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

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ANNEXES

SECTION A. General description of project activity

A.1 Title of the project activity:

Regional landfill projects in Chile
Version 8 - 17 /01/2008

A.2. Description of the project activity:

The project activity is to build, operate and maintain a landfill gas (LFG) collection and flaring system on three selected landfill sites in Chile:

- el ex-vertedero de Lajarilla , hereunder referred to as "Lajarilla landfill" ;
- el vertedero Viñita Azul en Copiapo , hereunder referred to as "Viñita Azul landfill";
- el relleno sanitario de Leña Dura, hereunder referred to as "Leña Dura landfill";

The location details of these landfills are provided in section A4 on next page.

The project aims at designing, building and operating a highly efficient landfill gas (LFG) collection and flaring system to burn the landfill gas collected on each of the selected sites.

The project scope on each site will include:

- the design and engineering of the extraction system according to the most modern standards, including an optimised and efficient network of vertical wells (with a typical density of 5 wells per hectare) connected to a suitably sized main surface collector, which will feed the LFG collected to a flare.
- the delivery, installation and exploitation of the most modern equipment, comprising a high efficiency enclosed flare and its associated measurement and monitoring equipment. This state-of-the-art equipment is chosen for its efficiency and reliability, and is compliant with the most stringent regulations applicable, as well as the CDM approved methodologies applicable.
- It is the intention of the project proponent to reshape, and eventually cover the closed landfills in order to maximize the LFG capture rate.

At a later stage, the landfill gas collected may be used as fuel for electricity generation. The feasibility of electricity generation will be revisited once the project is fully operational, and it is therefore not part of the project activity presented in this PDD.

The proposed project would increase the current capture, treatment and flaring or otherwise burning of the landfill gas, which contains typically about 50% of methane, a very powerful green-house gas (GHG). Hence the capture and destruction of this methane content will result in very significant GHG emission reductions:
Based on investigations and calculations the project will achieve more than 702,986 tCO_2eq over the period 2008 – 2018.

Besides climate change mitigation, the project would have important local environmental benefits. Currently, most of the landfill gas is released into the atmosphere without any treatment or control. This implies a potential fire and explosion risk as well as bad odours. Moreover, landfill gas contains trace amounts of volatile organic compounds, which are air pollutants. The capture and flaring of landfill gas

would greatly reduce all these risks and thereby contribute to sustainable development.

The Project will have very little or no negative impact on the environment: it does not use any scarce resources (like fuel or water), nor does it produce any waste or emissions to water and soil. The only noticeable impact will be the noise generated by the compressors and flare in operation, but the noise level is low, and will not be a nuisance for the local population.

The project will also have a small, but positive impact on employment in the local area as a number of staff will need to be recruited to manage the landfill gas capture operations.

More generally, on each site, the project will greatly enhance the awareness to the benefits of a proper management of waste, and demonstrate that environment preservation can also create jobs and wealth for the local community. Moreover, the local stakeholders will participate in improving their own environment, and being better informed of the key environmental issues the solutions that landfill gas techniques can bring, and how they can use them.

The project will also have several positive effects on the regional economic situation, by way of:

- Financial contribution to local communities,
- Hiring and training of local employees,
- Transfers of know-how, directly by training, or indirectly through the visibility of the Project and its interest as a successful local environmental initiative,
- Increased awareness to environmental issues (e.g. by organising site visits by academics and students) and how they can create economic opportunities,
- Emergence of local suppliers of equipment and local competitors launching their own business, using the project as a benchmark.

A.3. Project participants:

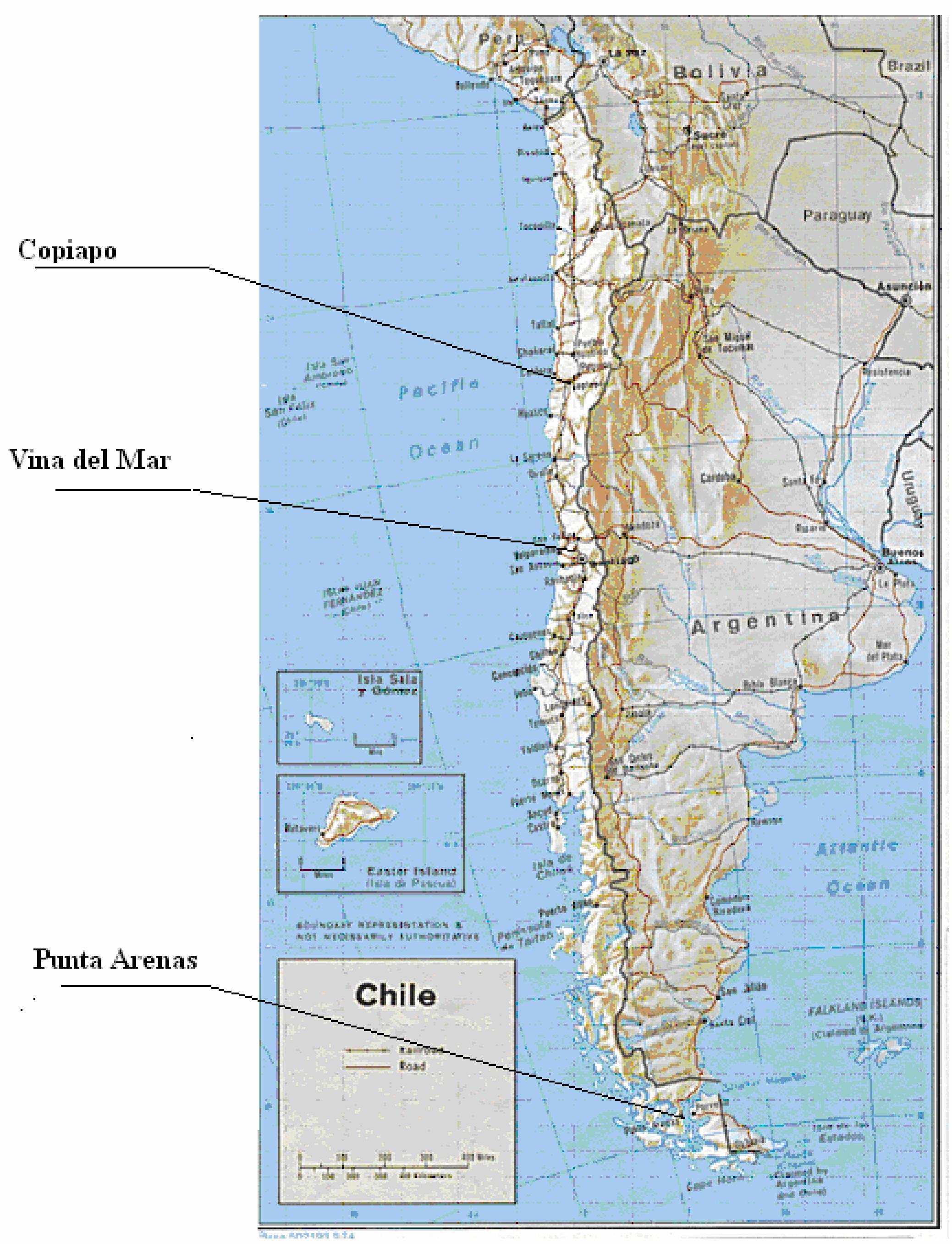
Name of Party involved	Private and/or public entities Project Participants	Does the Party involved wish to be considered as a Project Participant
Chile (Host country)	Sistemas de Biogases Bionersis Chile Ltda (private entity)	No
France	Bionersis S.A. (private entity)	No

Please refer to Annex 1 for detailed information on project participants.

A.4. Technical description of the project activity

A.4.1. Location of the project activity:

The project activity will be carried out on three locations in Chile as shown on map below.



A.4.1.1. Host Party:

The host country is Chile.

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

The Lajarilla landfill is located in Chile Region V
The Viñita Azul landfill is located in Chile Region III
The Leña Dura landfill is located in Chile Region XII

A.4.1.3. City/Town/Community etc:

The Lajarilla landfill is located within the boundaries of the city of Viña del Mar.
The Viñita Azul landfill is located within the boundaries of city of Copiapo
The Leña Dura landfill is located within the boundaries of the city of Punta Arenas

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

- **Lajarilla landfill - Viña del Mar (Region V):**

This landfill is designated locally as "el ex-vertedero de Lajarilla".
This landfill is located at km 10.7, Ruta 50, Antiguo Camino a Con Con, zona Cerro Torquemada, Viña del Mar.
Its geographic coordinates are 32°57 South, 71°30 West
It is a closed engineered landfill, managed by the municipality.

- **Viñita Azul landfill – Copiapo (Region III):**

This landfill is designated locally as: "el vertedero Viñita Azul en Copiapo"
This landfill is located at km 11 Carretera Sur, Viñita Azul Sector.
Its geographic coordinates are 27°27' South, 70°20' West.
It is an engineered landfill, managed by the municipality.

- **Leña Dura landfill – Punta Arenas (Region XII):**

This landfill is designated locally as: "el relleno sanitario de Leña Dura"
This landfill is located at Km 5, Carretera Sur Sector Leña Dura, Punta Arenas, Region XII.
Its geographic coordinates are 53°13' South, 70°56' West.
It is an engineered landfill, managed by the municipality.

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

The project belongs to Category 13: Waste handling and disposal.

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

The project activity is based on a landfill gas ("LFG") collection and flaring system, compliant with EU and Chile regulations. The equipment which will be used in this project activity on each of the three selected sites includes mainly:

- A gas collection network, permeable pipes, and gas wells
- A high temperature enclosed flare (Temperature = 1000°- 1200°C, retention time> 0.3s)
- monitoring and control systems to measure the actual flow and composition of the LFG,
- civil works,
- a composite or earth landfill cover installed over the entire dump and thus enabling to optimise the landfill gas recovery rate.

The project design engineering reflects current good practices for leachate infiltration.
LFG collection system installed is on:

- old waste body in Lajarilla
- old waste body in Viñita Azul
- old waste body, as zones get covered, in Leña Dura

The LFG collection system is composed of a network of wells and pipes interconnected pipes, and a depression is created in the system producing suction for the extraction of the LFG.
The LFG extracted is fed into a high temperature flare which enables 100% of the methane contained in the LFG to be completely oxidized by the flaring process.
The plants are equipped with a monitoring system to measure the flow, the pressure and the temperature.
The plants are connected to the public electric network to satisfy their own energy needs.
The operators will be qualified to carry out maintenance and control activities and they will have the support of an aid telephone line and experts will be in charge of maintenance whenever necessary.
The project activity is currently limited to the destruction of the LFG collected (project phase 1), however the possibility of generating electricity and delivering it to the local grid will be considered at a future stage (project phase 2) and as soon as it will be economically viable.

