CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: July 1, 2004

CONTENTS

SECTION A.   General description of project activity

A.1   Title of the <u>project activity</u>:

(1) The title of the project activity
   Landfill Gas to Energy Facility at the Nejapa Landfill Site, El Salvador.

(2) The version number of the document
   Project Design Document Form (CDM-PDD) - Version 02.

(3) The date of the document
   November 22, 2005.

A.2.   Description of the <u>project activity</u>:

The Nejapa landfill is receiving Municipal Solid Waste (MSW) from the San Salvador Metropolitan Area based on a twenty years (20) agreement signed with Mides S.E.M. de CV (Mides), the owner of the landfill. The population of the San Salvador Metropolitan Area is averaging approximately 2.1 million people. From 1999 through June 2005, some 2.7 million tonnes of MSW has been disposed at the Nejapa landfill and this tonnage is expected to grow to 12.5 million tonnes during the landfill expected 25 years life. Environmental impact, health and safety issues for the population and energy potential has led Biothermica Energie Inc (Biothermica) to conduct in 2003 feasibility studies at the site, designed to minimize these impacts and assess the potential for developing a LFG-to-Energy Facility. Biothermica was subsequently appointed by Mides to realise the development, the financing, the construction and the operation of the LFG collection system and flaring station (Phase 1) and of a landfill gas power plant (Phase 2) following an agreement signed to this effect in 2005.

The purpose of the project activity is to recover and utilise the landfill gas emanating from the Nejapa landfill in order to reduce greenhouse gas (GHG) emissions, and numerous other environmental related issues such as the destruction of the pollutants found in landfill gas (chlorinated and ozone depleting compounds) and of the odours, through the proposed gas flaring system and energy facility. The project activity has been designed to proceed in two (2) phases. Phase I involves the design, construction and operation of a landfill gas (LFG) collection and flaring system. Phase I is expected to start February 1st 2006 and be operational by June 1st 2006. Emission reductions are estimated at 74,111 tonnes of CO_2 per year (2006) to 217,991 tonnes of CO_2 per year (2012). With the full-scale LFG collection system in place, monitoring of the LFG collection and flare systems will help determine the quantity and quality of gas available from the site. The energy facility will be designed based on available methane production data. The design, construction and operation of this LFG-to-Energy system constitute Phase II of the project activity. Based on current estimation of the landfill gas generation curves, electricity production is estimated at 3 MW in 2007 going up to 4 MW in 2012. Electricity will be exported to the grid. Additional emission reductions are expected to arise from this activity attributable to displacement of grid electricity. These reductions are estimated at 14,735 tonnes of CO_2 per year (2008) to 19,647 tonnes of CO_2 per year (2012). Phase II is expected to start February 1st 2007 and be operational by December 1st 2007.

The project activity contributes to the sustainable development of the Republic of El Salvador and will improve environmental and health related conditions as well as socio-economic development through technological transfer and collaboration with Mides. It will also contribute to the reduction of oil import dependency. The project activity will serve as a demonstration platform, to other landfill owners, project

developers and energy companies in Salvador and in Central America, for environmental oriented technologies. It will permit also the creation of directs jobs (10) and the substitution of the equivalent of 60 000 barrels of oil per year. Over the seven years (7) crediting period, the project activity will eliminate some 1,29 million tonnes of CO_2 . The CERs will be transferred to the project participants.

Phase I of the project activity is intended to operate as a Full-Scale Clean Development Mechanism (CDM) project and phase II as a Small-Scale CDM project under Article 12 of the Kyoto Protocol, and as such the project will have to comply with all emerging UNFCCC and host country requirements and guidelines relevant for CDM projects, in particular for the selection of baseline methodologies. This Project Design Document (PDD) illustrates the activities related to Phase I and Phase II of the project. Reductions from both phases are intended to be claimed by the project participants.

A.3.	**Project participants:**

Participants to the project activity are the following:

Name of Party Involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of El Salvador (host)	**Biothermica Énergie Inc.**[1]	No
Canada	**Biothermica Énergie Inc.**	No

(1) Biothermica Energie Inc, a company incorporated under the laws of Canada and having its registered office at 426 Sherbrooke Street East, Montreal, Quebec, Canada (H2L 1J6). The contact for CDM Project Activity is Biothermica Energie Inc.

More detail is provided in the following sections. Contact information is available in **Annex 1**.

A.4.	**Technical description of the project activity:**

A.4.1.	**Location of the project activity:**

A.4.1.1.	**Host Party(ies):**

Republic of El Salvador.

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

Department of San Salvador.

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

Nejapa.

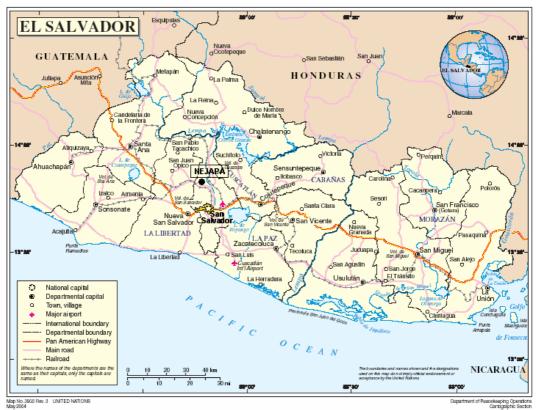| **A.4.1.4.**	**Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):**

The project will be located at the Nejapa landfill site, 17 kilometres north of the capital San Salvador, half way between the city of Quezaltepeque and Apopa. Location of the site is shown on the location plan below.

Map of El Salvador

Nejapa's population is averaging 30,000 people and the area primarily includes rural land uses. Regional topography is characterised by hills and valleys. The landfill itself is located six (6) kilometres outside of Nejapa on a hillside with a slope of 75 m north to south over a 1 km distance. The site is receiving 408,000 tonnes of waste per year from San Salvador metropolitan area and has a total capacity of 12.5 million tonnes in fifteen independent cells. Cells one to three have been partially completed and cell four is currently active. After completion, the site will cover 47 hectares.

Surrounding vegetation is a tropical type forest, composed of gallery forest (*Bosque de Galería*), heather (*Matronal*), *Chichinguastera*, sugar cane (*Caña de azucar*) and various grass type plants (*Granos básicos*). The local geological structure is composed of volcanic rock and debris ejected by volcanoes.

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

Phase I of this project involves landfill gas collection and flaring at the Nejapa landfill site. Project activity falls under "**Sectoral scope 13, Waste Handling and Disposal**." This project reduces anthropogenic emissions from landfills where the baseline scenario is the total atmospheric release of the gas. Phase I of the project meets the applicability requirements of the **Approved consolidated baseline methodology ACM0001 / Version 2, September 30, 2005.**

Phase II of this project will involve the generation of electricity from landfill gas capture at the Nejapa landfill site. Project activity falls under "**Sectoral scope 1, Energy industries (renewable / non-renewable sources)**." As noted in Section A.2.1, the electricity generated from the LFG-to-Energy system would be sold to the grid. Phase II meets the requirements of a Type I **Category I.D (Renewable electricity generation for a grid)** project[1]. As per Paragraph 23 and 24 of Appendix B of the simplified modalities and procedures for small-scale CDM project activities, this project represents a renewable energy source that replaces fossil fuel generated electricity in El Salvador and does not exceed the annual 15MW limit.

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

Landfill gas collection technology:

Eleven (11) passive vents made of high density polyethylene (HDPE) encased in a metallic protective shell are already installed at the site. Gradually, as more waste will be landfilled, more passive wells will be dug. The well network will eventually be connected via horizontal collectors on to a blower and flare station in order to collect the landfill gas.

The collection system is designed as simply and efficiently as possible for gas extraction: vertical wells and bentonite seal to reduce air infiltration, surface horizontal collectors for ease of inspection and repair, sole well head connection to main collector for easy balancing of the well pressure, condensate trap located at low points in the gas collection system to remove condensate to minimize clogging risk, blower and enclosed flaring station for methane combustion.

Energy generation technology:

The engine facility installed on site will be made of multiple 1 MW container type engine. Each internal combustion engine, especially designed to run on low BTU gas, will be equipped with its own electric generator. The uses of multiple engines will allow for a flexible operation over the years, as landfill gas volumes varies, as well as reducing installation cost and maintenance.

A gas treatment station will be added to the facility for contaminant removal before the gas can be used in the engines. These contaminants include moisture, solid particles, hydrogen sulphide, halide compounds, acids and siloxanes. This additional step will help prevent corrosion, premature wear and oil contamination.

Technology transfer related to the project will be provided by project participant to the host country through both the demonstration and operation of the LFG collection and flaring systems (Phase I) and the subsequent operation of the energy facility (Phase II). These systems will provide for lasting physical references to support technology transfer. Additionally, Salvadorian team members will be trained in the management, operation and maintenance of these systems.

