	Description
$n_{O2,h}$	kmol/kg residual gas	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/kg residual gas	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*** (from equation 4)
AM_j	kg/kmol	Atomic mass of element ***j***
j		The elements carbon (index C) and nitrogen (index N)

In which

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O}$$ eq. 15

Where

Variable	SI Unit	Description
F_h	kmol O_2/kg residual gas	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* (from equation 4)
AM_j	kg/kmol	Atomic mass of element *j*
j		The elements carbon (index C), hydrogen (index H) and oxygen (index O)

In which

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h}$$ eq. 16

Where

Variable	SI Unit	Description
$FM_{RG,h}$	kg/h	Mass flow rate of the residual gas in hour *h*
$\rho_{RG,n,h}$	kg/m³	Density of the residual gas at normal conditions in hour *h*
$FV_{RG,h}$	m³/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*

In which

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n}$$ eq. 17

Where

Variable	SI Unit	Description
$\rho_{RG,n,h}$	kg/m³	Density of the residual gas at normal conditions in hour *h*
P_n	Pa	Atmospheric pressure at normal conditions (101 325)
R_u	Pa.m³/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)

In which

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i)$$ eq. 18

Where

Variable	SI Unit	Description
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
$fv_{i,h}$	-	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

As a simplified approach, the volumetric fraction of methane is measured and the difference to 100% is considered as being N_2.

The parameters and data that is not monitored are the constants used in equations, as listed in table 4.2 below.

Table 4.2: constants used in equations

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_c	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_h	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_o	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_n	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101 325
R_u	$Pa.m^3/kmol.K$	Universal ideal gas constant	8 314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
MV_n	$m^3/Kmol$	Volume of one mole of any ideal gas at normal temperature and pressure	22.414
$\rho_{CH4,n}$	kg/m^3	Density of methane gas at normal conditions	0.716
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	

Annex 5

STAKEHOLDER CONSULTATION

WORKSHOP PARTICIPANT
FOR LANDFILL MANAGEMENT AND CITY CLEANNESS WITH CDM PROGRAM
GERF CENTER FOR ENERGY, ENVERONMENT, AND REGIONAL DEVELOPMENT
AT MUHHAMADIYAH MALANG UNIVERSITY
Malang, December, 5th, 2006

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22	Mukhlis	Local Representatif	Padang
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24	Saptono Waspodo	Local Representatif	Mataram
25	Irvan Tirta P	Local Representatif	Bandung

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30	Jamal Habib	Local Representatif	Samarinda, Kalimantan
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32	Joko Munari	Manager of TPA(Landfill)	Malang, East Java
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35	Agus Purnomo	Environmental Office	Jakarta
36	Ris N. butarbutar	Manager CDM	Jakarta
37	Ir. Yunan Rusdianto, MT	Board of Planning, Supervition and Development for University	Malang, East Java
38	Suwandi	Head of Fishery Departement	Balikpapan, Kalimatan
39	Nur Mahya	IER	Banjarmasin, Kalimantan
40	Eko Prasetyowati	Unit of Public Services	Tulung Agung, Java
41	Moh. Nurus Syamsi	Board of Planning, Supervition and Development for University	Sumenep, East Java
42	Drs. Ahmad Mubin, MT	Mecanical Enginering Faculty – UMM	Malang, East Java
43	Ir Mulyono	Mecanical Enginering Faculty – UMM	Malang, East Java

Workshop on Best Practices in Waste Management
and Biogas Utilization at Indonesian Landfills
Tuesday December, 5th