We will use the HOF*GAS*® extracting and flaring station that has been developed by the Swiss Hofstetter Umwelttechnik company, which is regarded commonly as one of the world's leading companies in landfill gas flaring solutions.

We would then use the complete extracting + flaring unit with the following particulars:

- the complete degassing unit is built in a ventilated container, providing securities against any weather or burglary risks and which would prove beneficial for noise reduction;
- safe and low emission combustion is guaranteed by a high temperature flare;
- safety devices:
  - EEX motor;
  - flame arrester;
  - slam shut valve;
  - burner control with UV detector.
- gas flow rate could be anything between 40 and 2,500 Nm^3/h, with associated burners between 200 and 12,500 kW.

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

The capture and combustion of the CH_4 component of the LFG in the project is the extraction and combustion of the LFG generated in the landfill sites. The main component of the LFG is CH_4, also known as methane, (representing about 50% of the content of the LFG) which is a greenhouse gas, 21 times more powerful than CO_2. Therefore, flaring the LFG, and thus destroying the CH_4 contained in the LFG, results in reducing emissions of a very harmful Greenhouse Gas (GHG).

In Chile, the technical, legal, economic and financial conditions are such that no LFG collection and destruction is occurring, resulting in continuous uncontrolled emissions of LFG into the atmosphere.

The capture and combustion of the CH_4 component of the LFG in the project activity would prevent 702,986 tonnes of CO_2 from spreading into the atmosphere over the fixed crediting period of 10 years, which is a CER crediting period consistent with the production period planned for the three sites included in the Project. The project will generate a reduction of greenhouse gas emissions that can be estimated as follows:

	Emission Reductions (tons CO_2eq)			
	Lajarilla	Leña Dura	Viñita Azul	**TOTAL**
2008	38,664	21,316	15,305	**75,285**
2009	38,131	24,360	15,243	**77,734**
2010	36,265	26,590	14,641	**77,496**
2011	34,491	28,797	14,062	**77,350**
2012	32,802	27,389	13,505	**73,697**
2013	31,197	26,050	12,971	**70,217**
2014	29,669	24,775	12,458	**66,902**
2015	28,216	23,563	11,964	**63,744**
2016	26,834	22,410	11,490	**60,735**
2017	25,519	21,314	11,035	**57,868**
2018	859	721	378	**1,958**
				702,986
Total number of crediting years				10
Annual average over the crediting period of estimated reductions (tons of CO_2eq)				**70,299**

At a later stage, the LFG may be used as a fuel for electricity generation but the emission reductions due to this future energy displacement are not considered in the present document.

A.4.5. Public funding of the project activity:

There will be no public funding, under any form, for the proposed CDM project. It will be financed exclusively by private capital. Please refer to annex 2 for further details.

SECTION B. Application of a baseline and monitoring methodology

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

ACM0001 version 5, "*Consolidated baseline methodology for landfill gas project activities*", has been applied to this project.

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

The *Consolidated baseline methodology for landfill gas project activities* ACM001 (version 05) is applicable because the current situation on all three sites included in the project (baseline scenario) is the total atmospheric release of the gas and the project activity is the flaring of the captured gas.

Hence, the project meets the applicability criteria described in the *consolidated methodology for landfill gas project activities.*

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

	Source	Gas	Included	Justification/Explanation
Baseline	Electricity for infrastructure	CO_2	No	Baseline and Project Activity emissions are the same
		CH_4	No	Baseline and Project Activity emissions are the same
	Methane emissions from decomposition of organic waste	CO_2	No	Baseline and Project Activity emissions are the same
		CH_4	**Yes**	**Main source of GHG on the landfill**
Project	Electricity for infrastructure	CO_2	No	Baseline and Project Activity emissions are the same
		CH_4	No	Baseline and Project Activity emissions are the same
	Additional electricity from grid for blower and flare system	**CO_2**	**Yes**	**Vinita Azul and Lajarilla use grid electricity**
		CH_4	No	Not Relevant
	Additional electricity from generator for blower and flare system	**CO_2**	**Yes**	**Leña Dura uses a dedicated diesel generator**
		CH_4	No	Not Relevant
	Methane emissions from decomposition of organic waste	CO_2	No	Baseline and Project Activity emissions are the same
		CH_4	**Yes**	**Methane that is not captured by the collection network**
	Methane emissions from flare	CO_2	No	Baseline and Project Activity emissions are the same
		CH_4	**Yes**	**Methane not burned due to flare efficiency correction**

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

In Chile, the technical, legal, economic and financial conditions are such that generally no LFG collection and destruction is occurring, even though some landfills are equipped of passive ventilation wells for the purpose of preventing potentially dangerous LFG concentration inside the landfill[1].

Based on this analysis, the baseline scenario describes an uncontrolled and continuous emission of LFG into the atmosphere; since the passive ventilation wells existing in some landfills would have to be completed by a strict routine of control and combustion of the collected LFG, which currently does not occur, to result in any significant reduction of LFG emissions.

Moreover, to account for the occurrence of spontaneous combustion, or occasional lighting of fires at the passive ventilation wells, a conservative adjustment factor of 4%[2] has been used in the calculations.

Please refer to annex 3 for further details.

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):

Additionality determination is done by using the CDM "*Tool for the demonstration and assessment of additionality*" version 03.
We do not apply step 3 (Barrier Analysis), which is optional and not necessary in our case, since step 2 (investment analysis) shows a clear conclusion.

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

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

Alternative 1: Continuation of the current situation.
On each of the three sites comprised in the Project, the landfill operator continues to maintain the existing equipment and the usual practice of venting (i.e., not actively or efficiently collecting and flaring) and takes action only to ensure local safety in accordance with the exploitation plan or closure plan approved by the Ministry of Health. Since there is currently no controlled capture and destruction of methane at the three landfill sites of the Project, and no regulation will require such capture and destruction in the foreseeable future, the release of the landfill gas directly into the atmosphere would continue.

Alternative 2: Improved landfill gas capture and flaring system
On each of the three sites comprised in the Project, the landfill operator improves the existing equipment by way of investing into a new landfill capping with an active landfill gas collection and destruction

[1] Inspection report from environmental consulting firm Inversiones88

[2] Refer to Annex 3 for details of the determination of the adjustment factor

system. This scenario corresponds to the Project activity not undertaken as a CDM project. This scenario involves significant investment and additional costs of landfill operations with no associated revenues.

Alternative 3: Utilization of landfill gas for generation of electricity
For generation of electricity, an initial investment is needed to collect the biogas from the landfill. After that, a substantial additional investment is needed for gas treatment, electricity generation system and connection to the grid.
Alternative 3 might be technically feasible but currently is not economically attractive. The expected revenue from electricity sales does not cover the additional costs incurred (depreciation, financing costs, added costs resulting from increased complexity of operations) in relation to electricity generation and grid connection.
Furthermore, it has to be noted that the electricity generation also adds considerable delays, because of the mandatory in-depth technical studies and lengthy regulatory process involved before delivering power to the grid. In the meantime, landfill gas emissions would continue unabated.

We determine the economic feasibility of a LFG-based power generation in the absence of the CDM.
Our analysis is based on the following assumptions:

1. The investments required to capture LFG remain basically the same as for the CDM project investments. These include the construction of the capture network, landfill cover, blowers, etc. to collect the LFG and feed it to the generators.
To be conservative, we excluded the investment required for a flare: We assume that when the power plant is not operating, the collected LFG would be vented, since there would be no reason to destroy the methane in the absence of the CDM. This improves the economic feasibility of this alternative scenario.
The size of generator installed on each site would vary depending on the volumes of LFG available on each site, throughout the life time of the plant:

- Two 1030 kW LFG generator would be purchased, respectively for Leña Dura and Lajarilla, at a cost of 550,000 € each
- One 600 kW LFG generator would be purchased for Viñita Azul at a cost of 350,000 €
- Each site would also require a gas treatment unit, to clean the LFG before it is fed into the generators, and a connection to the grid, to deliver the electricity generated, as well as engineering and installation costs.

The total investment would be 4,560,000 € in 2007. This equipment would be operational from 2008 for a period of 15 years (maximum expected life time for such LFG generation units).

2. Operation and maintenance cost are estimated at 0.023 € per kWh. Small, internal combustion engines have high operation and maintenance costs. Equipment will be imported from Europe. There is no experience in Chile with power generation using LFG equipment for such small capacity generation. Thus, we feel this value is conservative.

3. The electricity sale price (levelized) is 40 € per MWh (at prevailing exchange rate), for sale to the grid. There are no official projections for electricity prices, determined by market forces in Chile. A long range marginal cost for power made available to the grid may be estimated from the cost of power generation using new, coal-fired power plants, about 0.037 $ per kWh. While current wholesale power prices are higher, since there is a power shortage, we feel that 0.05 $ is a conservative value over the life of the project.

4. The corporate tax rate in Chile is17%.

5. Discount rate: 10%. Note that 10-year bonds of the Chilean government are currently offered at an interest rate of 6.16% as of Nov 2007 (http://www.bcentral.cl/eng/economic-statistics/series-indicators/index_ms.htm Interest Rates on Central Bank of Chile Instruments, 1990.xls, cell X222). For a small or medium-sized company borrowing a relatively small amount of money, the applicable interest rate is likely to be about 5% higher. Considering the risks of this new technology as well as the risks in effective biodegradation of waste and effective methane capture, another 2% may be added. Thus an appropriate benchmark rate for this type of investment would be 13.16%.
The chosen benchmark discount rate of 10% is therefore conservative.

For the assumptions stated above, the IRR for LFG capture and electricity generation is +0,1%, in the absence of the CDM.
Even if electricity sale prices were 20% higher, the IRR would be 5.1%, still considerably below the benchmark discount rate. Similarly, if investment requirements or O&M costs were 20% lower, the IRR would increase to 1.13% and 3.18%, considerably below the benchmark discount rate of 10%.

Overall, this Alternative is not realistic for financial/economic reasons

Alternative 4: Utilization of landfill gas for supply of heat or steam

There is no industry to which heat or gas could be supplied nearby the three landfill sites. There is no industrial demand for steam, therefore no potential market for steam usage in the region of any of the landfills.