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[1] *Referenced Document:* Annex II under Decision 21/CP.8 provided in United Nation Framework Convention on Climate Change (UNFCCC) Document FCCC/CP/2002/7/Add.3 was referenced to determine the type and category of the project activity. Specifically, Appendix B of the Simplified Modalities and Procedures for Small-Scale CDM Project Activities: Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories (Version 03: 30 June 2004) was used and is herein referred to as Appendix B.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

(1)   Mechanism of anthropogenic greenhouse gas reduction

Landfill gas is primarily composed of methane and carbon dioxide. Carbon dioxide from landfill gas is not considered an anthropogenic GHG but rather of biogenic origin by the Intergovernmental Panel on Climate Change (IPCC) and therefore part of the natural carbon cycle. CO_2 emissions will not be considered as a source of GHG and will not be accounted for in the baseline emission or in the project emission. Methane, however, is considered an anthropogenic GHG since it will not enter the carbon cycle unless flared.

Emission reductions will arise from the combustion of methane contained within the collected landfill gas. Combustion is an oxidation process by which methane (GWP 21) will be transformed into less potent carbon dioxide (GWP 1) resulting in one mole of carbon dioxide produced for each mole of methane combusted. Since global warming potential of methane is 21 times that of carbon dioxide, this process will reduce the net anthropogenic emissions of CO_2e significantly (1.19 million tonnes of CO_2 over the next 7 years).

The baseline scenario correspond to the emissions resulting from the uncontrolled release of methane gas to the atmosphere and those that would have occurred from the non-renewable energy source offset by the operation of the LFG-to-Energy facility. The associated (baseline) emissions for Phase I of the project is the amount of methane that would have been emitted to the atmosphere during the crediting period in the absence of this project activity. The emission baseline for Phase II of the project is defined as the amount of carbon dioxide that would have been produced by the combustion of diesel fuel to achieve the same electric load. Emissions can be derived from measured energy outputs (in kWh) multiplied by an emission coefficient for fossil fuel fired generating units. According to Appendix B for Category I.D. projects, the emission factor to be used is 0.712 kg CO_2e per kWh produced. Estimation shows that electricity displacement would reduce anthropogenic emissions by 97,825 tonnes of CO_2 over the next 7 years. See Section E.1 for formula / approach used to determine the baseline GHG emission reductions.

(2)   Why the emission reductions would not occur in the absence of the proposed project activity
This can be explained in terms of the following criteria:

(a)   Legal issue

Given that there is no regulation in El Salvador regarding emissions from landfill site and given that landfill gas migration do not pose safety concern for inhabitant since there is no building in close proximity to the site and that passive venting is sufficient to reduced pressure build-up to ensures safety of the site itself, situation describe as the baseline scenario is likely to endure in the absence of the project activity.

(b)   Commercial viability

Financial analysis involving electricity revenue from LFG without the CERs contribution has proven to be economically unattractive (see Section B.3).

A.4.4.1.   Estimated amount of emission reductions over the chosen crediting period:

The chosen crediting period is seven (7) years, renewable at most two times.

Net emission reductions due to the abatement of methane are expected to totalize 1.19 million tonnes of CO_2eq. within the first crediting period (June 2006 to May 2013) according to the chosen operating scenario. Annual reductions increase gradually form 74,111 (2006) to 198,344 tonnes of CO_2e per year (2012).

Net emission reductions due to electricity displacement are expected to amount to 97,825 tonnes of CO_2eq. within the specified crediting period. Yearly reductions are estimated at 14,735 tonnes in 2008 increasing to 19,647 tonnes of CO_2eq. by 2012.

A total of 1.29 million tonnes of CERs are projected to be generated over the next 7 years. As for the first compliance period (2008-2012), 975,353 tonnes of emission reductions are projected to be generated. The following table gives an annual estimation of emission reduction over the chosen crediting period (7 years, renewable at most two times).

Year[2]	Annual estimation of emission reduction in tonnes of CO_2e
2006	74,111
2007	141,420
2008	169,056
2009	180,212
2010	199,164
2011	208,930
2012	217,991
2013	95,189
Total estimated reduction (tonnes of CO_2eq.)	1,286,073
Total number of crediting year	7
Annual average over the crediting period of estimated reductions (tonnes of CO_2eq.)	183,725

A.4.5. Public funding of the project activity:

The project has received the support of the Canadian Government, through the Canadian Development Agency and DFAIT Canada. The following provides a brief summary of the contribution that has been made by each Public Sector Stakeholder.

Canadian International Development Agency (CIDA)

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[2] Since the crediting period start June 1st 2006 and end May 31st 2013, the table shows only 7 months for 2006 and only the first 5 months of 2013.

CIDA, through its Industrial Cooperation Program, has contributed financial support to the initial feasibility study of the Project. The public funding does not result in a diversion of Official Development Assistance (ODA). See Annex 2.

Department of Foreign Affairs and International Trade (DFAIT) Canada
As the government body overseeing Clean Development Mechanism (CDM) Projects on behalf of the Government of Canada, DFAIT, through Canada's CDM/JI Office, has contributed both financial and technical support to for the preparation of the PDD. The public funding does not result in a diversion of Official Development Assistance (ODA). See Annex 2.

SECTION B. Application of a <u>baseline methodology</u>

B.1. Title and reference of the <u>approved baseline methodology</u> applied to the <u>project activity</u>:

The baseline and monitoring methodologies are already approved methodologies taken from **ACM0001 / Version 2 Approved consolidated baseline methodology** for landfill gas capture and flaring and from Appendix B of the simplified modalities and procedures for **Small-Scale CDM project activities for project under Category I.D. Renewable electricity generation for a grid**.

B.1.1. Justification of the choice of the methodology and why it is applicable to the <u>project activity:</u>

This project fulfils the required applicability conditions of both baseline methodologies. As stated in ACM0001, "This methodology is applicable to landfill gas capture project activities, where the baseline is the partial or total atmospheric release of the gas and the project activities include situations as such as a) The captured gas is flared; or […] c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. […]".

ACM0001 selected approach from paragraph 48 of the CDM modalities and procedures is the most appropriate approach for the project activity: "Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment." Since there is no regulation related to the flaring of landfill gas in El Salvador, venting remains the most economically attractive course of action.

As indicated in Appendix B, phase II of this project will utilize landfill gas as a source of renewable energy for electricity production but do not involve the use of non-renewable components or combine heat and power systems. The generation capacity will be less than 15 MW$_{electrical}$.

These methodologies will be used in conjunction with their respective monitoring methodologies.

B.2. Description of how the methodology is applied in the context of the <u>project activity</u>:

The methodology will be applied by using option a) and c) of the Consolidated Methodology ACM0001. The captured gas will be used for electricity generation where emission reductions will be claimed; and the excess gas (if any) will be flared. The generation component of the project will use Methodology for Small Scale Activities Type I.D Renewable electricity generation for a grid (<15MW).

Emission reductions have been estimated using formulae taken from ACM0001 (there is no thermal energy component):

$$ER_y = \left(MD_{project,y} - MD_{reg,y}\right) \times GWP_{CH_4} + EG_y \times CEF_{electricity,y}$$

Where:
ER_y : greenhouse gas emission reduction achieved by the project activity during a given year "y" (tCO$_2$e);

$MD_{project,y}$: amount of methane actually destroyed/combusted during a given year (tCH$_4$);

$MD_{reg,y}$: amount of methane that would have been destroyed/combusted in the absence of the project activity during a given year (tCH$_4$);

AF : adjustment factor (%);

GWP_{CH4} : approved Global Warming Potential value for methane (21 tCO$_2$/tCH$_4$);

EG_y : net quantity of electricity displaced during the year "y" (MWh);

$CEF_{electricity,y}$: CO$_2$ emissions intensity of the electricity displaced during the year "y" (tCO$_2$/MWh);

The Landfill Gas Emission Model (LandGEM) was used to estimate the rate of methane generation from the site. This model was developed for the USEPA and is currently the industry accepted standard for modeling LFG production. The following data has been used:

$ **Waste landfilled** : 408,000 tonnes/Yr

$ **L$_0$** : 116.5 m^3/tonne

$ **k** : 0.075 Yr^{-1}

Uncertainties associated with this estimation method have led project participants to discount generation rates by 40% for conservativeness. Detailed baseline information is available in Annex 3.

The adjustment factor (AF) is determined using the following information:

$$MD_{reg,y} = MD_{project,y} \times AF$$

ACM0001 states that: "In case where regulatory or contractual requirement do not specify MD$_{reg,y}$ an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context."
The situation regarding Nejapa landfill is described as follow:

$ **Regulatory and contractual requirements:** The collection of LFG is not regulated for El Salvador. Existing regulations permit the natural release of methane from landfills. It is highly unlikely that regulation will change in the near future regarding landfill gas flaring. Even if regulatory conditions were imposed, the focus would likely be on the elimination of potential health and safety concerns with the operation of landfills as opposed to LFG collection and subsequent generation of energy from the LFG. Finally, there is no contractual requirement for landfill gas collection.

$ **Health and safety**: Landfill gas migration do not pose safety concern for inhabitant since there is no building in close proximity to the site, and that passive venting is sufficient to reduced pressure build-up to ensures safety of the site itself.

$ **Common practice:** Venting is the most common practice in El Salvador (see section B.3);

Based on the project context, an Adjustment Factor of 0% is used for the Nejapa project.