Draft Agenda

No.	Time	Description
1.	**08.00 - 08.30**	*Opening Session* Welcoming Speech by **Drs. Muhadjir Effendy, M.A.P.** President of Muhammadiyah Malang University
2.	**08.30 – 09:00**	*Keynote Address* **Drs. Peni Suparto** **Malang City Mayor** **Ir.Rachmat Witoelar** **Minister of the Environment, Indonesia**
3.	**09:00– 10.00**	***TBA*** **Ministry of Housing, Spatial Planning and the Environment, the Netherlands** **Or** **Representative of Royal Netherlands Embassy, Indonesia**
4.	**10.00 – 10.15**	***Coffee Break***
5.	**10.15 – 11.15**	**Ir. Gempur Adnan, MSc.** **Deputy for Minister of Environment** Waste management status in Indonesia - City waste management concept & application - Types of waste management (recycling, compost, combustion, anaerobic, digestion, gasifikasion, LFG, gas to thermal/electrical energy) - Technical & financing aspect - Examples of landfill managment
6.	**11.15 – 12.15**	**Dra.Masnellyarti Hilman, MSc.** **Deputy for Minister of Environment & Chairman of DNA** **The Kyoto Protocol and the Clean Development Mechanism in Indonesia** -Introducing CDM concept -CDM project cycle steps -CDM opportunities in waste management -Examples of CDM projects

7.	**12.15 – 13.30**	*Lunch Break*

No.	Time	Description
8.	**13.30 – 14.30**	**Joeri Jacobs** **Afvalzorg NV / BGP Engineers** **Concepts of sanitary landfill design** - design specifications - waste disposal practices - landfill management
9.	**14.30 – 15.30**	**Ir. Wim Maaskant** **BGP Engineers** **Methane Extraction Technology** - drivers of biogas generations - design of methane extraction system - potential for electricity generation
10.	**15.30 – 15.45**	*Coffee Break*
11.	**15.45 – 16.30**	**Bill Ryan / Matt van Domselaar** **International Eco-Rescue** **Financing and Feasibility of Landfill Gas Extraction Projects in Indonesia**
12.	**16.30 – 17.00**	**Discussion Session**
13.	**17.00 – 17.30**	***Closing Speech***

MINUTE MEETING OF WORKSHOP
FOR LANDFILL MANAGEMENT AND CITY CLEANNESS WITH CDM PROGRAM
GERF CENTER FOR ENERGY, ENVERONMENT, AND REGIONAL DEVELOPMENT
AT MUHAMMADIYAH MALANG UNIVERSITY
Malang, December, 5th, 2006

I. Opening Ceremony :

a. Rector of Muhammadiyah Malang University
Drs. Muhadjir Effendy, M.AP

b. Chief Executive Officer (CEO) GERF Indonesian
Prof. Dr. Laode M. Kamaluddin, M.Sc

c. Walikota Malang
Drs. Peni Suparto, M.AP

II. Presenter and Resume of Workshop Material:

A. **Deputy Assistant of Environmental Minister, field of domestic and small scale industries pollution control, The Ministry of Environment**.

By : ***Ir. Mohammad Helmy***
Topic : ***City Cleaness and Waste Management***
Note :

- Amount of world's population that settled in urban area for 2000 is approximatelly 47 % of the world's total population. In 2008, it was predicted that the population will increase for 50 % of world's population, where as in 2030 the amount will reach 61 % of the world's population and for urban Area in Asia is expected to be the most crowded in the region on the world.
- Sources of rural pollution are consisted of : (1) Municipal Solid Waste *(MSW)* that is domestic waste and others, Food Waste, Medical Waste, E – Waste, Waste Water, automotive (emission and noise), and Industry Waste.
- Waste pile management is presented.
- The concept and application of Urban waste management in Indonesia :
  1. Waste management – community basis is a waste management from the sources that is reducing, sorting, composting, recycling.
  2. Incentives from local government, for example compost purchasing and tools support that use Principe "no service no money; no waste no charge".

3. Waste management by local government in collaboration with private sector: sorting, composting, recycle, sanitary landfill, methane capture and energy (CDM), and also incinerator for energy.

- The objectives of waste management is to reduce waste pile, waste handling (sorting, collecting, transporting, and final processing in TPA (landfill) to realize good, clean, and healthy environment.
- The main subject of RUU concerning waste management in Indonesia :
    1. Implementation of waste management is public services domain by local government : the local government is responsible for supply facilities of waste management that involved third party and invite public participation.
    2. Implementing 3R and EPR principals, waste management from the down to up stream, but processing of landfill.
    3. Responsibility sharing between provincial and residency/municipality government, including cooperation among region, because the waste problems has no administrative boundaries.
    4. Public participation; implementing **3R** (recycle, reuse, recovery) at households, village of area level and also realizing clean and health living.
    5. Entrepreneurship participation: support to implement **EPR** on producer/importer that hazardous producing and plastic.
    6. Financial: it should be provided sufficient fund because waste management is a public services.
    7. Incentive – Disinsentive: stimulate the public and private sector to involve optimally.
    8. Law of strengthen : administrative sanction, criminal law and civil law.