Therefore this scenario is not realistic and will not be reviewed any further in the following steps (not a plausible baseline scenario or part of a baseline scenario).

Alternative 5: Utilization of landfill gas for co-generation of electricity and heat or steam
This scenario is basically a combination of Alternative 3 and 4.
There is no industry to which heat or gas could be supplied nearby the three landfill sites. There is no industrial demand for steam, therefore no potential market for steam usage in the region of any of the landfills.
Therefore this scenario is not realistic and will not be reviewed any further in the following steps (not a plausible baseline scenario or part of a baseline scenario).

Outcome of sub-Steps 1a: identified realistic and credible alternative scenario(s) to the project activity

The identification of alternatives to the project activity identifies 2 realistic and credible alternative scenarios:

- Alternative 1: Continuation of current situation
- Alternative 2: Improved landfill gas capture and flaring system, without CDM

All other alternatives are either technically or commercially unrealistic or both.

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

Currently, all the alternatives listed in sub-step1.a. meet the requirements of Chilean law, because the law regulating landfills only establishes general conditions for operation, including closure of the landfills concerned.
In general terms, it establishes requirements for all operational aspects of the landfills, including biogas and leachate treatment. The conditions for later stages are general to prevent hazardous situations, like

the installation of wells to release biogas. However, it does not establish specific characteristics for the wells, which is left to the operator of the landfill under previous authorization of the health authorities. Therefore, estimating the rate of efficiency of biogas collection is difficult, although according to those standards, it should be low.
Chile is evaluating a new law that establishes clearer conditions for the development and operation of landfills. This new law is still being debated and it is estimated that no final decision will be made for a few years. However, the possibility of future rules does not need to be taken into account here, as this sub-step does not consider national and local policies that do not have legally-binding status.

Outcome of sub-Steps 1b.

The only realistic, economically attractive and credible alternatives that are in compliance with mandatory legislation and regulations taking into account the enforcement in the region or country and EB decisions on national and/or policies and regulations are:

- Alternative 1: Continuation of current situation
- Alternative 2: Improved landfill gas capture and flaring system, without CDM

We now proceed to Step 2 - Investment analysis, for in-depth review of the proposed project activity.

Step 2. Investment analysis

Sub-step 2a. Determine appropriate analysis method

In accordance with the recommendations from the tool for determination of additionality, the simple cost analysis has to be used for the assessment of the proposed project activity - gas capture and flaring - because it generates no financial or economic benefits other than CDM related income, on all three sites comprised in the project.

Sub-step 2b. – Option I. Apply simple cost analysis

Analysis of the Project Activity
We document hereunder the costs associated with the CDM project activity in order to demonstrate that the activity produces no revenues other than CDM related income.
On all three sites involved in the project, the proposed project activity represents a significant investment in an optimised gas collection network, plus an appropriate covering of the landfill with reliable and efficient flaring equipment.

The investment necessary to develop the proposed Project activity will amount to 2,265,000 € in total for the three sites comprised in the project, while the costs of operation and maintenance of the new system can be estimated around 302,450 € annually.

The following table summarizes the financial costs associated with the proposed project activity, in terms of investment, and in terms of additional operating costs.
The Total Project column is the total of the three sites comprised in the proposed project.
All amounts are in Euros, unless otherwise specified.

Investment summary		**Lajarilla**	**Viñita Azul**	**Leña Dura**		**Total Project**
Gas capture		230,000	150,000	220,000		600,000
Landfill cover		330,000	160,000	470,000		960,000
Flare+blowers		175,000	164,000	216,000		555,000
Electricity Generator		-	-	15,000		15,000
Civil works		57,500	50,000	59,500		167,000
Total equipment + works		**792,500**	**524,000**	**980,500**		**2,297,000**
Engineering & project mgmt		120,000	100,000	148,000		368,000
Total investment cost		**912,500**	**624,000**	**1,128,500**		**2,665,000**
Operations summary						
Maintenance & Admin		79,000	52,000	96,650		227,650
Electricity – Grid		18,900	18,900			37,800
Electricity – Generator				37,000		37,000
Total yearly operations cost		**97,900**	**70,900**	**133,650**		**302,450**
Notes:						
1. Civil works include connection to the power grid and installation of dedicated electricity meters for Lajarilla and Viñita Azul						
2. Yearly consumption of the blower : 420 MWh; grid electricity price : 45€/MWh						

The proposed Project activity, without CDM, cannot generate any revenue or economic benefit, because it aims at capturing the landfill gas only to destroy it, and this process yields no by-product of any economic value (the heat generated by combusting the gas is dissipated into the atmosphere, via the flare).

The absence of any revenue deriving from the Project activity to cover the additional investment and operating costs clearly demonstrates that the Project activity cannot be developed without the CDM related income.

Outcome of Step 2

The proposed CDM project activity is not financially attractive (and hence would not be developed) in the absence of CDM related income.

We can now proceed to Step 4 (Common practice analysis).

Step 4. Common practice analysis

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

The current Chilean national legislation does not require landfills to collect and destroy the gas generated. So far, only a few landfills in Chile have incorporated technical devices to collect and partially flare the gas generated.
When landfill gases are collected, it is done for safety reasons, to avoid explosions and fires, and the volumes effectively collected and destroyed are insignificant.
Hence, investments done with this purpose are so far negligible and based on very low level technology (passive venting, no reliable combustion system), with a few exceptions (which are all CDM projects).

The table below presents an overview of the current practice in Chile. This overview is based on the latest available data on Chilean landfills (source: Ecoamérica, March 2006, Primer Cadastro de Sites de Disposicion Final, Gestion y Tratamiento de Residuos Solidos).

LANDFILLS CHILE						
Regio	Name landfill	Location	Biogas recollection system	Chimney	Flare	CDM
I Region	Camiña	Iquique	yes	no	no	no
	El Boro	Iquique	yes	yes	no	no
	Pica	Iquique	yes	yes	no	no
II Region	Calama	Tocopilla	no	yes	no	no
	Radomiro Tomic	Calama	yes	yes	no	no
	Sociedad Chilena del Lilio	Salar de Atacama	no	no	no	no
III Region	Diego De Almagro	Chañaral	yes	yes	no	no
IV Region	Andacollo	Elqui	no	no	no	no
	Rio Hurtado	Limari	yes	no	no	no
	Ovalle	Ovalle	yes	no	no	no
V Region	La Hormiga	San Felipe	yes	yes	no	no
	Puchuncavi	Valparaiso	yes	yes	no	no
	El Molle	Con Con	no	no	no	no
VI Region	Colihues- La Yesca	Cauquenes	no	no	no	no
	Las Quilas	Pichilemu	yes	yes	no	no
	Vichuquen	Vichuquen	no	no	no	no
VII Region	Ecomaule	Rio Claro	yes	yes	no	no
	El Retamo	San Javier	no	no	no	no
	La Lloica	Linares	no	no	no	no
VIII Region	Vertedero La Mancha	Cabrero	yes	yes	no	no
	Vertedero San Ignacio	Chillán	yes	no	no	no
	Mulchen	Mulchen	yes	yes	no	no
	Cosmito	Concepción	yes	yes	yes	yes
	Playa Negra	Coronel	yes	yes	yes	yes
	Copiulemu	Chaimavida	yes	yes	yes	yes
IX Region	Vertedero de Lumaco	Lumaco	no	no	no	no
	Vertedero de Victoria	Victoria	no	no	no	no
	Freire	Freire	yes	no	no	no
X Region	Vertedero Quilche	Panguipulli	yes	no	no	no
	Vertedero Morrompulli	Valdivia	yes	yes	no	no
	Vertedero Paillaco	Paillaco-Valdivia	yes	no	no	no
XI Region	Vertedero Puerto Aguirre	Aisén	no	no	no	no
	Vertedero Puluhuapi	Aisen	no	no	no	no
	El toqui	Mañihuales	yes	no	no	no
XII Region	Puerto Eden	Puerto Natales	no	no	no	no
	Vertedero Leña Dura	Punta Arenas	yes	no	no	no
	Vertedero Cameron	Porvenir	no	no	no	no
RM	Melipilla	Melipilla	yes	yes	no	no
	Lepanto	santiago	yes	yes	yes	yes
	Vertedero Popeta	Melipilla	no	no	no	no
	Santiago Poniente	Maipú	yes	yes	no	no

Source ECOAMERICA, March 2006
Primer Catastro de Sitios de Disposición Final, Gestión y Tratamiento de Residuos Sólidos

As demonstrated, some LFG capture and flaring projects are under development; however these are all being developed under the CDM. This fact emphasizes that without carbon revenue, development of these projects would not take place, and they are therefore not relevant to the common practice analysis. At all other landfill sites in Chile, the current practice is either no flaring, or uncontrolled flaring of some of the gas.

There are some preliminary plans to install efficient capture and flaring systems for other landfills, but these are all in the context of CDM. No examples exist in Chile of landfills that have been closed down that have an active gas capturing system

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

Where other similar projects are planned, these are all to be developed under the CDM. This does not call into question the claim that the proposed project activity is financially unattractive without the CDM.

Outcome of step 4a and 4b:

Activities similar to the proposed Project activity can be observed only on a very minor scale, for different purpose (avoiding explosions and fires) using low level technology with insignificant results in terms of GHG emission reductions. These are essential differences with the proposed project activity.

The proposed project activity is therefore additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

We use **ACM0001 (version 05) "Consolidated baseline methodology for landfill gas project activities"**

Justification:
The ACM0001 methodology is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:
a) The captured gas is flared; or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or
c) The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the ACM0002 "Consolidated Methodology for Grid-Connected Power Generation from Renewable". If capacity of electricity generated is less than 15MW, and/or thermal energy displaced is less than 54 TJ (15GWh), small-scale methodologies can be used.