Emission reductions from electricity displacement are determined with the following formula:

$$ER_{electricity,y} = EG_y[kWh] \times 0.712 \left[\frac{kg_{CO_2e}}{kWh} \right]$$

The project electricity system contains both renewable energy power plants, such as hydro and geothermal, and fuel oil/diesel fuel generators. Since conditions stated in paragraph 6 of Appendix B are

not fulfils, the emission coefficient must be defined regarding instructions of paragraph 7 of Appendix B. Therefore, the emission coefficient ($CEF_{electricity,y}$) is either an average of the "approximate operating margin" and the "build margin" or the weighted average emission (in kg CO_2eq./kWh) of the current generation mix.

The emission coefficient ($CEF_{electricity,y}$) has been calculated using the average of the "approximate operating margin" and the "build margin". Baseline Information Annex 3 presents the table which the emission coefficient ($CEF_{electricity,y}$) has been calculated. The afore mention table contains all the figures concerning the power generation system in El Salvador, it has been transmitted by the Ministry of Environment and Natural Resources of El Salvador.

B.3.   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:

This CDM project provides for significant reduction of anthropogenic GHG emissions from the Nejapa Landfill. The determination of project scenario additionality is done using the CDM consolidated tool for demonstration and assessment of additionality, which follows the following steps:

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

The starting date of the CDM project activity is expected to be February 1st 2006 when drawings for the gas collection system will be finalized and the equipment for the construction of the gas collection system will be ordered. Thus, the crediting period of the project activity will start at, or after, the date of registration, not before.

Step 1: Identification of alternatives to the project activity consistent with current laws and regulation

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

The following items are regarded as realistic and credible alternatives to the project activity:

$ **Alternative 1:** Continuation of current practice of passive venting of landfill gas to the atmosphere at Nejapa landfill. In this scenario, the landfill owner operator would continue the current business as usual (BAU) of not collecting and flaring landfill gas from the waste management operations. In this case, no electricity would be generated.

$ **Alternative 2:** Landfill gas capture and flaring not undertaken as a CDM project activity;

$ **Alternative 3:** Landfill gas capture and utilisation for electricity generation not undertaken as a CDM project activity. The landfill operator would invest in a landfill gas collection system and in LFG power generation equipment (the proposed project activity). The operation would reduce the generation of power for other grid-connected sources.

Other alternatives such as utilisation of landfill gas off site are not viewed as viable considering the remote location of Nejapa landfill site.

Alternative 2 can be discarded at this point since there are no incomes related to the collection and flaring system that can offset the investments needed. Electricity sales from Alternative 3 generate new incomes that could be an attractive course of action and therefore will be kept as a possible baseline scenario.

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

The El Salvador legislation does not require landfill operators to flare or recover landfill gas. Current laws prevent illegal domestic or industrial dumping in rivers, lakes, parks and in public or private areas. It is unlikely that the El Salvador authorities will introduce such regulation in the foreseeable future. Therefore, both alternatives (1 and 3) defined in 1a. are compliant with all regulations and laws.

Step 2: Investment analysis

Sub-step 2a. Determine appropriate analysis method

According to the methodology of development of additionality, if the alternative to the CDM project activity does not include investments of comparable scale to the project, the Options III (benchmark analysis) must be used. This will be applied for this project.

Sub-step 2b. Option III – Application of benchmark analysis

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 June 2005, El Salvador sold $375 millions in 7.65 percent coupon global 30-year bonds at a yield of 7.695%, which represent a premium of 345 bp over UST.

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

The table below summarizes the financial analysis of the project activity. As shown, the project is not economically feasible without carbon, providing an IRR of -2.60%, lower than the interest rates provided by government bonds in the Host Country.

	With carbon	**Without carbon**
Net Present Value ('000 US$)	1045	-5727
IRR – Project	17.00%	-2.60%
Discount Rate	**15%**	**15%**

Sub-step 2d. Sensitivity analysis

A sensitivity analysis was realized by changing the following parameters:
$ Increase in project revenue (price of electricity sold to the grid);
$ Reduction in project capital and running costs (O&M costs).
Those parameters were selected as being 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.

Scenario	**IRR – Project (%)**	**NPV (US$)**
Base case	-2.60%	-5727

| Increase in project revenue | 2.01% | -4773 |
| Reduction in project costs | 2.12% | -4291 |

In conclusion, the project IRR remain low even in the cases where the parameters would change in favour of the Project. These numbers are lower than the risk free returns of government bonds.

Step 4: Common practice analysis

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

Up to date, there is no project implemented, or currently underway, in El Salvador for landfill gas capture/flaring or utilisation for electricity generation purposes.

Except for Nejapa landfill, most of the waste generated in El Salvador is disposed in uncontrolled dumps. Landfill gas management practice at Nejapa landfill is to passively vent the gas to the atmosphere. These practices reflect current legislation that does not require landfill owner to dispose of the landfill gas.

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

As mention above, there is no project similar to the proposed project activity.

Step 5: Impact of CDM registration

The implementation of a LFG collection and flaring system and subsequent LFG-to-Energy facility requires significant financial investment. Initial forecasts show that the project activity (Phases 1 and 2) would require investments of 8.1 million US$. Political instability in El Salvador has created a high risk environment for investors. As shown in the previous steps (1 through 4), without the contribution of carbon credit revenues to help offset the capital costs of implementing the facility, the project does not represent an attractive course of action. Thus, the investment in such a project would only occur if alternative funding, such as that provided by this CDM program, were secured to offset the risk associated with the investment costs. Revenues from the sales of emission reductions credits, estimated at 6.2 US$/tonne, would increase IRR to an acceptable level and enable project participants to go forward with the construction.

B.4.   Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

As stated in the Glossary of CDM terms:*"The project boundary shall encompass all anthropogenic emissions by sources of greenhouse gases (GHG) under the control of the project participants that are significant and reasonably attributable to the CDM project activity."*

Thus, all relevant source of GHG are included in the project boundary (even if it is technically and economically unfeasible to fully capture and destroy all landfill gas that has been produced within the site).

The project boundary for Phase I is the site of the proposed activity where the gas is capture and destroyed/used (ACM0001).

The project boundary for Phase II encompasses the physical, geographical site of the renewable generation source, as provided by Paragraph 26 of Appendix B.
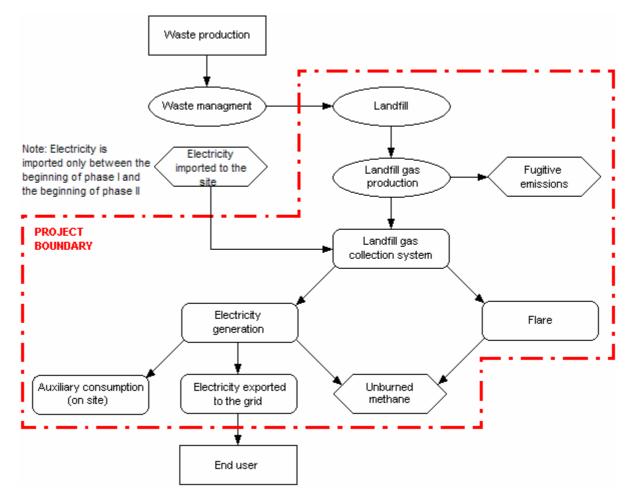
The following are part of the project boundary:

$ **Emissions from flare and engines**: Since methane collected from the landfill is organic in origin, carbon dioxide emissions released from the combustion of methane in the flare are a part of the natural carbon dioxide cycle and should not be counted as emissions from the project activity. This carbon was originally sequestrated in biomass so that the life cycle CO_2 emissions of landfill gas are zero. CO_2 emission in the natural cycle of life and decay should be considered neutral to the atmosphere.

$ **Methane generated by the landfill that is not captured** by the collection system or destroyed in the flare or engine;

$ **Unburned methane in the flare;**

$ **Electricity imported on site for the project activities should be considered in the project boundary:** Between the beginning of operation of phase I (June 1st 2006) and the beginning of operation of phase II (December 1st 2007), electricity will be imported on site to operate the landfill gas capture system. From the beginning of operation of phase II up to the end of the project activity, electric generators will supply enough electricity for the project activities resulting in a net export to the grid. Between June 1st 2006 and December 1st 2007, net electricity import will be monitored. After December 1st 2007, net electricity export will be monitored.

Project boundary

B.5.   Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

The baseline report[3] was completed on 25/03/2003.

The entity determining the baseline was Biothermica Technologies Inc.
426 Sherbrooke East
Montreal, Quebec
Canada
H2L 1J6
Tel: 514-488-3881
Fax : 514-488-3125
biotherm@biothermica.com

The contact details are included in Annex 1.

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[3] BIOTHERMICA, "Construction d'une centrale électrique alimentée au biogaz au site d'enfouissement de Nejapa, Salvador", ACDI E4936-K061048, Livrable no.3, n/ref 3780.51, Montreal, March 25th 200

SECTION C.   Duration of the project activity / Crediting period

C.1   Duration of the project activity:

C.1.1.   Starting date of the project activity:

The starting date of the project activity is February 1st, 2006.

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

The operational lifetime of the LFG collection and flaring system, as well as the electricity generation equipment, is expected to be twenty-one years (until 2026) or as long as the project is economically viable.

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

The renewable crediting period (maximum seven years with two options for renewal) has been selected for this project.

C.2.1.   Renewable crediting period

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

The selected starting date of the renewable crediting period is June 1st, 2006.