B. Deputy of asistant of Environmental Minister, Impact of Climate Change, Operation Affect Climate Change,The Ministry of Environment.

By ***: Ir. Sulistyowaty, MM***
Topic ***: CDM in The Waste Management***
Note ***:***

- Forecast Abatement from CDM Project TPA Sumur Batu
  Total emission abatement over 2006 – 2019 = 5,7 million ton CO_2eq and only for commitment 2006 – 2012 = 1,7 million ton CO_2eq

1st Credit Period (2006 - 2012)	1	2	3	4	5	6	7
	2006	2007	2008	2009	2010	2011	2012
Methane Abated through Landfill Organic Recovery (tonne CO_2e)	4,399	15,846	107,000	106,586	100,894	129,449	126,766
						sub total	**590,940**
Methane Abated through Collection and Destruction (tonne CO_2e)	58,759	93,288	133,393	170,434	213,983	251,546	286,685
						sub total	**1,208,088**
Total Methane Abatement per Credit Period (tonne CO_2e)							**1,799,028**
2nd Credit Period (2013 - 2019)	1	2	3	4	5	6	7
	2013	2014	2015	2016	2017	2018	2019
Methane Abated through Landfill Organic Recovery (tonne CO_2e)	115,685	142,698	128,506	125,226	115,725	131,444	125,059
						sub total	**884,344**
Methane Abated through Collection and Destruction (tonne CO_2e)	320,452	358,687	395,705	430,615	464,234	494,326	523,350
						sub total	**2,987,370**
Total Methane Abatement per Credit Period (tonne CO_2e)							**3,871,714**

- TPA Suwung – PT. NOEI : Fuel for Electricity Production :
  At TPA Suwung the waste composition is the following:
  1. 85% shall be organic waste and 15% non-organic waste.
  2. 55% of the organic waste is wet and 30% is dry organic waste.
  3. The non-organic waste consists of mainly of plastics & paper.
  4. 175 TPD can (100 tons feed stock) produce approximately 2.5 MW electricity.

  Recycles :
  1. There are very little recyclables of value delivered to landfill sites in Indonesia.
  2. All plastics and paper are of "low quality"
  3. Valuable metals like Copper and Aluminum is almost non existent at the landfill site.
  4. With the high volume of organic waste delivered at the site, compost may in the future create revenue for the project.

- Recomendation :
  1. Change of the landfill from open dumping to sanitary landfill.
  2. The Ministry of Environment will to be considering international regulation of CDM in the law compilation (RUU) about waste management in Indonesian.

C. BGP Engineers

By : Ir. Wim Maaskant
Topic : Landfill Improvement
Note :

- Landfills: background :
  1. Landfills are growing at rapid rate in Indonesia and elsewhere
  2. Decomposing organic matter (food, paper) produces "landfill gas"
  3. Landfill gas is composed mainly of methane (CH_4) and carbon dioxide (CO_2)
  4. Methane is 21 times more harmful to climate than CO_2
  5. Landfill projects are eligible under CDM
  6. Improving landfills by capturing and using methane benefits the climate, environment and communities
- Human sources of greenhouse gasses :
  1. Carbon dioxide from fossil fuel burning, iron, aluminum, ammonia and cement.
  2. Methane from agriculture (livestock and rice), waste disposal landfills and sewage treatment), leakage of natural gas.
  3. Nitrous oxide from nitrogen fertilizer and industrial production of nylon and nitric acid.
  4. Deforestation, forest fires and loss of carbon from agricultural soils.
  5. Fires in forests, coal mines and from gas flaring.
- Step of project development :
  1. Pre – Feasibility (is the project realistic)
  2. Gas production calculations (the potential of the project)
  3. Technical and financial and investment plan
  4. Project design document and validation
  5. Financing
  6. Design and engineering
  7. Construction (drilling of wells, pipes, equipment, processing
  8. Monitoring and verification
- Landfill gas solution :
  1. More than 40 project in Europe and elsewhere developed by BPG and partners.
  2. Landfill size : from 5 - 200 hectares
  3. Waste quantities : from 50,000 – 1,000,000 tonnes/year
  4. Technology includes : gas production, investigation, design, pilot test, engineering, drillings, construction management, etc.
  5. Remote control for monitoring in accordance to Kyoto Protocol
- Benefit :
  1. Reducing reliance on more polluting energy sources
  2. Providing a revenue stream from sale of greenhouse gas emission reduction credits.
  3. Bringing technology, investment and employment.