The Project Activity meets condition a)

The other methodological tools used are:
"Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" (Version 01)
"Tool to determine project emissions from flaring gases containing methane"

AMS-I.A and AMS-I.D

As specified by the methodology the emission reduction of CO_2e shall be calculated as follows:

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

Where:

ER	- Emission reduction in a given year y, in tonnes of CO_2 equivalent (tCO_2e)
$MD_{project,y}$	- The amount of methane that would have been destroyed/combusted by the project activity during the year, in tonnes of methane (tCH_4);
$MD\ MD_{reg,y}$	- the amount of methane that would have been destroyed/combusted during the year in the absence of the project, in tonnes of methane (tCH_4)
GWP_{CH4}	- Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4
$EL_{,y}$	- Net quantity of electricity exported during year y, in megawatt hours (MWh).
$CEF_{electricitry,y}$	- CO_2 emissions intensity of the electricity displaced, in tCO_2e/MWh. Since the capacity is within the small scale threshold values, this will be estimated using AMSI.D when grid electricity is used, or AMS-I.A when captive electricity from a generator is used.
ET_y	- incremental quantity of fossil fuel, defined as difference of fossil fuel used in the baseline and fossil fuel used 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

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

Where:

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

In this specific project there will be no electricity export during phase 1: $EL_{EX,LFG} = 0$

Therefore, $EL_y = EL_{EX,\,LFG} - EL_{IMP,y} = EL_{PR,,y}$

Where:

$EL_{PR,y}$ Quantity of electricity consumed by the project activity during year y, in MWh.

In this specific project there will be no fossil fuel used for thermal energy : $ET_y = 0$

As a result, ER calculation can be simplified as:

$$(1b)\ ER = (MD_{project\,y} - MD_{reg\,y}) * GWP_{CH4} - EL_{PR,y} * CEF_{electricitry,y}$$

On these landfills, there are no regulatory or contractual requirements specifying $MD_{reg,y}$, the amount of methane that would have been destroyed/combusted during the year in the absence of the project, in, tonnes of methane (tCH_4) *therefore* an "Adjustment Factor"(AF) will be used. The value of the adjustment factor (4%) is a conservative value estimated according to the current context of the landfills.[3]

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

Since there is no methane destroyed for electricity or thermal energy generation, all the methane destroyed is the one destroyed by flaring:

$$(3)\ MD_{project\,y} = MD_{flare,\,y}$$

Where:
$MD_{flare,\,y}$ is the quantity of methane destroyed by flaring in year y (measured in tCH4)

According to the equation (3a) and (4) of the ACM0001 / version 5 and considering the project will not generate any electricity, $MD_{flare,,y}$ can be calculated as follows:

$$(3b)\ MD_{flare,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) - (\frac{PE_{flare,y}}{GWP_{CH4}})$$

Where:

$LFG_{flare,y}$	Quantity of landfill gas flared during the year measured in cubic meters (m^3)
$W_{CH4,y}$	Average methane fraction of the landfill gas
D_{CH4}	Methane density expressed in t_{CH4}/m^3_{CH4}
$PE_{flare,y}$	Emissions from flaring of the residual gas stream in year y
GWP_{CH4}	Global Warming potential of CH_4

$PE_{flare,y}$ is calculated according to "the tool to determine project emissions from flaring gases containing methane", according to the following steps:
STEP 1: Determination of the mass flow rate of the residual gas that is flared
STEP 2: Determination of the mass fraction of carbon, hydrogen, and nitrogen in the residual gas
STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis
STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency

[3] Cf Annex 3 for details on the estimation of the Adjustment Factor

Step 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiency.

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

$$PE_{flare,y} = \sum TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1000}$$

Where:

PEflare,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
GWP_{CH4}	tCO_{2e}/tCH_4	Global Warming Potential

$\eta_{flare,h}$ is the hourly efficiency of the flare.

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

Where:

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*

$TM_{FG,h}$ and $TM_{RG,h}$ will be calculated applying the equations below:

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1000000}$$

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n}$$

Where:

$TM_{FG,h}$	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 the hour *h*
$TM_{RG,h}$	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 the hour *h*
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to fvi,RG,h where *i* refers to methane)
$\rho_{CH4,n}$	kg/m^3	Density of methane at normal conditions (0.7168)

Considering that the mass fraction of carbon, hydrogen and nitrogen of the residual gas ($fm_{j,h}$) can be calculated as follows:

$$fm_{j,h} = \frac{\sum_i fv_{i,h} * AM_j * NA_{j,i}}{MM_{RG,h}}$$

Where:

Variable	SI Unit	Description
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
$fv_{i,h}$	-	Volumetric fraction of component *i* in the residual gas in the hour *h*
AM_j	kg/kmol	Atomic mass of element *j*
$NA_{j,i}$	-	Number of atoms of element *j* in component *I*
$MM_{RG,h}$	kg/kmol	Molecular mass of the residual gas in hour *h*
j	The elements carbon, hydrogen and nitrogen	
i	The components CH_4, N_2	

Note: as a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N2).

$TV_{n,FG,h}$ is calculated as follows:

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h}$$

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*

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

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

$$V_{n,0_2,h} = n_{0_2,h} * MV_n$$

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 of O_2 in the exhaust gas of the flare per kg of residual gas flared in hour *h*
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)

$$V_{n,N2,h} = MV_n * \left\{ \frac{fm_{N,h}}{200 AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) * \left[F_h + n_{O_2,h} \right] \right\}$$

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}	-	Volumetric fraction of O_2 in the air (0.21)
Fh	kmol/kg residual gas	Stoichiometric 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*

$$V_{nCO2,h} = \frac{fm_{C,h}}{AM_c} * MV$$

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)

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

Where :

Variable	SI Unit	Description
$n_{O2,h}$	kmol/kg residual gas	Quantity of moles of O_2 in the exhaust gas of the flare per kg of 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)
Fh	kmol/kg residual gas	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg of residual gas in hour *h*
$fm_{j,h}$	-	Mass fraction of element *j* in the residual gas in hour *h*
AM_j	kg/kmol	Atomic mass of element *j*
J		The elements carbon (index C) and nitrogen (index N)

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

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*
AM_j	kg/kmol	Atomic mass of element *j*
J		The elements carbon (index C), hydrogen (index H), Oxygen (index O)

And $FM_{RG,h}$ will be calculated as follows:

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1000000}$$

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/m^3	Density of the residual gas at normal conditions in hour *h*
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} * T_n}$$

Where:

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

$$MM_{RG,h} = \sum \left(fv_{i,h} * MM_i \right)$$

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, N_2	

The following fixed constants will be used for the calculation

Parameter	SI Unit	Description	Value
MMch4	kg/kmol	Molecular mass of methane	16.04
MM_CO	kg/kmol	Molecular mass of carbon monoxide	28.01
MMco2	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
AMc	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AMh	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AMo	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AMn	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
Pn	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa.m3/kmol.K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
GWP_CH4	tCO2/tCH4	Global warming potential of methane	21
PCH4,n,h	Kg/m3	Density of methane gas at normal conditions	0.7168
NAi,j	Dimensionless	Number of atoms of element j in component i, depending on molecular structure	

In case of the continuous flare efficiency measurement system is unavailable for maintenance, or failure, the following methods will be used:

- 0% if the temperature in the exhaust gas of the flare (T_{flare}) is below 500 °C for more than 20 minutes during the hour *h* .
- 50%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h,* but the manufacturer's specifications on proper operation of the flare are not met at any point in time during the hour *h.*
- 90%, if the temperature in the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour *h* and the manufacturer's specifications on proper operation of the flare are met continuously during the hour *h.*

Project emissions from consumption of electricity are calculated based on the electricity consumed by the project activity and the CO2 emission intensity of the electricity consumed: $CEF_{electricity,y}$

$$(4)\ EL_{PR,y} * CEF_{electricitry,y}$$

Case A. Electricity imported from the grid.
According to AMS-I.D, the weighted average emission factor of the country can be calculated based on data from an official source, where available. Since this data is not available to us, we use a conservative default emission factor of 1.3 tCO_2/MWh (as stated in Option B3 from "Tool to calculate project emissions from electricity consumption"). Since the country generation mix relies strongly on hydro electricity, this default value is conservative.
In case A, $CEF_{electricitry,y} = 1.3\ tCO2/MWh$
This is relevant for **Lajarilla** and **Viñita Azul**, because these two sites use grid electricity.

Case B. Electricity imported from local diesel generator.
According to AMS-I.A, we may use a conservative default emission factor of 0.8 tCO_2/MWh (which is derived from diesel generation units).
In case B, $CEF_{electricitry,y} = 0.8\ tCO2/MWh$
This is relevant for **Leña Dura**, because this site uses a generator.

CONCLUSION:

Applying the above to the equation (1), the emissions reductions can be calculated following the below equation:

$$\begin{aligned} ER_Y = &\\ &\left[LFG_{flare,y} * w_{CH4,y} * D_{CH4}\right] * \left[(1 - AF) * GWP_{CH4}\right] \\ &- PE_{flare,y} * (1 - AF) \\ &- [EL_{PR,y} * CEF_{electricity,y}] \end{aligned}$$

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 of CH_4
Source of data used:	Defined by the methodology
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied :	The GWP of CH_4 is defined by the ACM0001 methodology as 21 for the first commitment period
Any comment:	

Data / Parameter:	**AF**
Data unit:	Percentage (%)

Description:	Adjustment Factor to the Baseline
Source of data used:	Estimated by independent auditor
Value applied:	4%
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value of the adjustment factor is a conservative value estimated according to the current context of the landfills See Annex 3 for details on the estimation of the Adjustment Factor
Any comment:	

Data / Parameter:	**$CEF_{,electricity,y}$**
Data unit:	tCO_2/MWh
Description:	CO_2 emission factor of the electricity consumed by the project activity
Source of data used:	Default values
Value applied:	1.3 *tCO_2/MWh* for electricity imported from the grid *0.8 tCO_2/MWh* for electricity generated on site
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value is a conservative value, based on AMS-I.A and "Tool to calculate project emissions from electricity consumption"
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

ACM0001 considers that: "No leakage effects need to be accounted for this methodology"

Baseline Emissions

According to ACM0001 for *ex-ante* emissions estimate: "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."

The volume of landfill gas generated by the landfill is evaluated by the EPA/Mex model, which has been developed by the US EPA for the purpose of evaluating landfill sites in Mexico. This model is therefore relevant for other countries in South America.

http://www.epa.gov/landfill/international.htm#3

The Mexico LFG Model can be used conservatively to estimate landfill gas generation rates from landfills, and potential landfill gas recovery rates for landfills that have or plan to have gas collection and control systems.

The Mexico LFG Model is an Excel spreadsheet model based on a first order decay equation. The model requires the user to input site-specific data for landfill opening and closing years, refuse disposal rates, average annual precipitation, and collection efficiency. The model provides default values for waste composition and input variables (k and L0). The default values were developed using data on climate, waste characteristics, and disposal practices in Mexico, and the estimated effect of these conditions on the amounts and rates of LFG generation.
The model does not require the waste composition, which is assumed to be mainly organic.