C.2.1.2.   Length of the first crediting period:

The selected length of the first crediting period will be seven years, ending on May 31, 2013.

C.2.2.   Fixed crediting period:

C.2.2.1.   Starting date:

Not Applicable.

C.2.2.2.   Length:

Not Applicable.

SECTION D. Application of a <u>monitoring methodology</u> and plan

D.1.   Name and reference of <u>approved monitoring methodology</u> applied to the <u>project activity</u>:

The monitoring methodologies are already approved methodologies taken from **ACM0001 Approved consolidated monitoring methodology** for landfill gas capture and flaring and Appendix B of the simplified modalities and procedures for **Small-Scale CDM project activities for Category I.D. Renewable electricity generation for a grid.**

D.2.   Justification of the choice of the methodology and why it is applicable to the <u>project activity</u>:

This project fulfils the required applicability conditions of both monitoring methodologies. As stated in ACM0001, "This methodology is applicable to landfill gas capture project activities, where the baseline is the partial or total atmospheric release of the gas and the project activities include situations as such as a) The captured gas is flared; or […] c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. […]".

ACM0001 selected approach from paragraph 48 of the CDM modalities and procedures is the most appropriate approach for the project activity: "Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment." Since there is no regulation related to the flaring of landfill gas in El Salvador, venting remains the most economically attractive course of action.

As indicated in Appendix B, phase II of this project will utilize landfill gas as a source of renewable energy for electricity production but do not involve the use of non-renewable components or combine heat and power systems. The generation capacity will be less than 15 $MW_{electrical}$.

These methodologies will be used in conjunction with their respective baseline methodologies.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the <u>baseline scenario</u>

Not applicable.

D.2.1.1. Data to be collected in order to monitor emissions from the <u>project activity</u>, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

Not applicable.

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 eq.)

Not applicable.

D.2.1.3. Relevant data necessary for determining the <u>baseline</u> of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.

Not applicable.

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 eq.)

Not applicable.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. $LFG_{total,y}$	Total amount of landfill gas captured	Flow meter[1]	m^3	Measured	Continuously	100%	Electronic database	Measured by a flow meter. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
2. $LFG_{flare,y}$	Amount of landfill gas flared	Flow meter	m^3	Measured	Continuously	100%	Electronic database	Measured by a flow meter. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
3. $LFG_{electricity,y}$	Amount of landfill gas combusted in power plant	Flow meter	m^3	Measured	Continuously	100%	Electronic database	Measured by a flow meter. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
4. $LFG_{thermal,y}$	Amount of methane combusted in boiler	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable as the Project will not include a thermal energy component

5. FE	Flare/combustion efficiency, determined by the operating hours (1) and the methane content in the exhaust gas (2)	1. Temperature sensor 2. Laboratory analysis	%	Measured / Calculated	1. Continuously 2. Quarterly, monthly if unstable	100%	Electronic database	1. Measured by a temperature sensor; 2. Periodic flue gas sampling & analysis Data will be summarized monthly. Data will be kept during the crediting period and two years after.
6. $w_{CH4,y}$	Methane fraction in the landfill gas	Gas analyser	m^3 CH4/ m^3 LFG	Measured	Continuously	100%	Electronic database	Measured by a gas analyser. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
7. T	Temperature of the landfill gas	Temperature sensor	ºC	Measured	Continuously	100%	Electronic database	Used for density calculation. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
8. P	Pressure of the landfill gas	Pressure sensor	Pa	Measured	Continuously	100%	Electronic database	Used for density calculation. Data will be summarized monthly. Data will be kept during the crediting period and two years after.
9.	Total amount of electricity and/or other energy carriers used in the project for gas pumping and heat transport (not derived from the gas)	Electric meter	MWh	Measured	Every day	100%	Electronic database	Once Phase II is operational, the Project will use electricity generated on site from the landfill gas, instead of importing electricity from the grid. Data will be kept during the crediting period and two years after.
10.	CO2 emission intensity of the electricity and/or other energy carriers in ID 9.	n/a	tCO_2/MWh	Calculated	Annually	100%	Electronic database	Once Phase II is operational, the Project will use electricity generated on site from the landfill gas, instead of importing electricity from the grid. Data will be kept during the crediting period and two years after.

11.	Regulatory requirements relating to landfill gas projects	n/a	Test	n/a	Annually	100%	Electronic database	Used to revaluate the adjustment factor (AF) or $MD_{reg,y}$. Data will be summarized annually. Data will be kept during the crediting period and two years after.
12. EG_y	Electricity supplied to the grid	Electric meter	MWh	Measured	Every day	100%	Electronic database	Double checked with receipts of sales. Data will be summarized monthly. Data will be kept during the crediting period and two years after.

N1.   The LFG flowmeter can record flowrates in multiple data units, i.e. m^3/h or m^3/min, etc. The most practical data unit for this project will be selected during commissioning of the various systems.

N2.   *Archiving Requirements* are based on duration since time of collection

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO$_2$ eq.):

In accordance with this methodology, the baseline GHG emission reductions for this project are equal to the amount of methane that would be emitted to the atmosphere in the absence of the project activity and shall be quantified by only those emissions that would not have been captured and flared in the absence of the project activity. Since there are currently no systems in place to capture and flare LFG at the site, the emissions can be quantified as those collected by the LFG collection system that will be installed.

As described in section B.4 project emissions come from the partial recovery of methane gas from the site, unburned methane from the flare and electricity imported on site.   The flare efficiency is calculated by dividing the methane content in the exhaust gas and the methane supplied to the flare. The flue gas analysis will be performed monthly during the first three months and thereafter if the flare efficiency is unstable; if not, the frequency will be four (4) times a year.

$$Flare\ Efficiency\,(FE) = 1 - \left(\frac{methane\ content\ in\ exhaust\ gas}{methane\ supplied\ to\ the\ flare} \right)$$

Emission reductions will be measured directly from the captured gas and corrected for the flare efficiency (FE) (flare efficiency is taken into account in emission reduction calculation in section B.2 and D.2.4); therefore it is not necessary to monitor emissions from methane that is not recovered by the collection system.

Between the beginning of operation of phase I (June 1st 2006) and the beginning of operation of phase II (December 1st 2007), electricity will be imported on site to operate the landfill gas capture system. The electricity imported is taken into account when calculating the net electricity export in section E.5. As a result, net electricity exported in 2006 has a negative value. The electricity imported results in reduction of greenhouse gas emission reduction of 71 tCO_2e in 2006 and 119 tCO_2e in 2007. After December 1st 2007, electric generators will supply enough electricity for the project activities, resulting in a net export to the grid. The net amount of electricity exported to the grid takes into account a factor for internal auxiliary uses and a factor for maintenance and unscheduled stop, as stated in section E.5. The internal auxiliary includes electricity used to operate the landfill gas capture system.

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

Not applicable.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO$_2$ eq.)

In accordance with ACM0001 monitoring methodology and paragraph 30 of Appendix B, no leakage calculation is required.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO$_2$ eq.)

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.

Emission reductions have been estimated using formulae taken from ACM0001 (there is no thermal energy component):

$$ER_y = \left(MD_{project,y} - MD_{reg,y}\right) \times GWP_{CH_4} + EG_y \times CEF_{electricity,y}$$

Where:

$$MD_{reg,y} = MD_{project,y} \times AF$$

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

$$MD_{flared,y} = LFG_{flared,y} \times w_{CH4,y} \times D_{CH4} \times FE$$

$$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH4,y} \times D_{CH4}$$

ER_y	: greenhouse gas emission reduction achieved by the project activity during a given year "y" (tCO$_2$e);
$MD_{project,y}$	: amount of methane actually destroyed/combusted during a given year (tCH$_4$);
$MD_{reg,y}$	: amount of methane that would have been destroyed/combusted in the absence of the project activity during a given year (tCH$_4$);
AF	: adjustment factor (%);
GWP_{CH4}	: approved Global Warming Potential value for methane (21 tCO$_2$/tCH$_4$);
EG_y	: net quantity of electricity displaced during the year "y" (MWh);
$CEF_{electricity,y}$	: CO$_2$ emissions intensity of the electricity displaced during the year "y" (tCO$_2$/MWh);
$LFG_{flared,y}$	: quantity of landfill gas fed to the flare (m^3);
$LFG_{electriciy,y}$	: quantity of landfill gas fed for the generation of electrical energy (m^3);
w_{CH4}	: average methane fraction of the landfill gas measured during the year "y" (m^{3}CH4/m^{3}LFG);
D_{CH4}	: methane density (tCH$_4$/m^{3}CH$_4$);
FE	: flare efficiency (%).

$LFG_{flared,y}$ and $LFG_{electriciy,y}$ are based on USEPA LandGem generation model. This first order decay model takes into account the amount of waste in place, the quality of the waste (in term of landfill gas potential, L$_0$), and the speed of decay (k). Emission reductions have been discounted by 40% for conservativeness. More detailed information is available in the Baseline Information Annex 3.

The carbon emission factor ($CEF_{electricity,y}$) has been calculated is using the average of the "approximate operating margin" and the "build margin" as stated in paragraph 7 of Appendix B.