D. Head of Palu Municipality

By : ***Rusdi Mastura***
Topic : ***Landfill Treatment on Palu***
Note :

- Landfill treatment on Palu :
  Profile of Palu Municipality :
  1. Palu Municipality has 395,06 KM^2 areas
  2. Number of population : 304.230 person
  3. Waste/person/day : 2,5 – 3 Litre
  4. Waste/zone/day : 300 X 3 Ltr =900,000 Ltr or 900 M^3
  5. Transportation : 20 Unit

E. BGP Engineers

By : ***Joery Jacobs***
Topic : ***Landfill Management***
Note :

- Success of waste management plans :
  1. Strongly depends on willingness of general public to change behaviour : (a) takes time to realise discipline, (b) need to be convinced of benefits, (c) demonstrate effects of technology that can be understood, used, executed and serviced with local means and personnel, (d) only gradually increase disposal cost.
  2. Awareness : can not be achieved by negative incentives (enforcements of regulations, fines) alone, (b) positive incentives need to be emphasized (healthier population, cleaner environment, attractive for tourism, job opportunities).
  3. Conclusions : (a) first priorities : appropriate, efficient collection and landfill services, (b) only then steps towards other options can be undertaken, (c) recommendations: incremental improvements, balance between regulations / enforcement / technology / cost / awareness.

- Planning and site identification :
  1. Before starting selection procedures : (a) determine area to be served, number of inhabitants, commercial & industrial activity, types and amounts of waste, and target life time of the landfill, (b) this will determine: transport limitations, expected environmental impact, required volumetric capacity, necessary inter-municipal cooperation, (c) determine appropriate selection criteria, (e) selection criteria may be grouped in: transport related, geotechnical, hydrological, hydrogeological, land use, public acceptability, and safety aspects.
  2. Landfill design and preparation :
     a. Design = (i) Nature : similar to civil engineering, (ii) skills required: similar to road construction; (iii) purpose : communicate how the site is to be developed.

   b. Should be sufficiently detailed to define how, where and when : (i) the site is to be prepared for accepting wastes; (ii) wastes are to be landfilled and water will be controlled; the site is to be restored; (iii) monitoring is to be carried out to ensure development and operation.
3. Disposal plan : (i) key element of design, (ii) describes appropriate sequence of filling to achieve final land form, (iii) purpose is to minimise environmental impact and at the same time minimise necessary construction works.
4. Minimising impact and construction : (i) minimising area being filled (12-18 months), (ii) accelerating restoration of filled parts, (iii) minimising double handling of excavated material, (iv) allowing progressive installation of gas and water controls, (v) permitting optimum development of access and haul roads.

- Key decisions for municipality :
  1. Technical resources and skills available?
  2. Required skills: waste management, civil engineering, hydrogeology, geotechnical engineering, hydrology.
  3. Acquisition options: building in municipal organisation, contracting to consultants, outsourcing to waste management contractors.
  4. Type of equipment to be used for placement and compaction (compactor or common equipment)?.
  5. Scavengers allowed on site (health and safety hazards)?

- Infrastructure :
  1. Waste acceptance requires : (i) access roads, (ii) reception facilities (office including heating/cooling, lighting, drinking water, toilet and wash facilities), (iii) registration facilities (volumetric estimation or weighbridge, administration system.
  2. Groundwater pollution : (i) … is one of the major concerns in landfill design, (ii) … is caused by leachate entering the subsoil, (iii) Quantity and quality of leachate depend upon local climate, nature of wastes, and measures to prevent entry of rain into the waste.
  3. Leachate treatment : (i) leachate can not be discharged untreated, (ii) Treatment is necessary, (iii) amounts of leachate can be reduced by recirculation, (iv) treatment options are municipal waste water treatment plant, lagoons, wetlands, activated sludge systems.