The output of this model is the LFG generated in Nm3/h ($LFG_{generatedl,h}$). In the ex-ante calculations of emission reductions, the outputs of the model are given at normal conditions (Temperature = 0°C and Pressure= 1.013 bar), therefore in the ex-ante calculations the methane density D_{CH4} is equal to $\rho_{CH4,n}=0.7168$ and will not change in the calculations regardless of the landfill considered. In the actual calculations, when the plant is in operation, the density will be calculated according to the measured pressure and temperature of the gas.

The inputs used in the model for each landfill sites are:

Lajarilla - Viña del Mar		Unit	Comments
Year opened:	1985		Year when the landfill began receiving waste
Average annual precipitation:	347	mm/yr	Select average annual precipitation from closest representative meteorological station. Website: www.worldclimate.com.
Methane Content of LFG Adjusted to:	50%		Model assumes 50% methane. Input value below 50% increases projected LFG flow; above 50% decreases projected flow.
Methane generation rate constant (k):	0,05	1/yr	Default k is calculated to 3 places based on precipitation relationship shown in table below.
Ultimate methane generation potential (L_0):	80	m^3/Metric tonne	Default Lo is calculated to the nearest m3/Mg based on precipitation relationship shown in table below.

Viñita Azul / Copiapo		Unit	Comments
Year opened:	1992		Year when the landfill began receiving waste
Average annual precipitation:	11	Mm/yr	Select average annual precipitation from closest representative meteorological station. Website: www.worldclimate.com.
Methane Content of LFG Adjusted to:	50%		Model assumes 50% methane. Input value below 50% methane increases projected LFG flow; above 50% decreases projected flow.
Methane generation rate constant (k):	0,04	1/yr	Default k is calculated to 3 places based on precipitation relationship shown in table below.
Ultimate methane generation potential (L_0):	60	m^3/Metric tonne	Default Lo is calculated to the nearest m3/Mg based on precipitation relationship shown in table below.

Leña Dura / Punta Arenas		Unit	Comments
Year opened:	1996		Year at which the landfill began receiving waste
Average annual precipitation:	369	mm/yr	Select average annual precipitation from closest representative meteorological station. Website: www.worldclimate.com.
Methane Content of LFG Adjusted to:	50%		Model assumes 50% methane. Input value below 50% methane increases projected LFG flow; above 50% decreases projected flow.
Methane generation rate constant (k):	0,05	1/yr	Default k is calculated to 3 places based on precipitation relationship shown in table below.
Ultimate methane generation potential (L_0):	80	m^3/Metric tonne	Default Lo is calculated to the nearest m3/Mg based on precipitation relationship shown in table below.

LOOK-UP TABLE FOR EPA/MEX MODEL INPUTS			
Precipitation (mm/yr)	K	Lo (m3/ Metric tonne)	English Units Lo (ft3/ton)
0	0,040	60	1 920
250	0,050	80	2 560
500	0,065	84	2 690
1000	0,080	84	2 690
2000	0,080	84	2 690

Lajarilla		
Year	Metric Tons Disposed	Cumulative Metric Tons
1985	81,407	81,407
1986	83,039	164,446
1987	84,704	249,150
1988	86,402	335,552
1989	88,134	423,686
1990	89,901	513,587
1991	91,703	605,290
1992	93,542	698,832
1993	95,417	794,249
1994	97,330	891,579
1995	99,281	990,860
1996	101,272	1,092,132
1997	103,302	1,195,434
1998	105,373	1,300,807
1999	107,486	1,408,293
2000	109,641	1,517,934
2001	111,839	1,629,773
2002	114,081	1,743,854
2003	116,368	1,860,222
2004	0	1,860,222
2005	0	1,860,222
2006	0	1,860,222
2007	0	1,860,222
2008	0	1,860,222
2009	0	1,860,222
2010	0	1,860,222
2011	0	1,860,222
2012	0	1,860,222
2013	0	1,860,222
2014	0	1,860,222
2015	0	1,860,222
2016	0	1,860,222
2017	0	1,860,222
2018	0	1,860,222

Viñita Azul		
Year	Metric Tons Disposed	Cumulative Metric Tons
1985	0	0
1986	0	0
1987	0	0
1988	0	0
1989	0	0
1990	0	0
1991	0	0
1992	46,621	46,621
1993	47,703	94,324
1994	48,810	143,134
1995	49,942	193,076
1996	51,101	244,177
1997	52,286	296,463
1998	53,499	349,963
1999	54,741	404,703
2000	56,011	460,714
2001	57,310	518,024
2002	58,640	576,663
2003	60,000	636,663
2004	61,800	698,463
2005	63,654	762,117
2006	65,564	827,681
2007	66,875	894,556
2008	0	894,556
2009	0	894,556
2010	0	894,556
2011	0	894,556
2012	0	894,556
2013	0	894,556
2014	0	894,556
2015	0	894,556
2016	0	894,556
2017	0	894,556
2018	0	894,556

Leña Dura		
Year	Metric Tons Disposed	Cumulative Metric Tons
1985	0	0
1986	0	0
1987	0	0
1988	0	0
1989	0	0
1990	0	0
1991	0	0
1992	0	0
1993	0	0
1994	0	0
1995	0	0
1996	23,569	23,569
1997	24,649	48,218
1998	24,901	73,119
1999	38,322	111,441
2000	63,475	174,916
2001	67,831	242,747
2002	65,543	308,290
2003	66,615	374,905
2004	78,037	452,942
2005	79,988	532,930
2006	81,987	614,917
2007	84,037	698,954
2008	86,138	785,092
2009	88,292	873,384
2010	90,499	963,883
2011	0	963,883
2012	0	963,883
2013	0	963,883
2014	0	963,883
2015	0	963,883
2016	0	963,883
2017	0	963,883
2018	0	963,883

The requested input information has been submitted to us directly by:

- the Municipality of Viña del Mar and the *Pontifica Universidad de Valparaíso* for Lajarilla,
- the Municipality of Punta Arenas for Leña Dura.
- the Municipality of Copiapó for Viñita Azul.

The Recovery Rate is set at 75% which is the optimal level of recovery as determined in *The Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean* prepared by the World Bank-ESMAP.
The project invests heavily in order to maximize recovery:

- covering the landfills with thick earth layer or draining composite artificial cover
- high density of well (more than 5/ha)

Therefore a recovery rate of 75% is realistic

The Methane Content of LFG is set to 50%, which is a conservative value.

$MD_{project\,y} = MD_{flared,\,y}$

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

Where

- $W_{CH4,y}$ is set to 50%
- D_{CH4} is set to 0.7168 kg/m^3 at standard conditions
- GWP_{CH4} is 21
- $PE_{flaree,y}$ is calculated using the default value for Flare Efficiency: 90% and assuming 8 712 hours of operation per year

  The flare efficiency is given by the "tool to determine project emissions from flaring gases containing methane". In this project, each site will be equipped with a high performance enclosed flare. If possible, the flare efficiency will be monitored and we expect a proven FE of 99.99%. For Ex-Ante calculation, a 90% default value will be used.

  The flare will be shut down for scheduled maintenance, as prescribed by the manufacturer, a maximum of 2 days per year or 48 hours. We will thus consider, in ex ante calculations that the flare will be in operation 8712 hours per year.

	MD_{flare} (tCH_4)			
	Lajarilla	**Leña Dura**	**Viñita Azul**	**TOTAL**
2008	1,924	1,061	765	**3,750**
2009	1,898	1,212	762	**3,872**
2010	1,805	1,323	732	**3,860**
2011	1,717	1,432	704	**3,853**
2012	1,633	1,362	676	**3,672**
2013	1,554	1,296	650	**3,499**
2014	1,478	1,233	624	**3,335**
2015	1,406	1,173	600	**3,178**
2016	1,337	1,115	576	**3,029**
2017	1,272	1,061	554	**2,887**
2018	43	36	19	**98**

$MD_{reg,y} = MD_{project,y} * AF$

A conservative value for the adjustment factor will be used: *AF = 4%.*[4]

	MD**flare* ***(tCH4)			
	Lajarilla	**Leña Dura**	**Viñita Azul**	**TOTAL**
2008	77	42	31	**150**
2009	76	48	30	**155**
2010	72	53	29	**154**
2011	69	57	28	**154**
2012	65	54	27	**147**
2013	62	52	26	**140**
2014	59	49	25	**133**
2015	56	47	24	**127**
2016	53	45	23	**121**
2017	51	42	22	**115**
2018	2	1	1	**4**

$EL_{PR,y} * CEF_{electricitry,y}$

Where :

$EL_{PR,y}$ is the quantity of electricity consumed by the project activity during the year *y* (MWh):

$CEF_{electricity,y}$ is set to 1.3 tCO_2/MWh for the sites using grid electricity
is set to 0.8 tCO_2/MWh for the sites using electricity from diesel generator

For ex-ante calculation, $EL_{PR,y}$ is estimated to 95.4 MWh/year for each site.

	Emissions for electricity consumption			
	Lajarilla	**Leña Dura**	**Viñita Azul**	**TOTAL**
2008	120	74	120	**313**
2009	124	76	124	**324**
2010	124	76	124	**324**
2011	124	76	124	**324**
2012	124	76	124	**324**
2013	124	76	124	**324**
2014	124	76	124	**324**
2015	124	76	124	**324**
2016	124	76	124	**324**
2017	124	76	124	**324**
2018	4	3	4	**12**

A calculation excel spreadsheet is given with this document explaining in detail the calculation of the ex-ante emission reductions.