D.3.   Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
D.2.2.1-1 to D.2.2.1-3	Low	Flow meters will be subject to a regular maintenance and calibration regime to ensure accuracy.
D.2.2.1-4	Not applicable	Not applicable as the Project will not include a thermal energy component.
D.2.2.1-5	Medium	A regular maintenance regime to ensure optimal operation of flares. Flare efficiency will be checked quarterly (monthly during the first three months and thereafter is the flare efficiency is unstable).
D.2.2.1-6	Low	Gas analyser will be subject to a regular maintenance and calibration regime to ensure accuracy.
D.2.2.1-7 to D.2.2.1-8	Low	Temperature and pressure sensors will be subjected to a regular maintenance and calibration regime to ensure accuracy.
D.2.2.1-9	Low	Electric meters will be subject to a regular maintenance and calibration regime to ensure accuracy. These procedures will be performed by the electric distribution company.
D.2.2.1-12	Low	Electric meters will be subject to a regular maintenance and calibration regime to ensure accuracy. These procedures will be performed by the electric distribution company.

D.4   Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

Data monitoring

On site technicians will be in charge of implementing the monitoring procedure which will consist of equipment maintenance (see below), landfill gas reading at each well head every two weeks to insure optimal capture of the landfill gas and verify the state of the collection system for air leak or collapsed pipe. Each month this data is integrated in a monitoring report, including calibration report of each instrument. This report also includes preventive maintenance performed by the staff especially in case of engine maintenance (phase II). In phase II, technicians will continuously monitor engine performance for any problem.

Data collected by the instrument will be recorded every four minutes in a data logger (FIELDGATE FXA250, *Endress+Hauser* or equivalent) located at the control station. The data logger memory will be accessible via an Internet link and will be downloaded on a daily basis into Biothermica computers.

Monitoring program

An Operational Manual will be prepared for monitoring procedures, maintenance procedures, trouble shooting and any additional information that is considered necessary for the well being of the project and Monitoring Plan.

The monitoring program will include follow-up of the landfill site gas production, data analysis, alarm management and monthly report. A follow-up program will also be in place for fast detection of shutdowns and anomalies, short response time of the intervention staff and aftershock analysis. This will help the staff to determine the cause of the problem and the best course of action.

Based on monitoring reports, the head office can easily modify the monitoring procedures for improvement and adapt to the staff or any changes on the site such as waste management for active section of the landfill. These feed back will include any addition work that is thought to be necessary during the following month.

Equipment maintenance

To insure optimal reading of the flow meters, a tranquilliser plate will be installed in front of each flow meter to reduced turbulence of the flow.
Each instrument will be equipped with a local visualisation screen for easy monitoring.

Calibration procedures will be performed every month by the staff accordingly with manufacturer recommendation. Calibration is usually done with two standardized gas sample, typically 45% and 25% methane. The system can also incorporate a self calibration system.
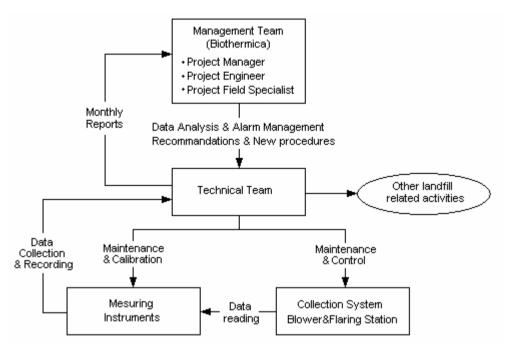
Portable instruments will be calibrated before every round of measurements by the on site technician and every six month by the manufacturer. A follow-up of the accuracy of reading is also performed before every round. This portable instrument measures, CH_4, CO_2, O_2 and N_2. This instrument will also help detect any drift in the continuous methane gas analyser.

Maintenance and calibration of the electrical meter will be performed by the local electricity company.

Operational and management structure described above is summarized in the following diagram.

Management structure & Information flow chart

D.5	Name of person/entity determining the monitoring methodology:

Biothermica has determined the Monitoring Methodology. Biothermica has been presented as a project participant in Annex 1.

E.1.   Estimate of GHG emissions by sources:

As noted in Section D.2.2.2 the anthropogenic emissions due to the project activity are already taken into account in the calculation of emission reductions. Therefore project emissions are not monitored.

E.2.   Estimated leakage:

No leakage calculation is required under ACM0001.

No leakage calculation is required for Categories I.D since the renewable energy technology is not equipment transferred from another activity.

E.3.   The sum of E.1 and E.2 representing the project activity emissions:

See E.1.

E.4.   Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

The following table gives information on greenhouse gases of the baseline for Phase I and II of the project activity:

Year[4]	Waste landfilled (t)	Landfill gas generation potential (m³)	Capture efficiency (%)	Landfill gas captured (m³)	Baseline emissions (Phase I) (tCO₂eq.)	Baseline emissions for displacing grid electricity (Phase II) (tCO₂eq.)
2006	238,000	12,803,169	70.2	8,987,824	107,829	0
2007	408,000	24,185,331	70.2	16,978,103	203,690	1,250
2008	408,000	26,260,733	70.2	18,435,034	221,169	15,004
2009	408,000	28,186,173	70.2	19,786,693	237,385	15,004
2010	408,000	29,972,487	71.4	21,400,356	252,430	20,006
2011	408,000	31,629,729	71.4	22,583,626	266,387	20,006
2012	408,000	33,167,224	71.4	23,681,398	279,336	20,006
2013	170,000	14,414,010	72.12	10,395,384	121,395	8,336
TOTAL	**2,856,000**	**200,618,856**		**142,248,418**	**1,689,620**	**99,611**

The next paragraphs will describe the amount of methane destroyed in the baseline scenario ($MD_{reg,y}$).

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[4] Since the crediting period start June 1st 2006 and end May 31st 2013, the table shows only 7 months for 2006 and only the first 5 months for 2013.

$$MD_{reg,y} = MD_{project,y} \times AF$$

Where:

$MD_{reg,y}$	: amount of methane that would have been destroyed/combusted in the absence of the project activity during a given year (tCH$_4$);
$MD_{project,y}$	: amount of methane actually destroyed/combusted during a given year (tCH$_4$);
AF	: adjustment factor (%).

ACM0001 states that: "In case where regulatory or contractual requirement do not specify MD$_{reg,y}$ an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context."

The situation regarding Nejapa landfill is described as follow:

$ **Legislation:** The collection of LFG is not regulated for El Salvador. Existing regulations permit the natural release of methane from landfills. It is highly unlikely that regulation will change in the near future regarding landfill gas flaring. Even if regulatory conditions were imposed, the focus would likely be on the elimination of potential health and safety concerns with the operation of landfills as opposed to LFG collection and subsequent generation of energy from the LFG.

$ **Health and safety**: Landfill gas migration do not pose safety concern for inhabitant since there is no building in close proximity to the site, and that passive venting is sufficient to reduced pressure build-up to ensures safety of the site itself.

$ **Common practice:** Venting is the most common practice in El Salvador (see section B.3);

Based on the project context, an Adjustment Factor of 0% is used for the Nejapa project.

E.5.   Difference between E.4 and E.3 representing the emission reductions of the <u>project activity</u>:

The total emission reductions will be quantified by the approach and equations described in section D.2.4.

$$ER_y = \left(MD_{project,y} - MD_{reg,y} \right) \times GWP_{CH_4} + EG_y \times CEF_{electricity,y}$$

$MD_{project,y}$ and $ER_{electricity,y}$ are determined as follow:

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

$$MD_{flared,y} = LFG_{flared,y} \times w_{CH4,y} \times D_{CH4} \times FE$$

$$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH4,y} \times D_{CH4}$$

and $ER_{electricity,y} = EG_y \times CEF_{electricity,y}$

Where:

ER_y	: greenhouse gas emission reduction achieved by the project activity during a given year "y" (tCO$_2$e);
$MD_{project,y}$	: amount of methane actually destroyed/combusted during a given year (tCH$_4$);
$MD_{reg,y}$	: amount of methane that would have been destroyed/combusted in the absence of the project activity during a given year (tCH$_4$);
AF	: adjustment factor (%);
GWP_{CH4}	: approved Global Warming Potential value for methane (21 tCO$_2$/tCH$_4$);
EG_y	: net quantity of electricity displaced during the year "y" (MWh);

$CEF_{electricity,y}$	: CO_2 emissions intensity of the electricity displaced during the year "y" (tCO$_2$/MWh);
$LFG_{flared,y}$	: quantity of landfill gas fed to the flare (m^3);
$LFG_{electriciy,y}$	: quantity of landfill gas fed for the generation of electrical energy (m^3);
w_{CH4}	: average methane fraction of the landfill gas measured during the year "y" (m^{3}CH4/m^{3}LFG);
D_{CH4}	: methane density (tCH$_4$/m^{3}CH$_4$);
FE	: flare efficiency (%).

As noted in Section D.2, the flow rate of methane captured and the emission reductions would be recorded continuously. Therefore the daily CO_{2e} captured would be equal to the sum of the values recorded.