- Landfill gas :
  1. Degradation of organics produces landfill gas (LFG).
  2. LFG contains mainly methane and carbon dioxide.
  3. Methane is potentially explosive and a greenhouse gas
  4. Carbon dioxide is potentially asphyxiating.
  5. Risks: on-site and migration off-site.

- Gas control :
  1. LFG risks can be reduced by means of a gas collection system.
  2. Options: passive venting and flaring or active extraction and utilisation and / or flaring.

F. International Eco-Rescue

By : Bill Ryan/Matt van Domselaar
Topic : Financing and Feasibility of Landfill Gas Extraction Projects in Indonesia
Note :

- Global Eco-Rescue Foundation :
  1. Eco-Rescue is an investment management group that is at the forefront of the transition to an ecologically and energy constrained global economy.
  2. Eco-Rescue is a taxable foundation dedicated to investing in the natural resource sector emphasising solutions faithful to the natural efficiencies of ecosystems.
  3. Eco-Rescue's shareholders have chosen the taxable foundation structure to best manifest their desire to re-invest the majority of their profits in environmental and conservation efforts.
  4. Eco-Rescue has a shared ethos and vision with its sister charitable organisation, the Borneo Tropical Rainforest Foundation ("BTRF"), combining capital and conservation.
  5. Eco-Rescue is developing, funding and managing a large, diversified portfolio of natural resource, renewable energy and environmental projects that will be run on a best practice, sustainable and profitable basis.
  6. Reduction of green house gas emission from methane abatement at Indonesian landfills is a natural fit to this portfolio.

- Overview :
  1. Landfills in Indonesia have good potential for methane extraction because of the high organic content of the waste.
  2. Technology to implement is straightforward and has been proven in the field.
  3. Immediate social benefits are visible to the local community.

- Kyoto Protocol :
  1. The Kyoto Clean Development Mechanism provides an incentive to develop methane capture programs that generate carbon credits.
  2. Carbon credits can be sold to industrialized nations that need to satisfy their mandatory Kyoto emission limits.
  3. This results in an income from credits that can potentially offset the implementation costs of methane extraction projects that would otherwise not have been viable.

- Landfill CDM challenges :
  1. The generation of credits is directly related to the amount of methane that is captured by the project.
  2. Even with expert guidance, this amount is very hard to determine accurately.
  3. Most methane extraction models are too optimistic and the carbon credits to be generated can be over-estimated as a result.
  4. The feasibility of a project depends on a good price for carbon which is not guaranteed. Since we started looking into this project some carbon prices in the European Trading System have halved.
  5. Implementation costs are often under-estimated.

6. Project construction can be delayed due to unforeseen circumstances.

- Landfill Characteristics :
  The following are general characteristics of a landfill that could be considered for a successful methane extraction system :
  1. Sanitary or semi sanitary design.
  2. Usually a minimum of 1 million tonnes of waste in place, depending on the history and design.
  3. Generally the oldest waste should be around 10 years old.
  4. A steady or increasing amount of incoming fresh waste daily.
  5. Landfill should be open for a lengthy period after the start date of the project.
  6. Willingness by management to implement best practices in waste management.

- Eco-Rescue's Indonesian Landfill Program :
  1. Eco-Rescue representatives in Indonesia identified landfill operators that were amenable to site inspections and Letters of Intent were signed.
  2. Expert engineers were hired to initially assess each of these landfills during the summer of 2006.
  3. A detailed report was prepared on methane production potential and implementation risk and costs.
  4. After reviewing the technical and financial viability report, a small group of landfills were selected for further inspection.
  5. With most of the landfills assessed, further enhancements were necessary in order to be considered for development.
  6. Some of the landfills, however, appear to be technically and financially viable and a second visit is planned to develop the pre-engineering plan and a Memorandum of Understanding will be signed to cover the period prior to a final decision as to implementation.
  7. If implementation is viable, Eco-Rescue and the Landfill owner will enter into a contractual agreement to develop the site.