[4] Refer to Annex 3 for details of the determination of the Adjustment Factor

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

	$ER = (MD_{flare} - MD_{reg}) *21 – PE_{elec}$			
	Lajarilla	Leña Dura	Viñita Azul	Total
2008	38,664	21,316	15,305	**75,285**
2009	38,131	24,360	15,243	**77,734**
2010	36,265	26,590	14,641	**77,496**
2011	34,491	28,797	14,062	**77,350**
2012	32,802	27,389	13,505	**73,697**
2013	31,197	26,050	12,971	**70,217**
2014	29,669	24,775	12,458	**66,902**
2015	28,216	23,563	11,964	**63,744**
2016	26,834	22,410	11,490	**60,735**
2017	25,519	21,314	11,035	**57,868**
2018	859	721	378	**1,958**
Total				**702,986**

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

B.7.1 Data and parameters monitored:

Data and parameters monitored for all sites:

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	Normalised m^3
Description:	Total amount of landfill gas captured and flared
Source of data to be used:	Flow meter
Value of data applied for calculating expected emission reductions in section B.6	Lajarilla: average = 573 Nm^3/h Viñita Azul: average = 183 Nm^3/h Leña Dura average = 337 Nm^3/h
Description of measurement methods and procedures to be applied:	Continuously. Measuring principle: turbine-based measure of the volume by electric signal from 4 to 20 mA Accuracy: from 99.5% at 50 m^3/h to 100% at 400 m^3/h and above
QA/QC procedures to be applied:	The flow meter will be subject to a regular maintenance and testing regime to ensure its accuracy. The manufacturer technician or manufacturer accredited agent in the host country will perform an independent verification onsite, according to the manufacturer specifications. The outcome of the independent verification is a certificate of good order and accuracy of the flow meter. One recommended agent is the company Soltex Chile SA - Avda. Victor Uribe 2260 - Quilicura, Santiago Calibration: not necessary Maintenance: quarterly
Any comment:	- This data will be archived electronically for the project duration + 2 years

	- No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized m^3

Data / Parameter:	$W_{CH4,y}$
Data unit:	%
Description:	Average fraction of methane in the LFG
Source of data to be used:	Analysis device
Value of data applied for calculating expected emission reductions in section B.6	50%
Description of measurement methods and procedures to be applied:	The Methane fraction on the LFG gas will be measured continuously. Measuring principle of CH_4 fraction is infra- red. Accuracy: +/- 1.0 % of the measured value (according to manufacturer documentation) There is a Low level of uncertainty on this type of equipment. Even so, the gas analyzer will be calibrated once a year. All the data will be recorded continuously, on an electronic database.
QA/QC procedures to be applied:	Calibration interval: monthly maintenance and testing regime (by comparison with a bottle of sample CH_4 gas obtained from certified provider such as AGA SA - Paseo Pdte. Errázuriz Echaurren 2631, Providencia, Santiago, Chile) to ensure accuracy
Any comment:	As a simplified approach, project participants will only measure the methane content of the residual gas and consider the remaining part as N_2.

Data / Parameter:	**T**
Data unit:	^{o}C (Celsius)
Description:	Temperature of the landfill gas
Source of data to be used:	Thermometers
Value of data applied for the purpose of calculating expected emission reductions in section B.6	Standard temperature and pressure - 0 ^{c}C
Description of measurement methods and procedures to be applied:	- The Temperature of the LFG gas will be measured continuously. - There is a Low level of uncertainty on this type of equipment. Even so, the thermometer will be calibrated once a year. - All the data will be recorded continuously, on an electronic database.
QA/QC procedures to be applied:	Thermocouples will be replaced or calibrated every year
Any comment:	Measured to determine the density of methane Dch4. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters. The data will be kept during the crediting and two years after.

Data / Parameter:	**P**

Data unit:	Pa (Pascal)
Description:	Pressure of the landfill gas
Source of data to be used:	Manometer
Value of data applied for the purpose of calculating expected emission reductions in section B.6	Standard temperature and pressure - 1,013 bar
Description of measurement methods and procedures to be applied:	- The Pressure of the LFG gas will be measured continuously. - There is a Low level of uncertainty on this type of equipment. Even so, the manometer will be calibrated once a year. - All the data will be recorded continuously, on an electronic database.
QA/QC procedures to be applied:	Manometer will be subjected to a regular maintenance and testing regime to ensure accuracy.
Any comment:	Measured to determine the density of methane CH_4. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters. The data will be kept during the crediting period and two years after.

The ACM0001 parameter $PE_{flare,y}$ (Project Emissions flaring the residual gas stream in the year y) need to be calculated from the following parameters that will be monitored, , according to "Tool to determine project emissions from flaring gases containing methane"

Data / Parameter:	**$PE_{flare,y}$**
Data unit:	tCO_2eq
Description:	Emissions flaring the residual gas stream in the year y
Source of data to be used:	Calculated according to "Tool to determine project emissions from flaring gases containing methane" – The flare efficiency will be continuously monitored.
Value of data applied for the purpose of calculating expected emission reductions in section B.6	For ex ante calculation was considered the default value 90% defined by the "Tool to determine project emissions from flaring gases containing methane".
Description of measurement methods and procedures to be applied:	The following parameter will be monitored, so $PE_{flare,y}$ can be calculated according to "Tool to determine project emissions from flaring gases containing methane".
QA/QC procedures to be applied:	See parameters FVi,h, tO_2,h, $fvCH_4$,FG,h and T_{flare}.
.Any comment:	As a simplified approach, project participants will only measure the methane content of the residual gas and consider the remaining part as N_2. The data will be kept during the crediting period and two years after.

Data / Parameter:	**tO_2,h**
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h
Source of data to be used:	Measurements by project participants using a continuous gas analyzer
Value of data applied for the purpose of	This factor was not considered on the ex-ante estimation.

calculating expected emission reductions in section B.6	
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzer for wet basis determination. Measurement principle: electrochemical + signal 4-20 mA Accuracy:0.25% of the measured value The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). Frequency: Continuously. Values will be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analyzers will be periodically (monthly) calibrated according to manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard gas.
Any comments	

Data / Parameter:	**$fvCH_4,FG,h$**
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
Source of data to be used:	Measurements by project participants using a continuous gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.6	This factor was not considered on the ex-ante estimation.
Description of measurement methods and procedures to be applied:	Extractive sampling analyzers with water and particulates removal devices or in situ analyzer for wet basis determination. Measurement principle: NDIR/Infra-red + signal 4-20 mA Accuracy:0.25% of the measured value The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). Frequency: Continuously. Values will be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analyzers will be periodically (monthly) calibrated according to manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard gas.
Any comment:	Measurement instruments may read ppmv or % values. 10,000 ppm = 1% converted to 0.7168 mgCH4/m3

Data / Parameter:	**T_{flare}**
Data unit:	°C
Description:	Combustion temperature
Source of data used:	Analysis device

Value of data applied for calculating expected emission reductions in section B.6	This factor was not considered on the ex-ante estimation.
Description of measurement methods and procedures to be applied:	Continuously.
QA/QC procedures to be applied:	Thermocouples will be replaced or calibrated every year
Any comment:	

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	Text
Description:	Regulatory requirements relating to landfill gas projects
Source of data used:	Laws and Regulations
Value of data applied for calculating expected emission reductions in section B.6	There are no regulatory requirements
Description of measurement methods and procedures to be applied:	- We will follow-up the evolution of the environmental laws & regulations in Chile through a review with our lawyers every 6 months. - All the data will be recorded yearly, on an electronic database.
QA/QC procedures to be applied:	Yearly review of the filing by Bionersis Paris
Any comment:	

Data / Parameter:	**$EC_{PR,y}$**
Data unit:	MWh
Description:	quantity of electricity consumed by the project activity during the year y
Source of data to be used:	Onsite measurement
Value of data applied for the purpose of calculating expected emission reductions in section B.6	Consumption per site: 95.4 MWh/year (11Kw base; 8712 hour of activity per year)
Description of measurement methods and procedures to be applied:	Continuously, aggregated manually by the electricity supplier, via onsite meter checking. Use electricity meters. The meter is a General Electric induction meter, owned and controlled by the state electricity company: « superiendencia de electricidad ». - accuracy: < 2% , measured at 25%, 50%, 75% and 100% of the maximum electric capacity - calibration frequency: every 5 years
QA/QC procedures to be applied:	Cross check measurement results with electricity invoices
Any comment:	

B.7.2 Description of the monitoring plan:

EQUIPMENTS

The flare unit is equipped with the following instruments to capture the required monitoring data:

No	Instrument	Data monitored
1	Flowmeter	**$LFG_{flare,y}$** Volume of gas sent to the flare **T** Temperature of the LFG **P** Pressure of the LFG
2	LFG Gas analyser	**$W_{CH4,y}$** Fraction of methane in LFG
3	Thermocouple	**T_{flare}** Temperature of the flare
4	Electricity meter	**$EC_{PR,y}$** Electricity consumed by the equipment
5	Exhaust gas analyser	**$fv_{CH_4,FG}$** concentration of methane and O2 in the exhaust gas

Note 1

$PE_{flare,y}$: The parameters used for determining the project emissions from flaring will be monitored as per the "Tool to determine project emissions from flaring gases containing Methane". The data following will be imputed on an electronic report.

- $Fv_{i,h}$: Volumetric fraction of component *I* in the residual gas in the hour *h* where *i*= CH_4 (already considered as $W_{CH4,y}$, above – as a simplified approach the CH_4 will be measured and the remaining part will be considered N_2);
- $t_{O2,h}$: Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h, continuous measurements will be made, as a preferred solution if technically feasible.
- $fv_{CH4,FG,h}$: Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h, continuous measurements will be made, as a preferred solution if technically feasible

Note 2

If it proves technically not feasible to monitor flare efficiency, a default Flare Efficiency (FE) of 90% will be used when the compliance with manufacturer's specification will be achieved and a Flare efficiency of 50% will be used if the flare temperature is out of the specified limits. In order to monitor the compliance with the manufacturer's specifications the combustion temperature of the flare will be measured continuously.

DATA MONITORING AND LOGGING

Monitoring Unit

The monitoring unit is composed of a MemoGraph (type: Visual Data Manager, Provider: Endress+Hauser), equipped with a Compact Flash card of 256 MB for the archive. The unit comes also with a preinstalled copy of software ReadWin2000 (from Endress+Hauser), that is used for the configuration and display of the MemoGraph.

The system also offers 2 different ways of communication for output:

- USB Interface
- Modem transmission, using either protocol RS232, protocol RS485 or Ethernet Interface

Data Log

The Monitoring unit currently collects on a minute by minute base and outputs the following parameters from the flare unit: (see Figure 1 - Example of Monitoring Output)

- Date & Hour:Min of the measure
- Status validity of the measure
- Average Gas Pressure in degree in mbar.

- Average Gas concentration in Methane (CH_4).
- Normalised gas Flow in nM^3/h.
- Average Gas Temperature in degree Celsius.
- Average Flare Temperature in degree Celsius.

Data are collected every minute.