The calculation of baseline GHG emissions reductions associated with the offset of electricity from the LFG-to-energy system (Phase II) are calculated in accordance with method specified under Paragraph 28 of Appendix B (Category I.D.).

$$ER_{electricity,y} = EG_y[kWh] \times 0.712 \left[\frac{kg_{CO_2e}}{kWh} \right]$$

The electricity system in El Salvador contains both renewable energy power plants, such as hydro and geothermal, and fuel oil/diesel fuel generators. According to Appendix B, the emission coefficient consists in the average of the "approximate operating margin" and the "build margin". Based on the information transmitted by the Ministry of Environment and Natural Resources of El Salvador, the combined margin value is calculated to be 0.712 kgCO2eq./kWh (see Baseline Information in Annex 3). Therefore, GHG emission reductions associated with the offset of electricity for the LFG-to-energy system are calculated by multiplying the energy generated (in kWh) by the emission coefficient.

The net amount of electricity produced is based on the gross capacity installed, an 87.5% factor to account for internal auxiliary uses (net vs gross capacity) and the 90% load factor that takes into account down time for maintenance and unscheduled stop.

$$Net\ capacity\ installed[MW] = Gross\ capacity\ installed[MW] \times 87.5\%$$

The gross capacity installed in 2007 is 3 MW and an additional 1MW will be added in 2010. This represents a net capacity of 2.625 MW$_{electric}$ and 3.50 MW$_{electric}$ respectively. Twelve and a half percent (12.5%) of the total power production is being diverted for internal electricity needs and is thus excluded of the net electricity produced. This internal electricity needs include electricity used to operate the landfill gas capture system.

For the year 2006 and 2007, since EG_y represent the net quantity of electricity displaced, electricity imported from the grid to operate the landfill gas capture system will thus be subtracted from the net quantity of electricity produced.

$$EG_y[MWh] = \left(Net\ capacity\ installed[MW] \times 8760 \left[\frac{hours}{year} \right] \times 90\% \right) - Electricity\ imported[MWh]$$

Since no electricity is generated in 2006, EGy has a negative value in 2006 (see below table). From 2008 to the end of the project, the factor of 12,5% for internal auxiliary uses includes the electricity needed for the landfill gas capture system operation, thus no electricity is imported to the site.

The amount of electricity imported is estimated from the power consumption required by the blower to pump the gas; that represents about 20 kW.

The following tables give detailed information on the project activity emission reductions:

Year	LFG_{flared} (m³)	$LFG_{electricity}$ (m³)	w_{CH4} (%)	D_{CH4} (tCH₄/m³CH₄)	FE (%)	MD_{flared} (tCH₄)	$MD_{electricity}$ (tCH₄)	$MD_{project}$ (tCH₄)
2006	8,987,824	0	55.95	0.0007168	98	3,532	0	3,532
2007	15,906,842	1,071,260	55.95	0.0007168	98	6,251	430	6,681
2008	5,579,912	12,855,123	55.95	0.0007168	98	2,193	5,156	7,349
2009	6,931,571	12,855,123	55.95	0.0007168	98	2,724	5,156	7,880
2010	4,260,192	17,140,163	55.95	0.0007168	98	1,674	6,874	8,548
2011	5,443,463	17,140,163	55.95	0.0007168	98	2,139	6,874	9,013
2012	6,541,234	17,140,163	55.95	0.0007168	98	2,571	6,874	9,445
2013	3,253,650	7,141,735	55.95	0.0007168	98	1,279	2,864	4,143
TOTAL	56,904,688	85,343,730				22,366	34,227	56,592

Year	$MD_{project}$ (tCH₄)	AF (%)	$MD_{reg,y}$ (tCH₄)	GWP_{CH4} (tCO₂/tCH₄)	EG_y [5] (MWh)	$COEF_{electricity,y}$ (tCO₂/MWh)	ER_y (tCO₂eq.)
2006	3,532	0	0	21	-99	0.712	74,111
2007	6,681	0	0	21	1,558	0.712	141,420
2008	7,349	0	0	21	20,696	0.712	169,056
2009	7,880	0	0	21	20,696	0.712	180,212
2010	8,548	0	0	21	27,594	0.712	199,164
2011	9,013	0	0	21	27,594	0.712	208,930
2012	9,445	0	0	21	27,594	0.712	217,991
2013	4,143	0	0	21	11,498	0.712	95,189
TOTAL	56,592		0		137,129		1,286,073

E.6.   Table providing values obtained when applying formulae above:

Above formulae will use actual instruments readings and therefore cannot be precisely calculated here. The following table give the predicted emissions based on a series of assumptions such as methane generation curve, collection efficiency and year of commissioning for each engine.

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[5] Amount of electricity imported from the grid (see Table D.2.2.1-9) have been subtracted from the net electricity produced to get the net electricity displaced (EG_y).

Year	Estimation of project activity emission reductions (tonnes of CO_2eq.)	Estimation of baseline emission reductions (tonnes of CO_2eq.)	Estimation of leakage (tonnes of CO_2eq.)	Estimation of emission reductions (tonnes of CO_2eq.)
2006		74,111	0	74,111
2007		141,420	0	141,420
2008		169,056	0	169,056
2009		180,212	0	180,212
2010		199,164	0	199,164
2011		208,930	0	208,930
2012		217,991	0	217,991
2013		95,189	0	95,189
TOTAL		**1,286,073**	**0**	**1,286,073**

See following tables for more detailed information on emissions.

Year	Phase I			Phase II		Total
	Baseline emissions (tCO_2eq.)	Fugitive emissions[6] (tCO_2eq.)	Emissions reductions[7] (tCO_2eq.)	Baseline emissions (tCO_2eq.)	Emissions reductions (tCO_2eq.)	(tCO_2eq.)
2006	107,829	33,647	74 111	0	0	74,111
2007	203,690	63 379	140 192	1,228	1,228	141,420
2008	221,169	66 848	154 321	14,735	14,735	169,056
2009	237,385	71 908	165 477	14,735	14,735	180,212
2010	252,430	72 912	179 517	19,647	19,647	199,164
2011	266,387	77 104	189 283	19,647	19,647	208,930
2012	279,336	80 992	198 344	19,647	19,647	217,991
2013	121,395	34 393	87 002	8,186	8,186	95,189
TOTAL	**1,689,620**	**501,183**	**1,188,247**	**97,825**	**97,825**	**1,286,073**

Crediting Period	Baseline Emissions	Fugitive Emissions	Project emissions Reductions
7 years	1,787,446	501,183	1,286,073
10 years	2,777,883	759,802	2,017,891
14 years	4,232,044	1,134,025	3,097,830
21 years	6,700,439	1,750,631	4,949,618

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[6] Fugitive emissions are showed for ease of understanding but will not be monitored (see section B.4. and D.2.2.2)

[7] Emission reductions have been reduced to take into account imported electricity from the grid, 71 tCO2e in 2006 and 119hn tCO2e in 2007.

SECTION F. Environmental impacts

The following is a summary of environmental impacts associated with this project.

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

As noted earlier, the implementation of this project will proceed in two Phases. The environmental impacts associated with the construction and operation of the various Phases of this project is discussed below.

Vegetation
Landfill gas collection will improve landfill surface and vegetation. By reducing surface emission on the landfill, this will create more suitable environment for the vegetation to grow. Landfill gas in the soil and air tend to prevent vegetation from growing. This is why, there is currently no vegetation on the Nejapa landfill.

Water quality
Landfill gas condensate will be collected by condensate trap and return to a leachate treatment facility.

Air Quality
Atmospheric emissions of the Energy Facility are well within the compliance limits of the Canadian regulation. It is important to point out that there is no regulation in El Salvador, at this time, regarding air quality for this type of installation. So, this project has been design with the Canadian regulation in mind.

Estimated emissions from internal combustion engines are summarise:
$ Emission rate of carbon monoxide (CO) is an average of 0,162 g per MJ which represent 8% of the Canadian environmental regulation of 1,8 g/MJ.
$ Emission rate of nitrous oxide (NOx) is an average of 0,017 g par MJ which represent 0,3% of the Canadian environmental regulation of 4,5 g NO_2/MJ.
$ Emission rate of total hydrocarbon is an average of 0,46 g/MJ which represent 21% of the Canadian environmental regulation of 2,2 g/MJ.

LFG collection and flaring system construction is not anticipated to have significant impacts to the surrounding environment of the landfill site. Local roadways located outside of the landfill are sufficient to transport equipment and materials to the site.

The implementation of the LFG collection and flaring system and the subsequent LFG-to-energy systems will significantly decrease the environmental impacts that are occurring under the present operating conditions of the landfill site. Methane and other compounds that are normally released from landfills that do not contain a LFG collection and flaring system will be greatly reduced. As discussed in Section A.4.3, the project activity will generate 1.3 million tonnes of CO_2e emission reductions over the first crediting period. This represents a significant reduction of GHG emissions from the landfill site.

The control of LFG emission through the employment of the LFG collection and flaring system represents many significant environmental and health benefits to the landfill site and local areas including:
$ Reduction of LFG migration throughout the landfill.
$ Improvement of landfill surface and vegetation.

$ Sustain local wildlife habitats.

$ Increase safety of landfill site operations through decreased potential for landfill fires.

$ Reduction of GHG emissions to the atmosphere.

$ Reducing fossil fuel consumption to generate equivalent energy.

$ Reduction in pollution from volatile organic compound (VOC) (smog, acid rain …).

$ Reducing ozone depleting compound emission such as CFC (Montreal Protocol). Landfills often receive waste such as refrigerators and spray cans that contain CFC compound. These compound are released when their container rust or break.

$ Reduction nuisance odours.

$ Reduction in health problem related to the landfill (respiratory distress, asthma, asphyxia, cancer …).

$ Enhancing the quality of life and the public security for the population living close to the landfill.

Noise

All engine installed will comply with rule nº 4996 of the City of Montreal and the directive from the Environment and Wildlife Ministry of Quebec for maximum noise level for a fixed source in continuous operation. These engines are container type package with acoustic barrier in compliance with the specified regulation. Regulation states that noise level must not exceed 50 dBA outside during the night. In industrial zones, this limit is fixed at 70 dBa and 90 dBa inside (work environment).

The use of a enclose burner will reduced the emitted noise from the flare; acoustic barrier can also be installed if noise need to be reduce further.

Visual impact

The operation of the LFG collection and flaring system will not pose environmental impacts on the surrounding areas of the landfill. The LFG collection system pipe network will be close to the ground and probably cover with soil and vegetation and thus will not pose a visual impact to the neighbouring properties. Any building installed on-site for this system will be relatively small. The flare will be elevated above the landfill surface; however it will be strategically placed in order to have minimum visual impact to the surrounding lands. The use of an enclose burner will eliminate the visible flame.

Visual impacts will be reduced by using building and landscape architectural techniques.

F.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:

No significant negative impacts are expected to result from the project activity.

SECTION G. Stakeholders' comments

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

Mides with the support of the council of the city halls of cities surrounding San Salvador (COAAMS) is managing all landfill activities. An environmental impact assessment was conducted by MIDES and given to the responsible authorities in Salvador in May 2001. A monitoring comity consisting of sixteen individuals, representative of the Health ministry, Environmental Ministry, town council of Nejapa, Procomes (non governmental entity) and local citizens is supervising all landfill related activities. This comity is focusing on insuring management and safe disposal of leachate and waste water.

G.2.   Summary of the comments received:

As mentioned in the previous section (G.1), leachate treatment and disposal was the main concern.

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

Based on the continuous interaction between the project participant and the monitoring comity, it has not been found necessary to modify the approach to the various Phases of this project. Stakeholder comments are already integrated in the management of landfill activities which will include landfill gas collection and utilisation. The project participant will continue to deliver the project according to the original plan.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Represented by:	Guy Drouin
Title:	President
Salutation:	Mr.
Last Name:	Drouin
Middle Name:	
First Name:	Guy
Department:	
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Public funding of the project activity was provided by the Government of Canada (Annex 1 Party) CDM-JI office and CIDA. The public funding does not result in a diversion of Official Development Assistance (ODA).

Foreign Affairs   Affaires étrangères
Canada   Canada

Ottawa, Canada
K1A 0G2

October 14th, 2005

Guy Drouin
Biothermica Energy Inc.
426, Sherbrook Est
Montréal (Québec)
Canada
H2L 1J6

Dear Mr. Drouin,

Re: Nejapa Landfill Project in El Salvador

The Marrakech Accords affirm that "public funding for clean development mechanism projects from Parties in Annex 1 is not to result in the diversion of official development assistance and is to be separate from and not counted towards the financial obligations of Parties included in Annex 1" (Decision 17/CP7, Preamble, pp. 20).

Biothermica Energy Inc. has indicated that public sources of funding for the Nejapa Landfill Project in El Salvador include:

1. Canada's Clean Development Mechanism and Joint Implementation Office, Foreign Affairs Canada
2. Industrial Cooperation Program, Canadian International Development Agency

This letter confirms that the above-mentioned federal funding for projects under Canada's Clean Development Mechanism and Joint Implementation Office, Foreign Affairs Canada and the Industrial Cooperation Program, Canadian International Development Agency, does not result in a diversion of Canada's official development assistance and is not counted towards the financial obligations of Parties included in Annex 1.

Sincerely,

Richard Ballhorn
Designated National Authority
Foreign Affairs Canada

Annex 3

BASELINE INFORMATION

I. LANDFILL GAS BASELINE

Mathematical model

Gas production from the degradation process of organic matter is adequately represented as decreasing exponentially following the first order formulae:

$$Q = W.L_0.k.e^{-k(t-t_i)}$$

Where

$Q =$ Methane generation after "t" years, m^3 per year;
$W =$ Waste in place, tonnes;
$L_0 =$ Methane generation potential, m^3 of CH_4 /tonne of waste;
$t =$ Elapsed time since waste disposal, year
$t_i =$ Latent period (period during which waste do not produce gas)
$k =$ Methane generation rate constant (1/yr).

Waste landfilled

The total amount of waste in place at the Nejapa landfill site was just over 1,300,000 tonnes by the end of 2002. Based on the average of waste received since the closure of Mariona landfill, 408,000 tonnes of waste is expected to be landfilled each year. For conservativeness (i.e. excluding population growth rate), it has been assumed that this amount will be constant overtime. As noted earlier in section A.3.1, Mides operates Nejapa landfill under a twenty (20) years concessional agreement with the cities of San Salvador metropolitan area; as such, waste produced in that region will be landfilled at Nejapa.

The following table gives the waste schedule:

Year	Tonnes	Total
1 999	228 298	228 298
2 000	323 871	552 169
2 001	337 543	889 712
2 002	412 212	1 301 924
2 003	408 000	1 709 924
2 004	408 000	2 117 924
2 005	408 000	2 525 924
2 006	**408 000**	**2 933 924**
2 007	**408 000**	**3 341 924**
2 008	**408 000**	**3 749 924**
2 009	**408 000**	**4 157 924**
2 010	**408 000**	**4 565 924**
2 011	**408 000**	**4 973 924**
2 012	**408 000**	**5 381 924**
2 013	408 000	5 789 924

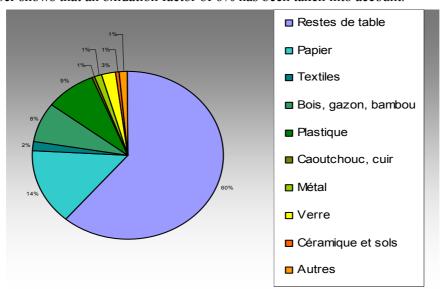|		
2 014	408 000	6 197 924
2 015	408 000	6 605 924
2 016	408 000	7 013 924
2 017	408 000	7 421 924
2 018	408 000	7 829 924
2 019	408 000	8 237 924
2 020	408 000	8 645 924
2 021	408 000	9 053 924
2 022	408 000	9 461 924
2 023	408 000	9 869 924
2 024	408 000	10 277 924
2 025	408 000	10 685 924
2 026	408 000	11 093 924
2 027	408 001	11 501 925
2 028	408 001	11 909 926
2 029	408 001	12 317 927
2 030[8]	182 073	12 500 000

Methane potential

Waste from the metropolitan area of San Salvador is characterised by a high content of organic material (61.1%) and humidity (42.1%). The following figure gives a more detailed analysis.

Field tests conducted in 2002 and 2003 (wet and dry seasons) showed that landfill gas produced by this organic matter contained on average 56.4% of methane. In comparison to the theoretical 60% value, this number shows that an oxidation factor of 6% has been taken into account.

Waste composition is San Salvador region

Based on these information, methane potential have been calculated using the following formula:

---

[8] The maximum capacity of the site is 12.5 million tonnes.

$$L_0 = 1000 \text{ kg of waste (humid)} . d . (1 - o) . c . \%CH4 . \zeta . a$$

Where
d =   Fraction of organic matter in waste;
o =   Humidity content;
c =   Fraction of organic carbon in waste;
%CH$_4$ Methane content in landfill gas;
ζ =   Fraction of organic carbon transformed in landfill gas;
a =   Unit conversion factor.

The following values have been used for modelling purposes:

Factor	Value
d	61.1%
o	42.1%
c	45,0%
%CH$_4$	56,4%
ζ	0,7
a	1.868
L$_0$	**116.5**

Methane generation rate constant

Default value of 0.05 1/yr is used for most landfill in North America. In high humidity region such as equatorial region with rain season, a value of 0.06 is more suited. In bioreactor landfill this value can go as high as 0.1. Considering local characteristics of the Nejapa landfill: high temperature, high humidity content and leachate recirculation; a value of 0.075 has been chosen for the "k" factor.

Collection efficiency

Typical value of collection efficiency for a site with geotextile membrane and final cover is 75%. The following table summarize the collection efficiency used in the model as a function of site completion.

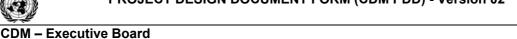| % Completion	% Collection
10%	68%
20%	68%
30%	70%
40%	71%
50%	72%
60%	73%
70%	73%
80%	73%
90%	73%
100%	**75%**

Modelling uncertainties

Modelling uncertainties has led project participants to reduce generation rate by 40% for conservativeness. Results obtained from the 2002 and 2003 (wet and dry seasons) field tests tend to corroborate these new estimates[9]. These tests consisted of surface sampling, subsurface migration, passive venting measurements and dynamic pumping.