- Project Arrangements :
  1. Eco-Rescue will fund the majority of the inspection costs and capital expenditures for construction.
  2. Landfill operators will not need to make significant investments, but will be asked to make enhancements to the landfill, operations and management and firm commitments as to guaranteed input of waste, landfill management and ongoing cooperation.
  3. Eco-Rescue will oversee the registration, certification and validation processes of the Kyoto cycle.
  4. Eco-Rescue will deploy local and foreign engineers to implement gas extraction system.
  5. The landfill owner will agree a new management plan for the landfill with Eco-Rescue so as to have the most efficient and safe methane capture project.
  6. Eco-Rescue will manage the sale of the carbon credits. The management of the carbon credits will be transparent and fully disclosed to the landfill owner.
  7. Initial revenue will be prioritized to cover the investment in the extraction system.
  8. After the investment is recovered any profits will be shared, on the basis to be agreed in the contract, between the landfill owner and Eco-Rescue.

- Risks :

Certain events could impact revenue or even terminate the project, such as :

1. Larger than expected implementation costs
2. Less methane being captured than expected
3. Operational and technical setbacks
4. Prolonged low price for carbon credits
5. Less fresh waste being deposited
6. Unanticipated closure of landfill

- Summary :
  1. Methane capture projects are a natural fit to Eco-Rescue's vision on ecologically focused investments.
  2. Strong emphasis on enhancing sanitary conditions, safety and local improvements in direct vicinity of the landfill.
  3. Once the investment is recovered, profits are shared.
  4. We will work closely with local organizations and stakeholders to benefit the community and transfer knowledge and expertise.
  5. We hope to establish long term relationship with regencies and municipalities for further collaboration on other renewable and sustainable investment opportunities.

GERF

Statements international stakeholder consultation

B T R F
BORNEO TROPICAL
RAINFOREST FOUNDATION

Monday, May 14, 2007

Wim Maaskant and
Members of BGP Engineering team,

I write to you on behalf of the Borneo Tropical Rainforest Foundation. We are a Swiss based Non-Governmental Organization charged to, inter alia, advise and inform the Government of Indonesia regarding new and innovative strategies for protecting rainforest reserves as well as to instigate and foster constructive links and partnerships with key institutions and interests so that the initiative may serve as a living model of international best practices in the field of protected area management, as well as an example of regional and international co-operation at the highest level.

I have been fully versed and had the privilege to review with detail the engineering strategy, implementation and operational plans for your impending project on landfill methane captures with Global Eco Rescue Foundation across Indonesia. We have looked at many potential adverse impacts of this project from both an environmental and social position.

In course of this, we would like to offer our applause to you in creating a project that is not only environmentally low impact, but actually provides a valuable environmental service on the global scale by removing large quantities of green house gasses from the atmosphere and on a local level by decreasing the threat that landfills pose to the public health of communities around them. Further to that, your interest in capacity building and providing employment for members of the local communities around the project areas is a testament to the social responsibility of your project, and thus an immediate reflection upon your company and that of the Global Eco Rescue Foundation. As community development is a central tenant of our work at BTRF, we are pleased to see that you have engineered a project that provides both environmental and social benefits, and in many cases interconnects the two together, providing mutually supporting benefits.

We have no concerns with either the project planning or implementation phases or of the soundness of it's engineering design. Please accept both our complements and much due congratulations on work done to date.

Cordially,
Gabriel A. Eickhoff
Technical Project Developer
Borneo Tropical Rainforest Foundation

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Malang, 05 June 2007

No. : E.1.a/527/UMM/VI/2007

To: **Wim Maaskant**
BGP Engineer B.V.
Loopkanststraat 45
Uden, 5405 AC
Netherlands

Dear Madam/Sir,

Hereby as the Rector of Muhammadiyah University of Malang, certifying that Muhammadiyah University of Malang will endorse and support all initiatives lead by Global Eco Rescue Foundation to provide the Landfill gas Recovery Project for the ten landfills as stated in the PDD. We agree with the described positive environmental impacts of the project.

As a University we support the project as well as all capacity building activities and technology transfer related to the project and landfill management in general.

In case you require further discussion regarding this issue please feel free to contact us at your convenience

With compliments and regard,

Rector of Muhammadiyah University of Malang

Drs. Muhadjir Effendy M.AP