	2						
Date/Time	Status	Pression Average mbar	CH4 Average %	FLUJO Average NM3/h	O2 Average VOL%	T Antorcha Average °C	T Gas Average °C
17/12/2007 13:32	OK	80	49	500.1	2.5	1223	37
17/12/2007 13:33	OK	80	49	499.8	2.5	1196	37
17/12/2007 13:34	OK	80	49	499.6	2.5	1165	38
17/12/2007 13:35	OK	80	49.1	499.5	2.5	1114	38
17/12/2007 13:36	OK	80	49	499.5	2.5	1170	38
17/12/2007 13:37	OK	80	49	499.5	2.5	1137	38
17/12/2007 13:38	OK	80	49	499.4	2.5	1141	38
17/12/2007 13:39	OK	80	48.9	499.3	2.5	1129	38

Figure 1 - Example of Monitoring Output

The data are recorded on spreadsheet file with a predefined format. The file will then be directly used for the verification report.

Logging Methodology

For all the parameters mentioned above, the logging methodology is 4 steps:

a) Automatic Logging:

The MemoGraph is configured to communicate by modem once a week the results. The results are sent using a direct dedicated phone line to a dedicated server machine that is physically installed in the office of Bionersis Chile in Santiago. The Monitoring Director is controlling that process works accordingly.

b) Manual Logging:

If Automatic Logging Failed, Monitoring Director will contact directly the monitoring unit from the server to collect the data.

c) Physical Logging:

If Physical Logging Failed, Monitoring Director will send a technician physically at site location to output data using the USB interface. These data will be then be sent back to the office and recorded on the server.

d) If all above failed, two solutions:

1. If data can be subsequently retrieved days after, they will be reintegrated on the server.
2. If not, they are lost.

Data Storage Methodology

- All data will be stored physically on the disk of the server machine.
- A monthly backup of the server will be done.
- Copy of the backup will be held securely in a safe.
- Copies of the files will be stored up to two years after termination of the project.

Reliability of Data

a) The MemoGraph is secured by means of a seal so the displayed value is true and protected against manipulation.

b) The persons having access to the server machine will be limited to the minimum, including:

- the IT manager
- the Chief Operating Officer
- the Monitoring Director

c) On a weekly basis, the Monitoring Director will review the performance of the project activity and take the necessary actions.
d) Missing Data:
If for whatever reason MemoGraph failed to record data during a certain period, no CER will be claimed for that period.

MAINTENANCE PROCEDURES

<u>Configuration / Calibration Procedures</u>
Instrumentation will be calibrated as recommended by manufacturers.
The critical calibration frequency and procedures are detailed below:

A) Flow Meter
The flow meter will be calibrated once a year by an external certified company.
Hofstetter recommends the following company who is present in Chile: Soltex Chile SA - Avda. Victor Uribe 2260 - Quilicura, Santiago

B) Gas Analyser
The gas analyser is calibrated every month according to its calibration protocol by a qualified operator. The calibration gases will be purchased from certified gas suppliers. All gas cylinders will be provided with a quality certificate.
Hofstetter recommends the following company who is present in Chile: AGA SA - Paseo Pdte. Errázuriz Echaurren 2631, Providencia, Santiago, Chile

C) Temperature and Pressure of the LFG
The temperature and pressure meters will be calibrated annually by an independent third-party.

D) Temperature of the flare
The thermocouple will be checked annually by an independent third-party

E) Electricity Meters
The reading from electricity meters will be cross-checked annually with the invoices from the national grid company.

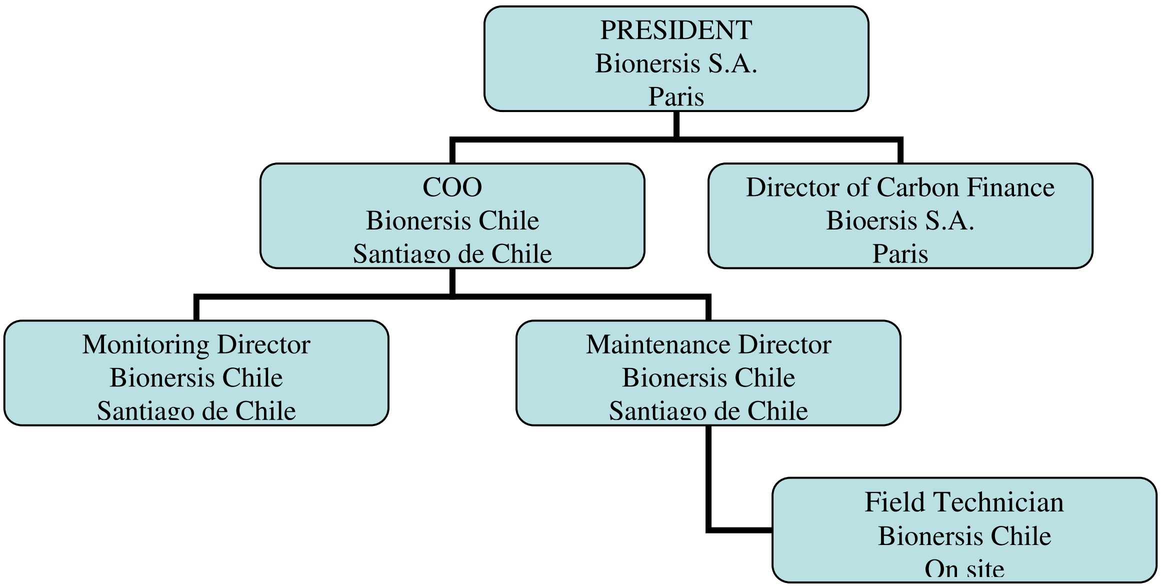
F) General Malfunction of equipment
If the equipment (flow meter, gas analyser, gauge, controller, MemoGraph, etc.) fails, the equipment supplier will be immediately notified. If possible, repairs will be carried out. If the damaged equipment cannot be repaired, it will be replaced at the earliest by the same or an equivalent unit. In some cases, portable tools will be used in order to carry out daily monitoring of the missing parameter(s). This data will be recorded on paper.

ID Number	Data Variable	Source of Data	Data Unit	Recording Frequency	Calibration Method and Frequency	Alternative procedure in case of failure
LFG flare,y	Total amount of landfill gas flared	Flowmeter	m3	evry minute	Annualy by external expert	N/A (data lost)
Wch4,y	Fraction of methane in measured gas	Gas Analyser	m3 of i / m3 of gas	every minute	Monthly	Manual measurements will be taken using and infrared portable device
T	Temperature of the landfill gas	Temperature Gauge	Celcius	every minute	Annualy	N/A (data lost)
P	Pressure of the landfil gas	Pressure Gauge	Pa	every minute	Annually	N/A (data lost)
Tflare	Temperature of the flare	Thermocouple	Celcius	every minute	Annually	N/A (data lost)
EC	Electricity consumed	Electricity meter	MWh	monthly	Annually	Manual reading and logging

MONITORING ORGANIZATION

Organisation Chart

The monitoring plan and data capture is the responsibility of the Monitoring Director .
The Maintenance Director supervises the calibration procedure under the supervision of the Monitoring Director.
The verification and certification process is managed by the Director of Carbon Finance, based in France.



Title	**Responsibilities**
President	Overall responsibility for governance and defining organisation
COO	Overall responsibility for maintenance and monitoring
Director of Carbon Finance	Overall responsibility for verification and certification process Responsible for providing data and reports to the DOE
Monitoring director	Responsible for data gathering and monitoring Responsible for organising training for monitoring team Responsible for planning calibration and planning maintenance according to PDD
Maintenance director	Responsible for daily preventive and corrective maintenance on site Responsible for the execution calibration and maintenance
Field Technician	Regular visit to the site, physical operation of the equipment Physical backup of data and manual transmission of data when required Performs calibration and maintenance tasks

Quality Assurance

- The monitoring director will be in charge of and accountable for the generation of the monitoring, logging and record keeping of all monitoring data.
- The director of carbon finance will be in charge of computation and recording of CERs,
- The monitoring director will officially sign off on all worksheets used for the recording of monitoring data.
- The director of carbon finance will officially sign off the calculation of CERs.
- Proper management processes and systems records will be kept by the monitoring director. The auditors can require copies of such records to judge compliance with the required management systems.

Training of Monitoring personnel

Employee participants to the Monitoring plan will be trained internally and/or externally at least once a year. Training will include:

a) Review of equipment and captors
b) Calibration requirement
c) Configuration of monitoring equipment
d) Maintenance requirement

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)

The application of the baseline study is dated 8-01-2007.
The responsible entity is CEFT, a French engineering company specialised in LFG units design and procurement.

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 27/04/2007

The starting date chosen is the date when the main equipment (the flare) was ordered, and is therefore the date when the implementation of the project activity begins.

The flare order and down payment was the first step taken for the project activity. The construction of the equipment (landfill cover, network) started after that date.

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

The expected operational lifetime of the project activity will be approximately 15 years, from the starting date of the project activity mentioned above.

The expected operational lifetime of the project is longer than 10 years, since:

- the period of significant LFG production for a closed landfill is about 15 years
- the lifetime of the equipment purchased is about 15 years, according to the information from the equipment provider (Hofstetter)

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:

The starting date of the fixed crediting period is 14/01/2008, or the date of registration, whichever is latter.

The starting date chosen is the date when the real action of the project operation begins.

C.2.2.2. Length:

The length of the fixed crediting period is 10 years, from 14/01/2008 to 13/01/2018.

SECTION D. Environmental impacts

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

An analysis was conducted by BIONERSIS for the local DNA, the CONAMA. The environmental impacts are as follows:

Impact on the landscape
The project activity will allow the closing of the landfill sites and accelerate the remodelling process of the sites. The implementation of techniques of compaction of waste as part of the remodelling will reduce the risks of fire on the landfills. The reshaping of the waste body is favourable for biogas production and also allows it to fit better in the landscape.

Impact on Fauna and Flora
The Project will have a positive influence on the local ecosystem by reducing the emissions of greenhouse gas into the atmosphere. Moreover the destruction of gases like H_2S and derivatives of methane, which constitutes a substantial nuisance in the neighbouring zones (because of their scents), will also contribute to the development of the local ecosystem.

Impact on air and climate
The flaring and destruction of the methane contained in landfill gas will contribute to the reduction of greenhouse gas emissions, which are proved to increase global warming. This is why the project activity can be considered as a CDM project.

The project activity will prevent all nuisance created by the total release of the landfill gas to the atmosphere, such as the release of H_2S, mercaptenes and other chemical compounds that result in bad odours and sanitary risks in the neighbouring populations, such as diseases and asthma due to the air pollution.
The improved management of waste, engendered by the project activity, will reduce the presence of rodents (rats or similar) or birds, thus reducing the sanitary risks for the neighbouring population.