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[9] BIOTHERMICA, "Construction d'une centrale électrique alimentée au biogaz au site d'enfouissement de Nejapa, Salvador", ACDI E4936-K061048, Livrable no.5, n/ref 3780.51, Montreal, December 11th 2003

II. **EMISSION RATE BASELINE**

Applies to CERs in 2004
Uses Data from Years 2002-2004
Resulting Baseline Emission Factor: 0.712 tCO2/MWh

A. Generation and Emission Rates by Unit for the Most Recent 3 Years[10]

Owner	Unit	Technology	Starting Year	Installed capacity (MW)	Type of Fuel	3-year net generation (MWh)	3-year CO2 emissions (tCO2)	3-year average emission rate (tCO2/MWh)
Duke Energy	Acajutla Unit 1	Steam Turbine	1967	30	Fuel Oil No. 6	56 358	61 884	1,098
Duke Energy	Acajutla Unit 2	Steam Turbine	1970	33	Fuel Oil No. 6	61 994	68 073	1,098
Duke Energy	Acajutla Unit 3	Gas Turbine	1992	38	Diesel	0	0	0,000
Duke Energy	Acajutla Unit 4	Gas Turbine	1994	38	Diesel	0	0	0,000
Duke Energy	Acajutla Unit 5	Gas Turbine	1994	82	Diesel	44 125	54 483	1,235
Duke Energy	Acajutla ICE 1	Internal Combustion	2000	99	Fuel Oil No. 6	1 510 613	1 013 377	0,671
Duke Energy	Acajutla ICE 2	Internal Combustion	2001	51	Fuel Oil No. 6	778 195	522 042	0,671
Acajutla Power Plant								
Duke Energy	Soyapango Unit 1	Gas Turbine	1972	18	Diesel	8 369	10 061	1,202
Duke Energy	Soyapango Unit 2	Gas Turbine	1972	18	Diesel	8 369	10 061	1,202
Duke Energy	Soyapango Unit 3	Gas Turbine	1974	22	Diesel	10 281	12 361	1,202
Duke Energy	Soyapango Unit 4	Internal Combustion	1974	15	Diesel	1 369	1 106	0,808
Soyapango Power Plant								
Duke Energy	San Miguel 1	Gas Turbine	1985	25	Diesel	1 607	2 088	1,299
Duke Energy	San Miguel 2	Internal Combustion	1992	7	Diesel	882	784	0,889
San Miguel Power Plant								
Total Duke Energy Power Plants								
Nejapa Power	Nejapa ICE 1	Internal Combustion	1995	91	Fuel Oil No. 6	1 568 870	1 213 018	0,773
Nejapa Power	Nejapa ICE 2	Internal Combustion	1998	54	Fuel Oil No. 6	922 358	713 148	0,773
Nejapa Power Plant								
CESSA	CESSA ICE 1	Internal Combustion	2001	19	Fuel Oil No. 6	339 966	244 343	0,719
CESSA	CESSA ICE 2	Internal Combustion	2001	13	Fuel Oil No. 6	237 268	170 531	0,719

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[10] THE MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES, EL SALVADOR AND THE PROTOTYPE CARBON FUND, "Electrical Power Sector Baseline Study for El Salvador", June 10 2003.

CESSA Power Plant								
TEXTUFIL	TEXTUFIL ICE1	Internal Combustion	2000	21	Fuel Oil No. 6	541 608	391 050	0,722
Textufil Power plant								
GESAL	AHUACHAPAN	Geothermal water-dominated system	1975 - 1980	95	Geothermal	1 476 028	0	0,000
GESAL	BERLIN	Geothermal water-dominated system	1992 - 1999	66	Geothermal	1 333 417	0	0,000
GESAL Geothermal Power Plants								
CEL	GUAJOYO	Storage	1964	20	Hydro**	139 590	0	0,000
CEL	CERRON GRANDE	Storage	1979	135	Hydro**	1 023 644	0	0,000
CEL	5 DE NOVIEMBRE	Run of River	1956	84	Hydro**	1 205 859	0	0,000
CEL **CEL Hydroelectric Power Plants**	15 DE SEPTIEMBRE	Run of River	1983	157	Hydro**	1 383 279	0	0,000

Total Capacity: 1 229 MW

B. Calculate Operating Margin Value

Weighted average of all units except must-run/low-cost units   **0,737**   tCO2/MWh

C. Calculate Build Margin Value

Generation of most recent 5 units   1 073 235   MWh
Most recent 20% of existing plants   879 558   MWh

Weighted average of most recent 5 units   **0,687**   tCO2/MWh

D. Calculate Combined Margin Value

0.712
[11]   tCO2/MWh

Annex 4

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[11]THE MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES, EL SALVADOR AND THE PROTOTYPE CARBON FUND, "Electrical Power Sector Baseline Study for El Salvador", November 9, 2005 Revision.
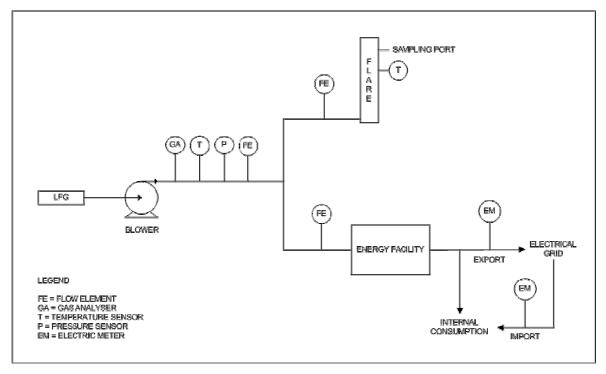
MONITORING PLAN

Phase I – LFG Collection and Flaring System (Methane Recovery)

Emission reductions will be based on measured quantities of methane actually destroyed in the flare and engines as well as on the amount of electricity exported to the grid. The approach described in section D.2.4 will be use to determine the following variables: the total amount of landfill gas captured $(LFG_{total,y})$, the amount of landfill gas fed to the flare and engine $(LFG_{flare,y}, LFG_{electriciy,y})$, the fraction of methane in the landfill gas (w_{CH4}), the gas density $(D_{CH4}, through\ temperature\ and\ pressure\ measurements)$, the flare efficiency (FE) and the amount of electricity exported to the grid (EG_y). Before Phase II is operational, the amount of electricity imported from the grid will also be monitored.

To conduct these measurements, three (3) continuous flow meters (that displays the gas flow in cubic meter per minute or alternate units[12]) will be installed on the recovery system: one at the blower, one at the flare and one at the energy facility. Using this type of instrument requires the use of pressure and temperature instrument as well. A flow tranquiliser will be installed in front of each of the flow meter to reduce the turbulence thus increasing the accuracy.

A gas analyser (Servomex, Maihak or equivalent) will also be installed at the blower location, in order to measure the methane content of the LFG (% CH_4 v/v) on a dry basis.

Monitoring instruments

An electric meter will measure the daily electric consumption imported from the grid (in MWh).

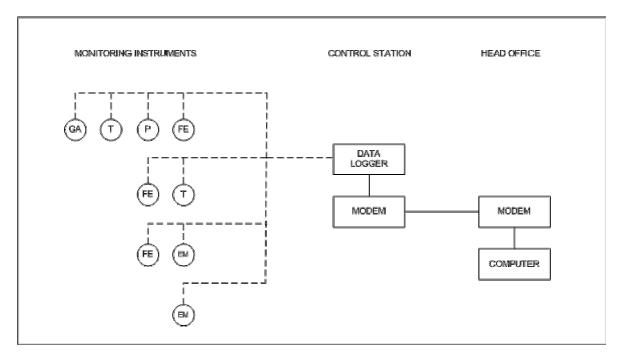[12] The LFG flow meter can record flowrates in multiple data units, i.e. m^3/min or m^3/h, etc. The most practical data unit for this project will be selected during commissioning of the various systems.

Based upon Biothermica's experience, the error based on repeatability of these instruments is relatively low 1.5% for the flow meter and 1% for the gas analyser.

The LFG flow and methane-content data will be continuously recorded (an interval of four minutes being necessary for the instrument to analyse the gas sample). All monitored data (see Table D.2.2.1) will be archived in a database. A telemetric (modem) link will allow the project participant, and/or the CER buyers, to have access to this data at any time.

Telemetric link

The monitoring methodology for the methane recovery component of the project (Phase I) will remain the same when the subsequent Phase (Phase II) is implemented. The total flow of methane from the collection system will be combusted regardless of the technology used.

In Phase I, combustion of methane will occur exclusively at the flare unit. In Phase II, a portion of the LFG will be diverted to the engines at the Energy Facility to generate electricity. However, since the engines will not use all the LFG available from the landfill, the remaining gas will still be combusted at the flare unit.

In Phase II of the project, emission reductions will be based on the amount of energy produced by LFG (in MWh). As such, monitoring techniques have been adapted and are detailed in the following paragraph. Recording and archiving methods remain the same as those specified for Phase I.

Phase II monitoring methodology involves the use of a single type of instrument. An electric meter will measure the daily electric generation delivered to the grid (in kWh) by each engine. One reading at the end of each day is sufficient to account for the cumulative kWh produced. This type of instrument is usually regulated by governmental agencies and widely used for billing purposes. Measurements errors are considered negligible. Reset is usually done annually.

All relevant regulations for LFG project will be monitored. The adjustment factor (AF) will be updated according with the specifics of the new regulation.

Operational and management practices needed to implement the monitoring plan have been described in section D.4.