Impact on safety
The collection and destruction of the landfill gas will reduce risks of explosion in the landfill sites and the neighbourhood. Indeed, for a specific content, in the presence of oxygen, the methane contained in the landfill gas can become explosive. The project activity implies continuous monitoring and control of the oxygen content of the landfill gas, thus continuously controlling the risk of explosions.

Noise
The installed equipment (flare) can produce some noise, however the noise level will always be below 69dB(A). This noise level will not result in any significant nuisance to the neighbouring population due to the distance between the flare and population dwellings (if any in the vicinity).

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:

As a result of this study, there are no negative environmental impacts due to the project activity. All the impacts of the project activity listed above will contribute to improve both local and global environment.

Following this study, the analysis was approved by the local DNA and the latter did not ask for further environmental study.

SECTION E. Stakeholders' comments

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

Lajarilla Landfill – City: Vina del Mar

The project was presented to the Regional Sanitary Authority, which recognised that the project constitutes an improvement concerning the one authorized originally by the same authority in September 1985, resolution N° 2 786 and then authorized for its operation in resolution N° 2.997 of the 11 October 1985. The project is defined in the resolution Nº 0823 of 06 June 2006, where the Regional Ministerial Secretary of Health approves the degassing project in the Lajarilla landfill
In an equivalent manner, the project was presented to the environmental authority, confirming in ordnance n° 062572 of 8 September 2006 that this project contributes to sustainable development in the country and has been voluntarily presented to the National Designated Authority (DNA)

On the 28th December, a public consultation was carried out and for which a meeting was organised in the dependencies of the Viña del Mar municipality, at which was present the representatives of all the community, such as the Regional Ministerial Health Secretary, the National Commission of the "Medio ambiente", the City unions and groups of neighbours. The call for this meeting was made with formal invitation from the department of operations of the Municipality of Viña del Mar.
The general public was invited through posters placated in the townhall of each municipality.

In the meeting, conducted on the 28th December, the following things were introduced: association between landfills and the generation of biogas; the impact in the zone and the world of biogas emissions; what the Kyoto Protocol and the clean development mechanism are; and finally the project of degasification in the Lajarilla landfill and how this project contributes to sustainable development.

Vinita Azul Landfill – City: Copiapo

The project was presented to the Regional Sanitary Authority, which judges that the project constitutes an improvement concerning the one approved by the same authority on the 11 December 1992 in resolution n°1236.
The project is defined in the Ord. BS3/Nº 1418 of the 11 November 2006, where the Regional Ministerial Health Secretary approves the degassing project mentioned.

In an equivalent manner, the project was presented to the environmental authority, confirming with the ordnance n° 062569 of 8 September 2006 that this project contributes to sustainable development in the country and has been voluntarily presented to the National Designated Authority (DNA)

On the 6th December, a public consultation was carried out and for which a meeting was organised in a Hotel of the city of Copiapo, at which was present representatives of Regional Ministerial Health Secretary, of the third region's Environmental National Commission, of the community, and community unions from the city Copiapó, representatives of environmental groups and organisations.
The general public was invited through posters placated in the townhall of each municipality.

The call for this meeting was made by the company Bionersis Chile Ltda and the Municipality of Copiapo
In the meeting, conducted on the 6 December, the following things were introduced: association between landfills and the generation of biogas; the impact in the zone and the world caused by the emissions of biogas; what is the Kyoto Protocol and the clean development mechanism; and finally the project of degasification in the Vinita Azul landfill and how this project contributes to sustainable development.

Lena Dura Landfill – City: Punta Arenas

The project was presented to the Regional Sanitary Authority, which recognised that the project constitutes an improvement concerning the one authorized originally by the same authority in November 1991, with its resolution N° 629.

The project is defined in the Ord. 258 of 20 March 2006, where the Regional Ministerial Secretary of Health approves the degassing project in the Lena Dura landfill.

In the same way, the project was presented to the environmental authority, confirming with the ordnance n° 062570 of 8 September 2006 that this project contributes to sustainable development in the country and has been voluntarily presented to the National Designated Authority (DNA).

On the 6th December, a public consultation was carried out, for which a meeting was organised in the dependencies of the municipality of Punta Arenas, at which was mentioned to the members of the Commission of Development and Planning of the Municipality of Punta Arenas, in which the Mayor and 8 councilmen, representative of the community in general; representatives of Secretary of the Regional Ministry of Health (Secretaria Regional Ministerial de Salud) , of the National Commission of the Medio ambiente Region of Magallanes, and the immediate neighbours to the Lena Dura Landfill.
The general public was invited through posters placated in the townhall of each municipality.

The call for this meeting was made with formal invitation from the municipality. In the meeting, conducted on 6 December, the following things were introduced: association between landfills and the generation of biogas; the impact in the zone and the world caused by the emissions of biogas; in which consists the Kyoto the Protocol and the clean development mechanism; and finally the project of degasification in the Lena Dura landfill how this project contributes to the sustainable development. Additionally, press articles were released in the magazine “Punta Arenas”, published by the Municipality with free access by the community, one released in October announcing the project to be developed and another one in December announcing the information meeting for the project. Moreover, in channel 72, the local channel, appeared press release with the same agenda for the meeting.

E.2. Summary of the comments received:

Lajarilla Landfill – City: Viña del Mar

We received comments in favour of the project.
- Interest was shown on how the project works, the duration and what the benefits are for the community
- Interest was shown on waste management in general
- The environmental and social benefits were very well received

Viñita Azul Landfill – City: Copiapo

We received comments in favour of the project
- People wanted to know how the Municipality will benefit from the alliance with the project participant
- Interest was shown to support this initiative to the rest of the community
- Interest was shown on waste management in general
- The environmental and social benefits were very well received

Leña Dura Landfill – City: Punta Arenas

We received comments in favour of the project
- Interest was shown in the possibility of, in the future, producing energy from the collection of biogas
- People wanted to know how the Municipality will benefit from the alliance with the project participant
- The environmental and social benefits were very well received
- The neighbouring population of the landfill reacted positively to the information

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

There were no negative response or comments that would engender changes in the project and the meetings' participants showed great interest in defending this initiative towards the rest of the community.

Annex 1

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There will be no public funding, under any form, for the proposed CDM project. It will be financed exclusively by private capital that is being raised from investments funds and/or banks, either locally or in the European Union.

Annex 3

BASELINE INFORMATION

In Chile, the technical, legal, economic and financial conditions are such that generally no LFG collection and destruction is occurring, even though some landfills are equipped of passive ventilation wells for the purpose of preventing potentially dangerous LFG concentration inside the landfill.
A specialised consultant (5) has conducted an inspection on Bionersis' behalf, and issued a report describing the current status of the landfills. Below are some extracts from this report.

Lajarilla landfill

A total of 47 chimneys has been identified, in line with the expected ratio of 20 to 25 meters – which would have meant a total of 56 wells.
As in Viñita Azul, the system consists of passive venting equipment, mainly pipes of 10 meters deep + 200 mm Ø stones protected by drums and lighted as and when applicable.
During the inspections, both in July 2005 and in May 2006, none of the chimneys were lighted although a number of them do register quite a quantity of landfill gas flow.
Many chimneys have collapsed and have not been repaired.
According to the report, in Lajarilla, as well as in Viñita Azul, all landfill gas that is currently generated is freely and totally released into the atmosphere either through the existing (and mostly collapsed) passive venting system or by migrating directly to the landfill surface or borders.

Vinita Azul /Copiapo Landfill

Nine (9) chimneys have been installed over an area of 7 hectares, which is insufficient, since it is commonly accepted that gas wells have an attraction radius of 20 to 25 meters – which would mean that an efficient gas collection system would have consisted of about 50 wells

The current system in place in Viñita Azul is therefore quite simple and consists of passive venting chimneys, of around 5 to 10 meters deep, inserted into metallic drums and scattered around the landfill without any specific order.
During the first inspection of October 2005, only one of the 9 chimneys was actually generating LFG – but was not lit.
All the other chimneys have collapsed over the past 5 years and have never been either consolidated or re-constructed.
During the second visit of June 2006, the chimney that has been passively generating gas was still in action but still was not lit and none of the other 8 chimneys had been repaired or re-constructed.

It is therefore clear that all landfill gas that is currently generated in Viñita Azul is freely escaping to the atmosphere either through the existing (and mostly collapsed) passive venting system or by migrating directly to the surface or the boundaries of the landfill.

Lena Dura – Punta Arenas

[5] Inversiones 88 - 94 Bd. du Souverain - B 1170 Bruxelles – Inspection Report

The site is equipped with a dense passive venting network of 40+ chimneys, a little bit below what could have been expected with the size of the landfill.

During the inspection of July 2005, 3 chimneys have been identified actually flaring landfill gas and many - if not all – of the others with quite an active gas flow.
One of the major difficulties is indeed the constant blowing of fierce winds that tend to blow the flames and prevent the correct elimination of all gases that could be collected out of this passive system.
The only way to eliminate correctly these gases would quite certainly go through the use of active venting systems with efficient flare…

In Leña Dura, it could be estimated that a maximum of 10% of the passively vented gases are actually destructed by flare – estimating that the passive venting system captures a maximum of 30% of the generated landfill gas, the estimates for destruction of landfill gas in Leña Dura would not be more than 3% of the total generated gases.

Therefore we may consider the following assumptions as realistic:

	Percentage of LFG currently destroyed
Lajarilla landfill	0%
Viñita Azul landfill	0%
Leña Dura landfill	3%

Even though there is no evidence of any burning of gas on sites other than Lena Dura, we shall consider as conservative estimate that 3% of the landfill gas generated is destroyed on average on all sites.

Furthermore, this conservative estimate of 3% has to be compounded with the 75% *Recovery Rate* set for the project resulting in a net Adjustment Factor of:

$AF = 3\%/75\% = 4\%$

In accordance with the formulas set in the Methodology, this percentage will be deducted from the value of the $MD_{project,y}$, to account for the estimated baseline scenario.

Considering that the baseline scenario describes an uncontrolled and continuous emission of LFG into the atmosphere; and that the passive ventilation wells existing in some landfills would have to be completed by a strict routine of control and combustion of the collected LFG, which currently does not occur, to result in any significant reduction of LFG emissions, the value of 4% is conservative.

Annex 4

MONITORING PLAN

The degassing system consists in one flare unit per site.

This model is a proven technology according to the EU and Chilean requirements. Certificate of Conformity of the unit was signed on 10/08/2007.

The installation will be continuously/permanently controlled thus insuring the safety and accurate data reporting of the emission reductions: