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

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SECTION A. General description of project activity

A.1 Title of the project activity:

Fundo Las Cruces Landfill Gas Recovery Project
Version 2
December 2, 2007.

A.2. Description of the project activity:

The objective of Fundo Las Cruces Landfill Gas Recovery Project is to capture, flare and use the landfill gas generated through the decomposition of the organic waste disposed at Fundo Las Cruces Landfill site. This will involve investing in a landfill gas collection system and a flare station. The principal components of landfill gas are methane (CH_4) and carbon dioxide (CO_2), both of which are greenhouse gases (GHG) listed as such in the Kyoto Protocol. Flaring involves methane destruction leading to GHG emissions reductions. Some of the landfill gas collected would be put to energy use at the landfill site and additional GHG emissions reductions —from CO_2 emissions— would accrue and would be credited within this CDM (Clean Development Mechanism) project.

Possible energy uses of landfill gas (LFG) include: (1) electricity generation for use at the landfill site and/or for sale to users elsewhere; and (2) on-site thermal use in the leachate treatment plants. Any use of LFG is subject to approval by Chile’s environmental authority, CONAMA.

Fundo Las Cruces is a municipal solid waste landfill (MSW) located on the way to Yungay, in the south of the administrative district of Chillan Viejo, Province of Ñuble, VIII Region of Bio Bio, Chile. The Landfill is owned and operated by HERA Ecobio S.A., a subsidiary of the Spanish Group HERA Holding. HERA is worldwide known as an environmental services company offering solutions to industries and municipalities for waste treatment and final destination. This company has developed several Landfill Gas to Energy Projects (LFGTE) in Spain, such as compressed biogas for cars and buses, and cogeneration projects. Additionally, HERA Holding has a waste valuation program (plasma generation) and is continuously implementing new technologies.

HERA Ecobio S.A. owns a total area of 77 hectares (ha), of which 38.3 ha are destined for the Industrial and Hazardous Waste Landfill and the other 38.7 ha for the MSW “Fundo Las Cruces” Landfill. The CDM Project will be developed only at Fundo Las Cruces Landfill, where 28 ha (700 meters by 400 meters) are planned for municipal waste disposal.

The area around the Landfill may be considered humid, with an average annual precipitation of 1,100 mm and an average temperature of 13°C. The zone is a little eroded and has no much vegetation. The climate is classified as “warm temperate with winter rains”.

The Landfill began accepting waste in mid-2002. By the end of December 2006, more than 370,000 tonnes of waste had been filled over 4 of the Landfill’s 28 hectares. Upon completion, maximum waste thickness is expected to be about 30 meters; current maximum landfill height is about 12 meters. The Landfill closure is expected to be in 2031 (30 years lifetime), after which the landfill gas and water monitoring processes would follow. Currently, the Landfill is filling at a rate of about 14,000 tonnes per month (500 tonnes per day), or greater than 160,000 tonnes per year. Besides that, an increase of 4% per year is expected in the current filling rates. About six percent (6%) of the total waste received consists of sludge coming from wastewater treatment plants, which is being disposed mixed with the MSW.

Currently, there are 10 landfill gas vents (or passive gas wells) installed over an area of 4 hectares, venting landfill gas to the atmosphere. No flare station has been connected to those wells and this would establish the baseline scenario.

Following the implementation of the proposed CDM project, the predicted LFG recovery rate for the Landfill in 2008 is about 420 m^3/h (assuming 70% capture of LFG generated, starting in April), increasing to more than 540 m^3/h (70% capture) in 2009. After the 21-years period of this project, the predicted LFG recovery would exceed the 2,380 m^3/h (70% capture efficiency). The overall predicted recovery rate will continue to increase until the landfill closes, which is anticipated to occur in 2031, after which the rate will decrease as the organic fraction is degraded.

Some electricity might be generated using landfill gas for on-site use. It is estimated that the landfill would need a 0.5 MW installed capacity for satisfying the electricity demand of the LFG plant (blower), the existing leachate treatment plants (through reverse osmosis, at both MSW and industrial landfills) and the envisioned leachate evaporation plants. For fuelling such power plants, around 350 m^3/h of LFG (with 50% methane content) will be needed.

Besides climate change mitigation, the project would have important local environmental benefits. All the landfill gas is currently released to the atmosphere without any treatment. This implies a potential fire and explosion risk as well as bad odors. 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.

Social benefits will mainly consist of sponsoring two small schools located near the landfill site, Llollinco and Quilmo schools, assuming the compromise to provide computers or other materials needed, as well as the support in managing and disposing their residues. In addition, it is expected that the project will generate new prospects for employment and access to new knowledge (through the specialization of labour force) for the members of the Llollinco and Quilmo community. Besides that, HERA Ecobio will continue offering a contribution to the Ministry of Public Works (MOP) for the maintenance of the public road, whether it is by using its own machinery or providing granular material, and will continue to do so insofar no definitive solution is projected.

A.3. Project participants:

Name of Party involved (*). ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicates if the Party involved wishes to be considered as project participant (Yes/No)
Chile (host)	HERA Ecobio S.A. Private entity. Project Sponsor.	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Chile

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

Province of Ñuble, VIII Region (or "Region de Bio-Bio")

A.4.1.3. City/Town/Community etc:

Administrative district ("Comuna"): Chillan Viejo
City: Chillan

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

Fundo Las Cruces Landfill is located in the south-west sector of the administrative district ("Comuna") of Chillan Viejo, part of Chillan City, in the south of Chile. Chillan Viejo is located 118 meters above sea level. According to the last census, it has a population of 22,000 inhabitants, covering an area of 259 square kilometres (km^2). The distance between the landfill and the nearest settlement, Llollinco, is more than 1 km, which has a population of four families.

The nearest international airport is at the city of Concepción, which is located 112 km south-west of Chillan city.

Landfill coordinates: 36º 41' S, 72º 11' W

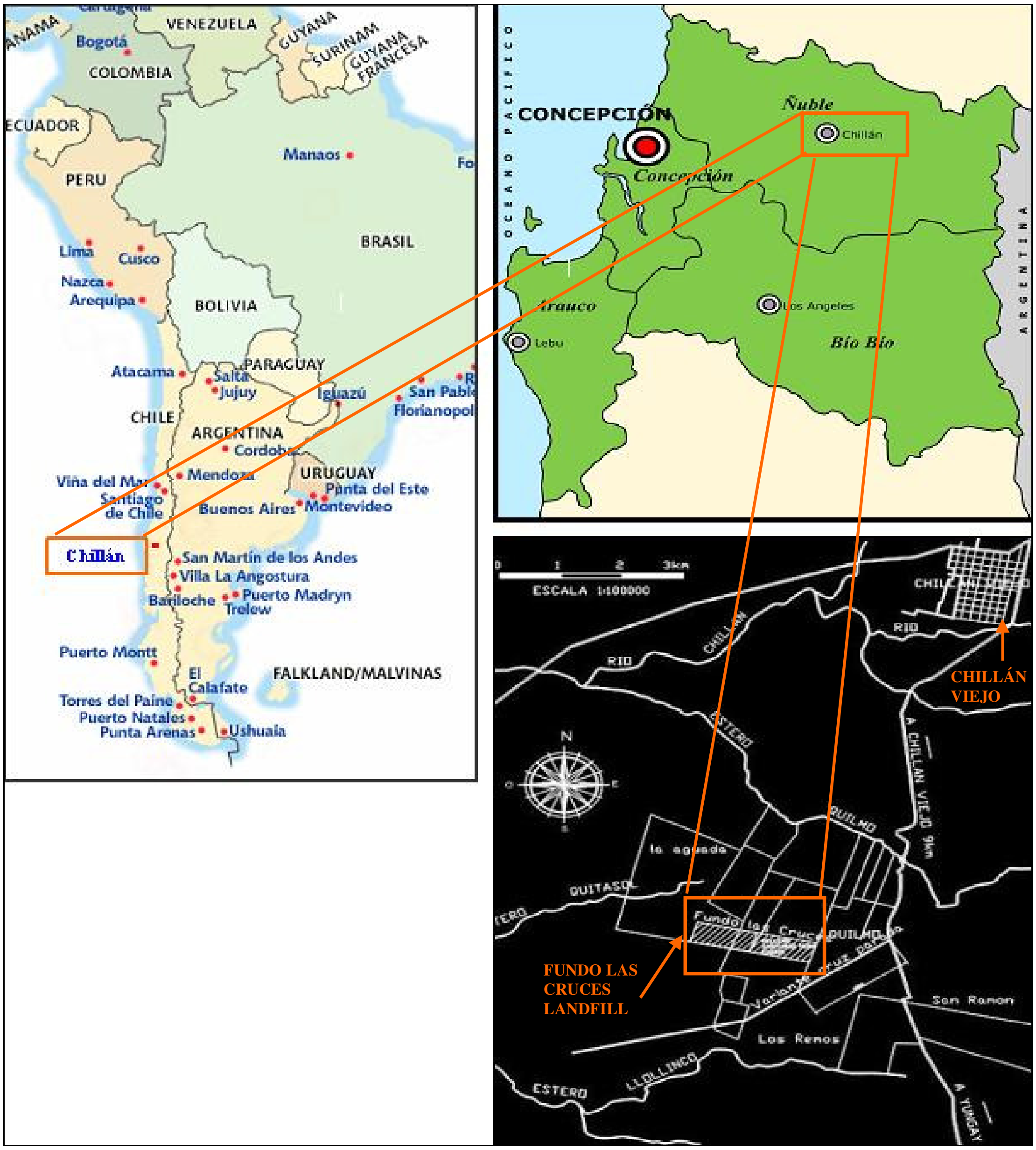

Figure 1 – Fundo Las Cruces Landfill Location

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

According to the "Sectoral Scope" classification, the project categories are:
- "13. Waste handling and disposal", and
- "1. Energy industries (renewable - / non-renewable sources)".

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

Fundo Las Cruces Landfill is a very well managed landfill which already includes a bottom liner, leachate collection system, waste compaction, daily cover of the waste disposed, leachate treatment plant, among other technologies. Since mid-2007, the waste mass that reaches an intermediate or final grade is being covered with geomembrane, avoiding the air intrusion, thus favouring the anaerobic conditions for landfill gas generation.

In order to maximize LFG recovery rates, and thus GHG emission reductions, an active LFG collection system will need to be installed. The system will consist of a series of vertical extraction wells interconnected by header piping. The LFG will be extracted from the landfill by a blower and conducted to a single point for flaring. Some LFG may be used as fuel at the leachate evaporation plants or may be burnt to produce electricity. The essential characteristics of the LFG collection and flaring system are listed below:

- Construction of deep and shallow vertical wells in intermediate or closed areas, trying to not interfere with the landfill operation. Depending on future development plans, some horizontal wells might be installed, to capture the gas in areas that continue to be filled.

- Installation of a piping network to include connection to extraction wells, serving the blower/flare station with a specific diameter piping, suitable for the anticipated flow rates. In general, connection should be made to those extraction wells that have been constructed to final or intermediate grade, and to which the piping connection will have a minimal impact on current filling operations.

- Installation of a leachate pumping system (if needed), to extract the excess of leachate from the gas wells.

- Installation of a condensate management system. The LFG collection piping will be designed to include self-draining condensate traps and condensate manholes with pumps where necessary.

- Installation of the blower and flaring station. The flaring station will consist of an enclosed flare, which will enable the measurement of exhaust gas composition (in case it is required).

- Improvement of the reliability of electrical service to the blower and flaring station, if necessary, installing backup power capacity (e.g. diesel generator). Installation of an LFG-fuelled power generator is being considered.

One possible use of LFG is for evaporating leachate. The envisioned technology is shown in Figure 2. The system is designed to dry sludge through improved natural evaporation instead of by heating. It comprises a honeycomb matrix made of HDPE (high density polyethylene) where each m^3 of matrix provides 200 m^2 of surface area to facilitate evaporation. Mechanical ventilation provides an air speed of 4 m/s on the drying surfaces. The effluent is sprayed on the matrix. A part of the liquid evaporates, and the rest returns to the pond. As effluent from the pond is sprayed on the matrix, evaporation continues and the effluent in the pond loses water. About 95% of the effluent can be evaporated through this cyclical process, so that the remaining sludge can be deposited at a landfill. While no heat is needed for this process, pre-heating the air before it reaches the honeycomb matrix can speed up evaporation. One way to heat the air would be by using landfill gas to heat water and using a water-to-air heat exchanger.

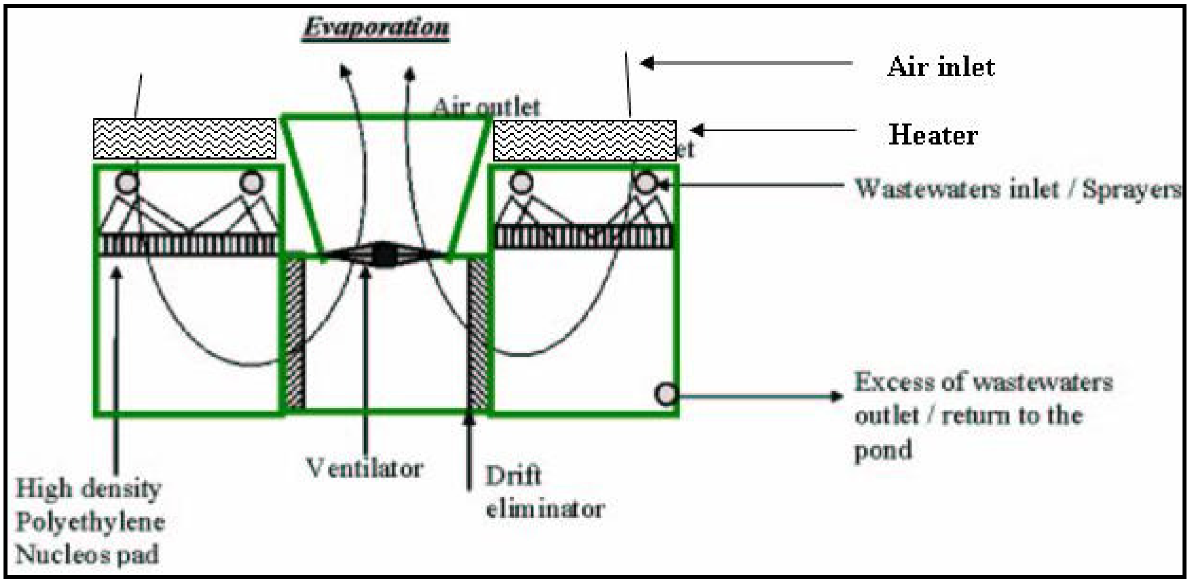

Figure 2 – Envisioned Leachate Evaporation Plant

The capacity of the evaporation system will depend on real landfill gas flow rates. It is a modular system, in which each module has the capacity to treat between 350 m^3 and 500 m^3 of leachate per year. The system would be designed to treat up to 10,000 m^3 of leachate per year. To treat this maximum amount of leachate approximately 1,000 m^3/h of landfill gas (at 50% methane by volume) would be required. The energy demand of this thermal plant will depend on how many evaporators (modules) are being used. Based on manufacturer's information, the energy demand could be estimated by using the following formula:

Energy demand = 12 + 3 * nEvap

where nEvap is the number of evaporators (modules).

The excess flow will continue to be treated in the existing leachate treatment plants, using reverse osmosis.

Until recently, there were no projects to capture and flare (or otherwise use) landfill gas in Chile. During 2006 and 2007, seven other projects have been presented for implementation under the CDM. Once this PDD is validated, engineering studies would be conducted and detailed designs will be made. Some of the key equipment: flares, blowers, LFG treatment, flow measurement devices, gas analyzers, etc. will be provided by specialty manufacturers from other countries. Thus the project would provide a significant opportunity for technology transfer, with design, equipment and installations complying with international standards with regard to quality, reliability, operational safety and environmental aspects.

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

Table 1: Estimation of emission reduction at Fundo Las Cruces landfill, including methane destruction and electricity (from fossil fuel combustion) displacement.

Year	Estimation of emission reduction in tonnes of CO_2e
2008 (from April)	18,529
2009	34,719
2010	41,224
2011	50,459
2012	56,904
2013	63,810
2014	69,794
2015 (up to March)	18,843
Total estimated reductions during the first crediting period (tonnes of CO_2e)	**354,288**
Total number of crediting years in first crediting period	**7**
Annual average over the first crediting period of estimated reductions (tonnes of CO_2e)	**50,612**

A.4.5. Public funding of the project activity:

The project sponsors will not receive any national or international public funding whatsoever for the development of this project.

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:

The baseline and monitoring methodology to be applied for the proposed project activity is the approved consolidated methodology ACM0001, version 7 (valid from November 02, 2007), from CDM Executive Board 35th meeting: ***"Consolidated baseline and monitoring methodology for landfill gas project activities"***.

For project emissions calculation or emissions reduction associated with electricity generation using landfill gas and eventual project emissions from electricity consumption from the grid, ACM0001 recommends the ***"Tool to calculate the emission factor for an electricity system",*** from CDM Executive Board 35th Meeting, Annex 12. This is Version 1 of the Tool.

We use the ***"Tool to calculate project emissions from electricity consumption"***, recommended by the Executive Board 32nd Meeting Report, Annex 10. This is Version 1 of the Tool.

We use the ***"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 01)"*** recommended by the Executive Board 32nd Meeting report, Annex 09.

For additionality assessement, we use the tool recommended by the CDM Executive Board (as Annex 1 of their 16th Meeting Report) ***"Tool for the demonstration and assessment of additionality, version 3"***.

In order to determine the flare efficiency and/or to monitor the flare exhaust gases, we use the ***"Tool to determine project emissions from flaring gases containing methane"*** recommended by the CDM Executive Board 28th Meeting Report, Annex 13. It is implicitly Version 1 of the Tool.

In order to estimate the potential LFG recovery rate for the landfill, we use the ***"Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"*** , recommended by the CDM Executive Board at its 35th Meeting Report, Annex 10. It is implicitly Version 1 of the Tool.

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

The methodology chosen 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; and/or*
b) *The captured gas is used to produce energy (e.g. electricity/thermal energy);*
c) *The captured gas is used to supply consumers through natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodologies AM0053.*

The proposed project activity corresponds to the first and second of these three alternatives. The collected landfill gas will generally be flared —option a) above— or would be used to produce energy. Thus, the gas would be used on-site as fuel at a leachate evaporation plant (thermal use) or to generate electricity to meet power requirements of the project itself or for other applications at the landfill site, and for sale to the power grid. Emissions reductions would be claimed for displacing electricity from the grid.

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

According to ACM0001 baseline and monitoring methodology, the project boundary is the site of the project activity where the gas will be captured and destroyed/used. The project boundary should encompass the physical, geographical site of the renewable generation source.

ACM0001 version 7 states: *"If the electricity for project activity is sourced from grid or electricity generated by the LFG captured would have been generated by power generation sources connected to the grid, the project boundary shall include all the power generation sources connected to the grid to which the project activity is connected."*

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

Table 2: Summary of gases and sources included in the project boundary, and justification / explanation where gases and sources are not included.

	Source	Gas	Included?	Justification/Explanation
Baseline	P Emissions from decomposition of waste at the landfill site (Passive LFG venting and no flaring)	CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted.
		CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are very small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
	Emissions from electricity consumption	CO_2	Yes	Electricity may be consumed from the grid or generated onsite/offsite in the baseline scenario.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from thermal energy generation	CO_2	Yes	If thermal energy generation is included in the project activity.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	Yes	May be an important emission source.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	Yes	May be an important emission source.
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small.
	Active LFG capture and flaring	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable
	LFG combustion for thermal energy generation	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable
	LFG combustion for power generation	CO_2	No	It is not considered because it is part of the natural carbon cycle.
		CH_4	Yes	Included as main component of LFG.
		N_2O	No	Not applicable

For the determination of baseline emissions of the possible electricity generation component of the project, the project boundary will account for the CO_2 emissions from electricity generation in fossil fuel power stations operating in the grid system, which will be displaced by electricity generated in the project activity. For the electricity generation component, according to the methodological "**Tool to**

calculate the emission factor for an electricity system", (ver. 1), *"a project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity".*

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

ACM0001, version 7, establishes procedures for the selection of the most plausible scenario. According to them, there are two steps to be followed:

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

The methodology states:

> *"Project participants should use step 1 of the latest version[1] of the "Tool for the demonstration and assessment of additionality", to identify all realistic and credible baseline alternatives. In doing so, relevant policies and regulations related to the management of landfill sites should be taken into account. Such policies or regulations may include mandatory landfill gas capture or destruction requirements because of safety issues or local environmental regulations. Other policies could include local policies promoting productive use of landfill gas such as those for the production of renewable energy, or those that promote the processing of organic waste. In addition, the assessment of alternative scenarios should take into account local economic and technological circumstances."*

Step 1 of the tool (Identification of alternatives to the project activity consistent with current laws and regulations) comprises a number of sub-steps:

"Sub-step 1a. Define alternatives to the project activity."
ACM0001, version 7, indicates the separate determination of applicable baselines for landfill capture and for electricity generation. The possible alternatives for each part are considered below, using the codes defined in ACM0001, ver. 7.

ACM0001, ver. 7 states:
"Alternatives for the disposal/treatment of the waste in the absence of the project activity, i.e. the scenario relevant for estimating baseline methane emissions, to be analysed should include, inter alia:

- *LFG1. The project activity (i.e. capture of landfill gas and its flaring and/or its use) undertaken without being registered as a CDM project activity;*
- *LFG2. Atmospheric release of the landfill gas or partial capture of landfill gas and destruction to comply with regulations or contractual requirements or to address safety and odour concerns."*

In principle, solid waste could be disposed off in other ways besides landfills, e.g. incineration, composting, conversion to Refuse-derived fuel (RDF), thermochemical gasification, and biomethanation. None of these are realistic alternatives for the project proponents, who have an obligation to the

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[1] As mentioned earlier, we use Version 3 of the Tool.

government to dispose solid waste at the specific landfill, and there is enough space and capacity to use the landfill for many years in the future. Moreover, these alternatives all involve advanced processes for treatment of solid waste; they all require very large investments and high operating costs compared to landfilling[2]. Finally, there is only limited experience with these alternative processes in Annex 1 countries, and almost none in non-Annex 1 countries, except for a handful of projects being submitted through the CDM.

Therefore, options LFG1 and LFG2 are the only realistic alternatives.

The project proposes to generate a certain amount of electricity. ACM0001 states:
"If LFG is used for generation of electric energy for export to a grid and/or to a nearby industry, or used on-site realistic and credible alternatives should also be separately determined for power generation in the absence of the project activity.

For power generation, the realistic and credible alternative(s) may include, inter alia:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity;
P2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant;
P3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant;
P4. Existing or Construction of a new on-site or off-site fossil fuel fired captive power plant;
P5. Existing or Construction of a new on-site or off-site renewable based captive power plant;
P6. Existing and/or new grid-connected power plants."

Other renewable sources are not applicable to the project site, so that options P3 and P5 may be discarded. Similarly fossil-fuel-based captive power plants or cogeneration plants would not be economically competitive with purchasing power from the grid, so that P2 and P4 may also be discarded.

The only remaining options for plausible baselines are then:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and
P6. Power plants connected to the grid.

The project also proposes to generate some thermal energy for on-site use. ACM0001 states:

"*For heat generation, the realistic and credible alternative(s) may include, inter alia:*
H1. Heat generated from landfill gas undertaken without being registered as CDM project activity;
H2. Existing or Construction of a new on-site or off-site fossil fuel fired cogeneration plant;
H3. Existing or Construction of a new on-site or off-site renewable based cogeneration plant;
H4. Existing or new construction of on-site or off-site fossil fuel based boilers;
H5. Existing or new construction of on-site or off-site renewable energy based boilers;
H6. Any other source such as district heat; and
H7. Other heat generation technologies (e.g. heat pumps or solar energy)."

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[2] For instance, even the least expensive of these alternatives, composting, to be economically viable, the waste management company must receive USD 20 - 40 per tonne of waste. Source: *International Source Book on Environmentally Sound Technologies (ESTs) for Municipal Solid Waste Management (MSWM)*, Report of the United Nations Environment Programme, Division of Technology, Industry, and Economics. http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/sp/sp4/sp4_1.asp

No credits will be claimed for emissions displaced by LFG used for heat in this project, because this emission reduction is assumed to be very small (this is conservative). Therefore, the most appropriate baseline is:
H1. Heat generated from landfill gas undertaken without being registered as CDM project activity; and no heat generation.

Thus the options listed above (LFG1 and LFG2; P1 and P6; and H1) are the only realistic alternatives to be considered as possible alternative baselines. These alternatives will be considered below and further analyzed, in Section B.5.

ACM0001, version 7 states how national and sectoral policies must be taken into account using Sub-step 1b of the additionality tool and the adjustment factor *AF*.

"Sub-step 1b. Consistency with mandatory laws and regulations".

This sub-step requires that:

> *"The alternative(s) shall be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. to mitigate local air pollution.."*

There are no national or regional laws requiring landfill gas capture and flaring/use. The Environmental Impact Assessment (EIA), approved by the Regional Environmental Commission ("CONAMA Region del Bio-Bio") in November 1999, states that the LFG would be treated with controlled burning, but this has not happened because the amount of gas that would be captured with the current density of gas wells would not justify the system installation. Moreover, the existing final cover enables the release of almost all the gas to the atmosphere. The new project activity will increase the well density and will cover the waste mass with geomembrane, enabling the optimal conditions for a landfill gas recovery system.

It is important to note that Fundo Las Cruces was one of the first landfills in Chile that entered into the Environmental Impact Evaluation System (Sistema de Evaluación de Impacto Ambiental, SEIA) in 1999. On a voluntary basis, the Environmental Impact Assessment (EIA) submitted by HERA Ecobio S.A. establishes more commitments than the ones required by the local authorities; therefore it is one of the best managed landfills in Chile.

Current practice in the country is the uncontrolled release of landfill gas. At present there are no projects similar to that proposed here: the active collection and flaring/use of landfill gas, with the exception of projects under CDM structure which are made possible due to carbon credits revenues.

In the current configuration (baseline scenario) of passive venting system, undertaken to meet safety requirements at Fundo Las Cruces Landfill, all the landfill gas is being released to the atmosphere. The existing well density is low (less than 2 wells per hectare), considering that a medium drainage of gas consists of about 5 wells per hectare. In this particular project, HERA is planning to install an average of 4 vertical wells per hectare.

As there is no destruction of landfill gas in the baseline scenario, the adjustment factor (*AF*) is assumed to be 0%.

Therefore both LFG1 and LFG2 would comply with local regulations, and the current situation at Fundo Las Cruces Landfill corresponds to LFG2 above. This scenario meets all legal requirements established by the local environmental authorities.

ACM0001, ver. 7 further declares:

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

For power generation we have considered two plausible baselines:
P1. Power generated from landfill gas undertaken without being registered as CDM project activity, and
P6. Power plants connected to the grid.

There is no specific fuel choice to be made. The fuels in the power plants connected to the grid are what they are, with their emissions factor determined by the methodological "**Tool to calculate the emission factor for an electricity system"** (ver. 1), depending on the power generated using LFG, that would be generated in the grid in the baseline.

As for LFG used for heat, we have assumed, very conservatively, that this heat does not displace any fossil fuel used in the baseline. Thus no baseline fuel needs to be chosen for this case.

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):

A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would occur in the absence of the registered CDM project activity, i.e. in the baseline scenario.

Following a review of how individual baseline methodologies deal with the issue of additionality, the CDM Executive Board published, as Annex 1 of their 16th Meeting Report, a "Tool for the demonstration and assessment of additionality." Note that version 7 of *Approved consolidated baseline and monitoring methodology ACM0001* "Consolidated baseline and monitoring methodology for landfill gas project activities" makes the following comment regarding additionality:

> *"Step 2 and/or step 3 of the latest approved version of the "Tool for demonstration and assessment of additionality" shall be used to assess which of these alternatives should be excluded from further consideration."*

Thus, in keeping with ACM0001, we apply the mentioned "Tool for the demonstration and assessment of additionality, version 3".

After applying Step 1 of the Additionality Tool in section B.4 above, the additionality tool then offers two options: Step 2 (Investment Analysis) or Step 3 (Barrier Analysis), with a third option of applying both Steps.

ACM0001, ver. 7 requires that the additionality test "*shall be applied for each component of the baseline, i.e. baseline for waste treatment, electricity generation and heat generation*".

With this in mind, the alternative LFG1 may be further subdivided as follows:
LFG1.1. Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralised flaring;
LFG1.2. Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for electricity generation;
LFG1.3. Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for heat generation; and
LFG1.4. Disposal of the waste at the landfill with ***active*** extraction of landfill gas and use of landfill gas for electricity and heat generation.

First we consider LFG1.1, and we apply ***Step 2 (Investment Analysis)*** of the Additionality Tool.

Here it can be seen that LFG1.1 (active landfill gas collection and centralised flaring) involves substantial investments and no revenues, in the absence of the CDM. Hence, on the basis of a Simple Cost Analysis (Investment Analysis, Option 1), we can discard this option as a possible baseline scenario.

Something similar happens with on-site thermal use of the landfill gas (LFG1.3), specifically if HERA Ecobio uses it as fuel for leachate evaporation. As HERA is currently operating two advanced leachate treatment plants (one at the MSW landfill and the other at the industrial landfill), by the use of reverse osmosis technology, the thermal use of the LFG for leachate evaporation would involve additional investment and no revenues, in the absence of the CDM. Therefore, on the basis of a Simple Cost Analysis (Investment Analysis, Option 1), we can also discard LFG1.3 as a possible baseline scenario.

Since heat generation has no value (as it was discarded as possible baseline scenario), there is no difference between options LFG 1.2 and LFG 1.4, so that we can denominate this combined option as LFG 1.2.

For electricity generation (alternatives LFG1.2 and LFG1.4), there are substantial investments as well as revenues from electricity sales, so that the additionality should be carefully evaluated.

In the spirit of ACM0001, ver. 7, we consider the following two possible baselines for evaluating the additionality of power generation:

1. LFG2. Disposal of the waste at the landfill with no burning of gas passively vented from the landfill, so that baseline destruction of LFG is zero.
2. LFG1.1 Disposal of the waste at the landfill with ***active*** extraction of landfill gas and centralised flaring.

The two situations differ in the following way. In the first case, the economic benefits from electricity generation need to be more than the investments and operating costs of LFG collection and electricity generation, with no CDM revenues. In the second case, CDM revenues are sufficient to pay for LFG collection and flaring, and we need to determine if the *marginal investments and operating costs* for power generation are adequately compensated by the benefits from electricity sales.

To be conservative in making the economic analysis for the electricity generation alternatives, we assumed in this case that thermal generation will be zero, thus most of the gas could be used for generating electricity. The LFG flow rates, the electricity generation capacity, the CER estimation and all other calculations used for this analysis are presented in “Fundo Las Cruces_CER estimation_ACM0001 ver7 (28Nov07) – elec". Please note that this spreadsheet is only used to support the additionality demonstration; this is not expected to be a plausible scenario.

Case 1: LFG collection and electricity generation without the CDM

For electricity generation, there are substantial investments as well as revenues from electricity sales. We determine the cost effectiveness for LFG capture and power generation in the absence of the CDM. Our analysis is based on the following assumptions[3]:

- Substantial investments are required to capture LFG. These include the construction of active extraction wells, a well field and blowers, etc. to collect the LFG and take it to the location where the power plant would be located. For this project, this involves about US$ 0.52 million in 2008, about US$ 0.43 million y 2010, 2020 and 2025, and about US$ 30,000 yearly during the other years for well field expansion as the landfill expands.
- Operating costs for landfill gas collection are expected to be US$ 75,000 in 2008 and increase slowly as the landfill expands. These costs include: electricity consumption costs, salaries, equipment calibration and maintenance, insurance, well field and flare station maintenance, and contingency.
- LFG power generators, each with a capacity of 1,000 kW, would be purchased in 2008, 2014, 2018, 2022 and 2024, for a total investment including auxiliary equipment, such as power conditioning and connections, of 1 million dollars. The first power generator would be operational in 2009 and maximum generation capacity would reach 2,500 kW in 2023.
- The generators would cost US$ 850,000. This does not include power conditioning equipment, engine room, engineering and installation costs. Including these elements, we estimate total investments to be US$ 1,000,000.
- Operation and maintenance cost: US$ 0.03 per kWh. Small, internal combustion engines have high operation and maintenance costs. Equipment would be imported from Europe or from North America. There is no experience in Chile with power generation using LFG equipment. Thus, we feel this value is conservative.
- Equipment life: 10 years.
- Electricity sale price (levelised): US$0.05 per kWh, for sale to the grid, including estimated wheeling charges. 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.
- Corporate tax rate: 17%.
- Discount rate: 10%. Note that 10-year bonds of the Chilean government are currently offered at an interest rate of 5.15% (on July 2007, when this analysis was done, http://si2.bcentral.cl/Basededatoseconomicos/951_455.asp?f=M&s=TPM&LlamadaPortada=SI). 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

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[3] Note that the size and timing of generators to be installed will depend on equipment availability at the time specific decisions are made. The size and dates shown here are representative assumptions.

investment would be 12.15%. The chosen benchmark discount rate of 10% is therefore conservative.

The detailed economic analysis is shown in the electronic workbook:
Economic analysis LFG capture and power generation_FLC_26Nov07.xls.

For the assumptions stated above, the NPV for LFG capture and electricity generation is negative (about US$ -2.06 million), in the absence of the CDM. Indeed the value is so negative, that no meaningful IRR can be determined. (This means that even if the discount rate were zero, the revenues are less than expenses.) The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. Over the range considered, the NPV remains negative (and the IRR remains meaningless), which means that the project is not profitable without CER revenues.

Table 3. Sensitivity Analysis for LFG collection and electricity generation

Electricity Sale Price

	-20%	-10%	0%	10%	20%
NPV	(2,462,074)	(2,258,687)	(2,055,300)	(1,851,913)	(1,648,527)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

O&M Costs

	-20%	-10%	-	10%	20%
NPV	(1,707,980)	(1,881,640)	(2,055,300)	(2,228,960)	(2,402,620)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

Investment

	-20%	-10%	-	10%	20%
NPV	(1,584,787)	(1,820,043)	(2,055,300)	(2,290,557)	(2,525,813)
IRR	N.A.	N.A.	N.A.	N.A.	N.A.

With CER revenues, assuming a CER price of US$ 10 per tCO_2e, the NPV would be US$ 0.26 million and the IRR would be 13.17%, and the project would be profitable.

Thus, for this case, the proposed project meets the condition of economic additionality.

Case 2: LFG collection and flaring through CDM and electricity generation without the CDM (marginal case)

The assumptions are similar to those above, the only difference being that investments and operating costs for LFG collection are not considered, since these are justified on the basis of CDM revenues. In other words, we determine if the electricity generation component is additional.

The detailed economic analysis for this case is shown in the electronic workbook:
Economic analysis LFG capture and power generation_marginal_FLC_26Nov07.xls.

In the absence of CDM revenues, the NPV would be negative, about: US$ -636,000. The IRR would be -10.94%, i.e. not cost effective. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. The results of the sensitivity analysis are shown in the table below. The project would not be cost effective either with CERs revenues, or without CER revenues.

Table 4. Sensitivity Analysis for electricity generation only

Electricity Sale Price

	-20%	-10%	0%	10%	20%
NPV	(1,015,475)	(818,441)	(636,437)	(458,773)	(289,961)
IRR	N.A.	N.A.	-10.94%	-3.77%	1.94%

O&M Costs

	-20%	-10%	0%	10%	20%
NPV	(425,010)	(529,838)	(636,437)	(743,036)	(856,578)
IRR	-2.54%	-6.46%	-10.94%	N.A.	N.A.

Investment

	-20%	-10%	0%	10%	20%
NPV	(351,988)	(494,213)	(636,437)	(778,662)	(920,887)
IRR	-3.00%	-7.17%	-10.94%	N.A.	N.A.

The economic additionality for Case 1 and Case 2 were clearly established above. Nevertheless, we will reinforce this analysis by using barrier analysis to demonstrate additionality.

Therefore, we also apply ***Step 3 (Barrier Analysis)*** of the Additionality Tool, with special reference to electricity generation using LFG.

In order to apply barrier analysis to the proposed project activity, we are required to show that the project activity faces barriers that:

(a) Prevent a wide spread implementation of this activity and thus preventing the baseline scenarios from occurring; and
(b) Do not prevent a wide spread implementation of at least one of the alternatives.

The demonstration involves two sub-steps:

"Sub-step 3a. Identify barriers that would prevent a wide spread implementation of the proposed CDM project activity".

The tool states:

"It is necessary to establish that there are realistic and credible barriers that would prevent the proposed project activity from being carried out if the project were not registered as a CDM activity. Such realistic and credible barriers may include, among others:

1) *Investment barriers, other than the economic/financial barriers in Step 2 above,* inter alia*:*

- *For alternatives undertaken and operated by private entities: Similar activities have only been implemented with grants or other non-commercial finance terms. Similar activities are defined as activities that rely on a broadly similar technology or practices, are of a similar scale, take place in a comparable environment with respect to regulatory framework.*
- *No private capital is available from domestic or international capital markets due to real or perceived risks associated with investment in the country where the proposed CDM project activity is to be implemented, as demonstrated by the credit rating of the country or other country investments reports of reputed origin.*

2) *Technological barriers,* inter alia*:*
   - *Skilled and/or properly trained labour to operate and maintain the technology is not available, which leads to an unacceptably high risk of equipment disrepair and malfunctioning or other underperformance;*
   - *Lack of infrastructure for implementation and logistics for maintenance of the technology (e.g. natural gas can not be used because of the lack of a gas transmission and distribution network).*
   - *Risk of technological failure: the process/technology failure risk in the local circumstances is significantly greater than for other technologies that provide services or outputs comparable to those of the proposed CDM project activity, as demonstrated by relevant scientific literature or technology manufacturer information.*
   - *The particular technology used in the proposed project activity is not available in the relevant region.*
3) *Barriers due to prevailing practice,* inter alia*:*
   - *The project activity is the "first of its kind".*
4) *Other barriers, preferably specified in the underlying methodology as examples."*

According to our interpretation of ACM0001, ver. 7, the proposed project activity for which we need to demonstrate additionality needs to be divided into two parts:

- LFG collection and flaring
- LFG collection for thermal use
- LFG collection for electricity generation using LFG (Case 2-marginal)

Below, we show that both two parts face technological barriers as well as barriers due to prevailing practice.

Technological barriers

Skilled and/or properly trained labour to operate and maintain the technologies involved (LFG collection, use of LFG for electricity) is scarcely available in Chile, leading to difficulties in equipment operation and maintenance.

There is also a lack of infrastructure for implementation of the technology. There are no Chilean providers of equipment and services for work related to landfill gas recovery and use. If the proposed project is registered under the CDM, it will be a company outside Chile (like HERA Holding in Spain) that would have to provide technical expertise in order to conduct detailed engineering studies and support project implementation.

It is possible that the successful implementation of the proposed project and a few others in Chile would be the key to breaking the technological barriers to this type of project.

Considering specifically the case of disposal of the waste at the landfill with delivery of gas captured from the landfill site to nearby industry for heat supply, we may note that the landfill is located in an isolated area very distant from an industrial centre. So this alternative becomes very difficult to be implemented due to the difficulty to find an end user for the energy and if so, the costs of transportation are likely to make the business unfeasible.

For electricity and thermal generation using LFG, we may also note that there is no experience in Chile for electricity or thermal generation using LFG outside the CDM. Indeed we do not know of any use of LFG use for electricity even within the few landfill gas projects registered within the CDM. Thus, this option faces significant barriers too, especially for the project operators, whose primary experience is in waste handling and disposal, and not in the power sector.

Barriers due to prevailing practice

The proposed project activity would be one of the first of its kind in Chile. As mentioned above, there are very few landfill gas recovery and use projects in Chile, so that the uncontrolled release of landfill gas is common practice. These other projects to capture landfill gas in Chile have all been proposed within the CDM context in recent months, so that they are in the early part of the learning curve, and it will be several years before LFG collection with or without power generation is a well established technology in Chile.

The additionality tool also provides a Sub-step 3b.

"Sub-step 3 b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)".

The barriers identified above apply to the combination of activities involving LFG collection and use of LFG for electricity. The barriers identified do not prevent the continuation of the current situation at the landfill —passive venting of landfill gas with no burning— which does not require additional investments neither additional training nor skilled workers.

The tool now states: "*If both Sub-steps 3a – 3b are satisfied, proceed to Step 4 (Common practice analysis).*"

"Step 4. Common practice analysis"

The tool states:

> *"The above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3)."*

Step 4 comprises two Sub-Steps, which are discussed below.

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

> *"Provide an analysis of any other activities implemented previously or currently underway that are similar to the proposed project activity. Projects are considered similar if they are in the same country and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Provide quantitative information where relevant."*

As it has been stated in the context of Step 3 above, with the exception of the seven landfills registered during 2006 and 2007 as CDM projects, there is no other project of this kind currently operating in Chile.

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

As stated above, there are a few projects of gas collection and flaring or use currently under development in Chile. All these projects are being presented under the CDM.

The proposed project activity meets the conditions of Step 4 of the Additionality tool.

Thus, we can assert that all components of the proposed project activity —active collection for flaring, thermal use of collected LFG, and electricity generation using LFG— are additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

According to ACM0001, version 7:

The greenhouse gas emission reduction achieved by the project activity during a given year *"y" (ER_y)* is given by:

$$BE_y = \left(MD_{project,y} - MD_{reg,y}\right) * GWP_{CH_4} + EL_{LFG,y} * CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y} \qquad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e).
$MD_{project,\,y}$	=	Amount of methane destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario.
$MD_{reg,y}$	=	Amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tonnes of methane (tCH_4).
GWP_{CH4}	=	Global Warming Potential value for methane for the first commitment period is 21 tCO_2e/tCH_4.
$EL_{LFG,y}$	=	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year *y*, in megawatt hours (MWh).
$CEF_{elec,BL,\,y}$	=	CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh.
$ET_{LFG,y}$	=	The quantity of thermal energy produced utilizing the landfill gas, which in the

		absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year *y* in TJ.
$CEF_{ther,BL,y}$	=	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ.

Note that there are uses of electricity unrelated to the project activity that would remain in the absence of the project. Following project implementation, some of the electricity generated using landfill gas may go to meet this demand, and not exported out of the site.

ACM0001, version 7 offers several ways for determining MD_{reg}. One option is *"In cases where regulatory or contractual requirements do not specify* $MD_{reg,y}$ *an "Adjustment Factor" (AF) shall be used and justified, taking into account the project context."*

$$MD_{reg,y} = MD_{project,y} \times AF \qquad \textbf{(2)}$$

This is the approach taken in this PDD. As discussed in section B.4, an appropriate value of *AF* is 0%, thus $MD_{reg,y}$ will be zero too.

In order to calculate $MD_{project,y}$, the methodology states:

"The methane destroyed by the project activity ($MD_{project,y}$*) during a year is determined by monitoring the quantity of methane actually flared and gas used to generate electricity and/or produce thermal energy, if applicable, and the total quantity of methane captured."*

"The sum of the quantities fed to the flare(s), to the power plant(s) and to the boiler(s) and to the natural das distribution network (estimated using equation (3)), must be compared annually with the total quantity of methane captured[4]. The lowest value of the two must be adopted as $MD_{project,y}$*".*

This is meant to be conservative, claiming the lower amount of methane destroyed. In case the total methane collection is the highest, $MD_{project,y}$ is given by:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y} \qquad \textbf{(3)}$$

Where:

$MD_{flared,y}$	=	Quantity of methane destroyed by flaring (tCH_4)
$MD_{electricity,y}$	=	Quantity of methane destroyed by generation of electricity (tCH_4)
$MD_{thermal,y}$	=	Quantity of methane destroyed for the generation of thermal energy (tCH_4)
$MD_{PL,y}$	=	Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)

In the case of Fundo Las Cruces Landfill, the LFG will not be sent to pipelines for feeding the natural gas distribution network, thus $MD_{PL,y}$ will be zero.

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[4] ACM0001 version 7 (and earlier versions) refers to the total quantity of methane generated, but this is believed to be an error, because it is not possible to monitor methane generation. Moreover, the quantities of methane captured will be fed to the flare(s), power plant(s) and thermal plant(s), thus methane destroyed in project will be related to methane *captured*.

Then, the methodology states: *"Right Hand Side of the equation (3) is sum over all the points of captured methane use in case the methane is flared in more than one flare, and/or used in more than one electricity generation source, and/or more than one thermal energy generator. The supply to each point of methane destruction, through flaring or use for energy generation, shall be measured separately."*

Calculation of $MD_{flared,y}$:

$$MD_{flared,y} = \left(LFG_{flare,y} * w_{CH4,y} * D_{CH4}\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \qquad \textbf{(4)}$$

Where:

$MD_{flared,y}$	=	Quantity of methane destroyed by flaring (tCH_4)
$LFG_{flare,y}$	=	Is the quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3)
w_{CH4}	=	Is the average methane fraction of the landfill gas as measured[5] during the year and expressed as a fraction (in m^3 CH_4 / m^3 LFG)
D_{CH4}	=	Is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)[6]
$PE_{flare,y}$	=	Are the project emissions from flaring of the residual gas stream in year y (tCO_2e) determined following the procedure described in the "*Tool to determine project emissions from flaring gases containing methane*" (ver. 1). If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the tool.

In order to determine the amount of methane sent to the flare in a year, we need to sum the mass of methane over the year. Since the methane fraction of landfill gas and gas density are, in general, changing with time, a more precise formula for methane destroyed by flaring is:

$$MD_{flared,y} = \left(\sum_{h=1}^{8760}(LFG_{flare,h} * w_{CH4,h} * D_{CH4,h})\right) - \left(\frac{PE_{flare,y}}{GWP_{CH4}}\right) \qquad \textbf{(4a)}$$

Here the mass of methane sent to the flare is determined hourly, with hourly values added over the year.

The gas density depends on temperature and pressure, and flow meter likely to be used for monitoring in LFG capture projects automatically compensate for gas density in flow measurement, so that in Eq (4a), $LFG_{flare,h}$ is already expressed in terms of standard temperature and pressure, so that $D_{CH4,h}$ (methane density) is in fact a constant, 0.0007168 tonnes/m³, at standard temperature and pressure conditions (0°C, 1.013 bar). Thus, in practice, there is no difference between equations (4) and (4a).

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[5] Methane fraction of the landfill gas to be measured on wet basis.

[6] At standard temperature and pressure (0 degree Celsius and 1.013bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

Not all the methane that reaches the flare is destroyed, and the *"Tool to determine project emissions from flaring gases containing methane"* (ver. 1) is meant to take this into account.

The tool differentiates between open and enclosed flares. The project proposed here would use enclosed flares, since these are more effective in destroying methane.

For enclosed flares, the Tool proposes two options to determine the flare efficiency*:*

> *(a) To use a 90% default value. Continuous monitoring of compliance with manufacturer's specification of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50%*[7] *default value for the flare efficiency should be used for the calculations for this specific hour.*
> *(b) Continuous monitoring of the methane destruction efficiency of the flare (flare efficiency).*

The Tool further requires that the temperature in the exhaust gas of the flare to be measured in order to determine whether the flare is operating or not. *"In both cases, if there is no record of the temperature of the exhaust gas of the flare or if the recorded temperature is less than 500 °C for any particular hour, it shall be assumed that during that hour the flare efficiency is zero."*

"This tool involves the following seven 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, oxygen and nitrogen in the residual gas
STEP 3: Determination of the volumetric flow rate of the exhaust gas on a dry basis
STEP 4: Determination of methane mass flow rate of the exhaust gas on a dry basis
STEP 5: Determination of methane mass flow rate of the residual gas on a dry basis
STEP 6: Determination of the hourly flare efficiency
STEP 7: Calculation of annual project emissions from flaring based on measured hourly values or based on default flare efficiencies.

Project participants shall apply these steps to calculate project emissions from flaring ($PE_{flare,y}$) based on the measured hourly flare efficiency or based on the default values for the flare efficiency ($\eta_{flare,h}$). Note that steps 3 and 4 are only applicable in case of enclosed flares and continuous monitoring of the 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."

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[7] Whenever the default value for the flare efficiency (either open flare or enclosed flare) is to be used for calculation of project emissions in equation T.15 below, the value should be converted into fraction (e.g. 50/100= 0.5) before use in the equation.

The project is likely to use the 90% default value. However, if project operator decides to monitor emissions continuously, then the Tool procedures for continuous monitoring will be applied. When continuous monitoring is not in place, the default value will be applied, thus Steps 3 and 4 of the Tool should not be included here.

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

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

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h} \qquad \textbf{(T.1)}[8]$$

Where:

$FM_{RG,h}$	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 hour *h*

And:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n} \qquad \textbf{(T.2)}$$

Where:

$\rho_{RG,n,h}$	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)

And:

$$MM_{RG,h} = \sum_i \left(fv_{i,h} * MM_i \right) \qquad \textbf{(T.3)}$$

Where:

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

[8] Equation numbers from the Tool are prefixed with the letter "T" to distinguish them from equations from the methodology.

The Tool states that "*As a simplified approach, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2).*"

Note that the Tool is applicable to a wide variety of residual gases to be flared, while landfill gas is the product of anaerobic decomposition, which does not produce hydrogen or carbon monoxide, so these two gases can be eliminated from the calculations, without any assumptions. The simplification proposed in the tool involves considering CO_2 and O_2 as N_2. While this leads to minor errors, we use this simplified approach, since it greatly simplifies measurements, and does not significantly affect the estimate of flare efficiency.

With this simplification, Eq. (T.3) becomes:

$$MM_{RG,h} = \sum_{i} \left(fv_{i,h} * MM_{i} \right) \qquad \textbf{(T.3a)}$$

Where:

$MM_{RG,h}$	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 (Note that only CH_4 would be measured and N_2 determined as the balance)

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

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

Step 2 states:

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

$$fm_{j,h} = \frac{\sum_{i} fv_{i,h} * AM_{j} * NA_{j,i}}{MM_{RG,h}} \qquad \textbf{(T.4)}$$

Where:

$fm_{i,h}$	-	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, oxygen and nitrogen. Note that the simplified approach, involving measurement of methane and assuming the balance to be nitrogen, implies that there is no elemental oxygen in the gas, and that all the carbon is in the form of methane. The only hydrogen is also in methane, but this

	does not involve any simplification, since there is no H_2 in the other components that might be present in landfill gas: CO_2 and O_2.
I	The components CH_4 and N_2 (Note that with the simplified approach, the concentrations of other gases would not be determined)

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

Since the methane combustion efficiency is to be continuously measured in the proposed project, this step is applicable.

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

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h} \quad \textbf{(T.5)}$$

Where:

$TV_{n,FG,h}$	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 hour *h*

$$V_{n,FG,h} = V_{n,CO_2,h} + V_{n,O_2,h} + V_{n,N_2,h} \quad \textbf{(T.6)}$$

Where:

$V_{n,FG,h}$	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*

$$V_{n,O_2,h} = n_{O_2,h} \times MV_n \quad \textbf{(T.7)}$$

Where:

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

The Tool states:

$$V_{n,N_2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{200AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times \left[F_h + n_{O_2,h} \right] \right\} \quad \textbf{(T.8)}$$

Where:

$V_{n, N2, h}$	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 hour *h*
$fm_{N, h}$	-	Mass fraction of nitrogen in the residual gas in the hour *h*
AM_N	kg/kmol	Atomic mass of nitrogen
MF_{O2}	-	O_2 volumetric fraction of air (0.21)
F_h	kmol/kg residual gas	Stoichiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour *h*

and other variables are as defined earlier.

Note that if the mass fraction is expressed as a fraction, as the definition above implies, and not as a %, the number in the first denominator of Eq. T.8 should be 2 and not 200, so that the correct equation would be:

$$V_{n,N_2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{2AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times \left[F_h + n_{O_2,h} \right] \right\} \quad \textbf{(T.8a)}$$

Next we have:

$$V_{n,CO_2,h} = \frac{fm_{C,h}}{AM_C} \times MV_n \quad \textbf{(T.9)}$$

Where:

$V_{n, CO2, h}$	m^3/kg residual gas	Quantity of CO_2 volume free in the flare exhaust gas 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

and other variables are as defined earlier.

$$n_{O_2,h} = \frac{t_{O_2,h}}{\left(1 - \left(t_{O_2,h} / MF_{O_2}\right)\right)} \times \left[\frac{fm_{C,h}}{AM_C} + \frac{fm_{N,h}}{2AM_N} + \left(\frac{1 - MF_{O_2}}{MF_{O_2}} \right) \times F_h \right] \quad \textbf{(T.10)}$$

Where:

$t_{O2, h}$ - Volumetric fraction of O_2 in the exhaust gas in hour *h*

and other variables are as defined earlier.

Note that the second term in the large brackets $[..]$ is $\frac{fm_{N,h}}{2AM_N}$, with 2 in the denominator, not 200, confirming our observation of Eq. (8) above.

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{O,h}}{2AM_O} \quad \textbf{(T.11)}$$

Where:

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*
$fm_{H,h}$	-	Mass fraction of hydrogen in the residual gas in hour *h*
$fm_{O,h}$	-	Mass fraction of oxygen in the residual gas in hour *h*
AM_H	kg/kmol	Atomic mass of hydrogen
AM_O	kg/kmol	Atomic mass of oxygen

and other variables are as defined earlier.

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

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

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH_4,FG,h}}{1{,}000{,}000} \quad \textbf{(T.12)}$$

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

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

The Tool states:
"The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis)."

Note that this is identical to the first part of our reformulation Eq. (4a) of Eq. (4) of ACM0001.

The Tool further elaborates:
"It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis)."

$$TM_{RG,h} = FV_{RG,h} * fv_{CH_4,RG,h} * \rho_{CH_4,n} \qquad \textbf{(T.13)}$$

Where:

$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*
$FV_{RG,h}$	m^3/h	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h*
$fv_{CH4,RG,h}$	-	Volumetric fraction of methane in the residual gas on dry basis in hour *h* (NB: this corresponds to $fv_{i,RG,h}$ where *i* refers to methane).
$\rho_{CH_4,n}$	kg/m^3	Density of methane at normal conditions (0.716)

Note that the Tool uses terms of the type $fv_{CH4,FG,h}$ in Eq. (T.12) expressed as mg/m^3 and similar terms $fv_{CH4,RG,h}$ in Eq. (T.13) expressed as a dimensionless quantity. While it would have been better if Equation (T.12) had used a different letter (other than "fv") to designate concentration, the equations are correct as long they are applied noting that there are two types of "fv".

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

Step 6: Determination of the hourly flare efficiency

The Tool states:
"The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the approach selected by project participants to determine the flare efficiency (default value or continuous monitoring)."
"In case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

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

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \qquad \textbf{(T.14)}$$

Where:

$\eta_{flare,h}$	-	Flare efficiency in hour *h*
$TM_{FG,h}$	kg/h	Methane mass flow rate in exhaust gas averaged in hour *h*[9]
$TM_{RG,h}$	kg/h	Mass flow rate of methane in the residual gas in the hour *h*

STEP 7. Calculation of annual project emissions from flaring

[9] Note that the first version of the Tool (EB28 Annex 13) defines $TM_{FG,h}$ as "Methane mass flow rate in exhaust gas averaged over a period of time t (hour, two months or year)". We believe this is a misprint. For hourly flare efficiency to be meaningfully determined, the definition should be as stated here in the PDD.

The Tool states:

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

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH_4}}{1000} \qquad \textbf{(T.15)}$$

Where:

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

In case of use of the default value for the methane destruction efficiency, the manufacturer's specifications for the operation of the flare and the required data and procedures to monitor these specifications should be documented in the CDM PDD."

Once project emissions $PE_{flare,\ y}$ has been calculated, the next formula from the methodology ACM0001 ver. 7 is:

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH_4,y} * D_{CH_4} \qquad \textbf{(5)}$$

Where:

$MD_{electricity,y}$	=	quantity of methane destroyed by generation of electricity (tCH_4/yr)
$LFG_{electricity,y}$	=	quantity of landfill gas fed into electricity generator (m^3/yr)
$w_{CH4,y}$	=	average methane fraction of the landfill gas as measured during the year (m^3 CH_4 /m^3 LFG)
D_{CH4}	=	methane density at normal conditions (tCH_4/m^3 CH_4)

Considering hourly variations in methane density and methane concentration in LFG, a more precise form of Eq. (5) is:

$$MD_{electricity,y} = \sum_{h=1}^{8760} (LFG_{electricity,h} * w_{CH_4,h} * D_{CH_4}) \qquad \textbf{(5.a)}$$

Then,

$$MD_{thermal,y} = LFG_{thermal,y} * w_{CH4,y} * D_{CH4} \qquad \textbf{(6)}$$

Where:

$MD_{thermal,y}$	=	quantity of methane destroyed for generation of thermal energy
$LFG_{thermal,y}$	=	quantity of landfill gas fed into the boiler or into the industrial wastewater evaporation system

Applying the same reasoning as that applied to electricity generation, the formula is modified as follows:

$$MD_{thermal,y} = \sum_{h=1}^{8760} (LFG_{thermal,h} * w_{CH_4,h} * D_{CH_4}) \qquad \textbf{(6.a)}$$

<u>Ex-ante estimation of the amount of methane destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$)</u>

Further, ACM0001 version 7 requests that:
"The ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$) will be done with the latest version of the approved "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"".

This tool was elaborated to calculate baseline emissions of methane from waste that would in the absence of the project activity, be disposed at solid waste disposal sites (SWDS). Emissions reducctions are calculated with a first order decay model. Despite the fact that this tool is for avoided waste to disposal sites, it is very useful in order to calculate the quantity of methane generated by the waste landfilled in this project case.

The main formula is:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k(y-x)} \cdot (1-e^{-kj}) \qquad \textbf{(TW.1[10])}$$

Where:

$BE_{CH4,SWDS,y}$	=	Methane emissions avoided during the year y from preventing waste disposal at the solid waste disposal site (SWDS) during the period from the start of the project activity to the end of the year y (tCO_2e)[11]
φ	=	Model correction factor to account for model uncertanties (0.9)
f	=	Fraction of methane captured at the SWDS and flared, combusted or used in another maner
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)
F	=	Fraction of methane in the SWDS gas (volume fraction) (0.5)
DOC_f	=	Fraction of degradable organic carbon (DOC) that can decompose
MCF	=	Methane correction factor
$W_{j,x}$	=	Amount of organic type j prevented from disposal in the SWDS in the year x (tonnes)
DOC_j	=	Fraction of degradable organic carbon (by weight) in the waste type j

[10] Equation numbers from the Waste Emission Tool are prefixed with the letter "TW" to distinguish them from equations from the methodology.

[11] Note that "methane emissions avoided" in this project case means methane emissions generated by the landfill. So, the period in consideration here will be since the landfill opening to the landfill closure.

k_j	=	Decay rate for the waste type j
j	=	Waste type category (index)
x	=	Year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year y for which avoided emissions are calculated (x=y)
y	=	Year for which methane emissions are calculated

The value and source of information for each of the variables above are given in section B.6.2. and Annex 3.

ACM0001 further states:

$$MD_{project,y} = \frac{BE_{CH_4,SWDS,y}}{GWP_{CH_4}} \quad \textbf{(8)}$$

Then, ACM0001 establishes different ways to determine the CO_2 emissions factors involved in the estimation of project emissions and in the estimation of additional emissions reduction due to energy displacement.

Determination of $CEF_{elec,BL,y}$:

The methodology states: *"In case the baseline is electricity generated by plants connected to the grid the emission factor should be calculated* according to "Tool for calculation of emission factor for electricity systems"".

Determination of $CEF_{elec,BL,y}$

The methodology states: "*In case the baseline is electricity generated by plants connected to the grid the emission factor should be calculated according to "Tool for calculation of emission factor for electricity systems*"".

The calculation of the emission factor for the electricity system is demonstrated in Annex 3 using the tool recommended.

Determination of $CEF_{ther,BL,y}$

The formula provided by the methodology is as follows:

$$CEF_{therm,BL,y} = \frac{EF_{fuel,BL}}{\varepsilon_{boiler} \cdot NCV_{fuel,BL}} \quad \textbf{(10)}$$

Where:

ε_{boiler}	=	The energy efficiency of the boiler used in the absence of the project activity to generate the thermal energy
$NCV_{fuel,BL}$	=	Net calorific value of fuel, as identified through the baseline identification procedure,

used in the boiler to generate the thermal energy in the absence of the project activity in TJ per unit of volume or mass

$EF_{fuel,BL}$ = Emission factor of the fuel, as identified through the baseline identification procedure, used in the boiler to generate the thermal energy in the absence of the project activity in tCO_2 / unit of volume or mass of the fuel

According to the methodology, the boiler[12] efficiency can be assessed by two options:

"Option A: Use the highest value among the following three values as a conservative approach:

1. *Measured efficiency prior to project implementation;*
2. *Measured efficiency during monitoring;*
3. *Manufacturer's information on the [thermal plant] efficiency*

Option B: Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach."

Here we choose *Option B* above in order to be conservative.

For EF_{fuel} the methodology states: "*In determining the CO_2 emission factors (EF_{fuel}) of fuels, reliable local or national data should be used if available. Where such data is not available, IPCC default emission factors should be chosen in a conservative manner*".

Project Emissions:

$$PE_y = PE_{EC,y} + PE_{FC,j,y} \quad \textbf{(11)}$$

Where:

$PE_{EC,y}$ = Emissions from consumption of electricity in the project case. The project wmissions from electricity consumption ($PE_{EC,y}$) will be calculated following the latest version of *"Tool to calculate project emissions from electricity consumption"*. We used Version 1 of the Tool. If in the baseline a part of LFG was captured then the electricity quantity used in calculation is electricity used in the project activity net of that consumed in the baseline.

$PE_{FC,j,y}$ = Emissions from consumption of heat in the project case. The project emissions from fossil fuel consumption ($PE_{FC,j,y}$) will be calculated following the latest version of *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*. We used Version 1 of the Tool. For this purpose, the processes j in the tool corresponds to all fossil fuel combustion in the landfill, as well as any other on-site fuel combustion for the purposes of the project activity. If in the baseline part of a LFG was captured, then the heat quantity used in calculation is fossil fuel used in project activity net of that consumed in the baseline.

$PE_{EC,y}$ will be calculated using the "Tool to calculate project emissions from electricity consumption", ver. 1.

[12] In the general case, this can be any heat producing equipment. For this project, it is a leachate evaporation plant.

The tool presents three different possibilities, and the Fundo Las Cruces Landfill Project is inserted in Case A: Electricity consumption from the grid. In this case, the tool declares:
"Project emissions from consumption of electricity from the grid are calculated based on the power consumed by the project activity and the emission factor of the grid, adjusted for transmission losses, using the following formula:"

$$PE_{EC,y} = EC_{PJ,y} \times EF_{grid,y} \times (1 + TDL_y) \quad \textbf{(TE.1}^{13}\textbf{)}$$

Where:

$PE_{EC,y}$	=	Are the project emissions from electricity consumption by the project activity during the year y (tCO_2 / yr)
$EC_{PJ,y}$	=	Is the quantity of electricity consumed by the project activity during the year y (MWh)
$EF_{grid,y}$	=	Is the emission factor for the grid in year y (tCO_2/MWh)
TDL_y	=	Are the average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.

The value and source of information for the elements above are given in section B.6.3 and B.7.1.

$PE_{FC,j,y}$ will be calculated according to the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (ver. 1)* and is given by the formula:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad \textbf{(TF.1}^{14}\textbf{)}$$

Where:

$PE_{FC,j,y}$	=	Are the CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr)
$FC_{i,j,y}$	=	Is the quantity of fuel type i combusted in process j during the year y (mass or volume unit / yr)
$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
i	=	Are the fuel types combusted in process j during the year y

In order to calculate $COEF_{i,y}$, we chose the Option B of the tool, that is:
"The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type i, as follows:"

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad \textbf{(TF.4)}$$

Where:

$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type i in year y
$NCV_{i,y}$	=	Is the weighted average net calorific value of the fuel type i in year y (GJ/mass or

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[13] Equation numbers from the Electricity Consumption Tool are prefixed with the letter "TE" to distinguish them from equations from the methodology.

[14] Equation numbers from the Fossil Fuel Consumption Tool are prefixed with the letter "TF" to distinguish them from equations from the methodology.

volume unit)

$EF_{CO2,i,y}$	=	Is the weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)
i	=	Are the fuel types combusted in process j during the year y.

At last, according to ACM0001 ver.7, emission reduction can be calculated as follows:

$$ER_y = BE_y - PE_y \quad \textbf{(12)}$$

Where:

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

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

Some of the parameters and data used in these equations are not monitored since they are constants, as listed in the table below. Most of the table is taken directly from the **"Tool to determine project emissions from flaring gases containing methane"**, ver. 1. The remaining parameters and data that are available at the time of validation, and are not monitored are listed in individual data tables further below.

Table 5: Parameters and data used in equations that are not monitored.

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101,325
R_u	Pa m^3/kmol K	Universal ideal gas constant	8,314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O_2 volumetric fraction of air	0.21
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane	21
MV_n	m^3/kmol	Volume of one mole of any ideal gas at normal temperature and pressure	22.414
$\rho_{CH4,n}$ / D_{CH4}	kg/m^3	Density of methane gas at normal conditions	0.7168
$NA_{i,j}$	Dimensionless	Number of atoms of element *j* in component *i*, depending on molecular structure	

Data / Parameter:	Regulatory requirements relating to landfill gas projects
Data unit:	Dimensionless

Description:	Regulatory requirements relating to landfill gas projects
Source of data used:	Estimate (see justification below)
Value applied:	0%
Justification of the choice of data or description of measurement methods and procedures actually applied:	In the absence of the proposed project, all the landfill gas will be released to the atmosphere. As explained in B.4, the current configuration is passive venting and no burning at Fundo Las Cruces Landfill, undertaken to meet safety requirements.
Any comment:	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the credit period. Relevant regulations for LFG project activities shall be updated at renewal of each credit period. Hence, because this value may change at the end of each crediting period, in case of changes in regulatory requirements, it will be monitored as table for variable 25 in B.7.1 below.

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of CH_4
Source of data used:	IPCC
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied:	For the first commitment period. Shall be updated according to any future COP/MOP decisions.
Any comment:	

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

Data / Parameter:	**$BE_{CH4,\ SWDS,y}$**
Data unit:	tCO_2e
Description:	Methane generation from the landfill in the absence of the project activity at year y
Source of data used:	Calculated as per "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", ver. 1.
Value applied:	See B.6.3 and Annex 3.
Justification of the choice	As per "Tool to determine methane emissions avoided from dumping waste

of data or description of measurement methods and procedures actually applied:	at a solid waste disposal site", ver. 1.
Any comment:	Used for ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year.

Data / Parameter:	**$CEF_{elec,BL,y}$**
Data unit:	tCO_2e/MWh
Description:	CO_2 emissions intensity of the baseline source of electricity displaced, which in this case corresponds to electricity provided from the Chilean grid connected to the project site, tCO_2e/MWh.
Source of data used:	The data correspond to the Central Interconnected System of the Republic of Chile (SIC), where the project activity is located.
Value applied:	0.392 (Combined Margin). Details of calculations are presented in Annex 3.
Justification of the choice of data or description of measurement methods and procedures actually applied:	For power generation below 15 MW, the emissions factor may be calculated using *"tool to calculate the emission factor for an electricity system"*, recommended by ACM0001 ver 7. We used Version 1 of the Tool.
Any comment:	A single, fixed value is used for each crediting period. More calculation details are provided in Annex 3.

Data / Parameter:	**$CEF_{elec,PR,y}$**
Data unit:	tCO_2e/MWh
Description:	CO_2 emissions factor for electricity generation in the Chilean grid connected to the project site, tCO_2e/MWh. Power generated using landfill gas would displace power generated in the interconnected power grid.
Source of data used:	The data correspond to the Central Interconnected System of the Republic of Chile (SIC), where the project activity is located.
Value applied:	0.392 (Combined Margin). Detailed calculations are presented in Annex 3.
Justification of the choice of data or description of measurement methods and procedures actually applied:	For power generation below 15 MW, the emissions factor may be calculated using *"tool to calculate the emission factor for an electricity system"*, recommended by ACM0001 ver 7. We used Ver. 1 of the Tool.
Any comment:	A single, fixed value is used for each crediting period.

B.6.3 Ex-ante calculation of emission reductions:

An ex-ante emission reduction calculation requires an estimation of landfill gas production from the waste at the site. This estimation is made using the *'Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"*, ver. 1. For more information on this model and the parameters used, please refer to Annex 3.

The LFG collection efficiency for ex-ante estimations is assumed to be 70%, considering the use of a geomembrane as final cover. The amount of methane collected would represent $MD_{project,y}$.

As discussed in section B.4, in the absence of the proposed project activity, the configuration at Fundo Las Cruces Landfill is passive venting and no burning of the LFG. Thus an appropriate value of AF is 0%.

It is envisioned that the leachate evaporation plant would be installed after the first year of operation. Additionally, there is the possibility of installing an electricity generation plant in the third year, thus most of the methane destruction would normally take place at the thermal plant and/or at the power plant. When those plants are not operational or when there is excess flow, the methane would be sent to the flare and destroyed there.

It is estimated that the leachate evaporation plant would have an energy demand of 77.08 TJ per year, considering that the plant will operate an average of 8,600 hours per year (i.e. 95% of the year). For fuelling such a thermal plant, a constant flow of about 500 m^3/h of landfill gas would be needed. Based on manufacturer's information, the energy demand could be estimated by using the following formula:

$$\text{Energy Demand} = 12 + 3 * \text{nEvap}$$

where nEvap is the number of evaporators (modules, of 350 -500 m^3 of leachate treatment capacity per year).

After satisfying the demand of the thermal plant, the gas might be used to generate electricity.

The maximum electricity generation potential (MW) can be estimated from the flow rate of landfill gas collected (m^3/h). We estimated that a dedicated LFG engine-generator would need a flow of 688 m^3/h of landfill gas (@50% methane) to generate 1 MWe (one electric megawatt). This assumption was based on information sent by an LFG engine manufacturer (Waukesha Motors). This allows us to calculate the maximum power generation potential if all the LFG were converted to electricity.

The results are shown in Table 6 below.

Table 6: Possible scenario for power generation at Fundo Las Cruces Landfill

Year	Maximum electricity generation potential (MW)	Possible scenario for power generation (MW)
2008 (from April)	0.79	0.00
2009	0.95	0.00
2010	1.11	0.40
2011	1.25	0.50
2012	1.38	0.70
2013	1.52	0.80
2014	1.64	0.90
2015 (up to March)	0.79	0.00

While LFG generation may vary continuously over time, power generation equipment is only available at specific power output capacities. Based on the amount of landfill gas available, we assume that initial power generation in 2011 would be 0.4 MW, reaching up to 2 MW in 2023. While the LFG model indicates that gas may be available to generate about 3.5 MW during the 21-year crediting period, given that no firm decision on power generation has yet been made and due to local regulations, the present estimation limits power generation to a maximum of 2.0 MW. It is envisioned that 0.5 MW-capacity generators would be installed as the power generation potential increases.

All the remnant gas will be combusted in an enclosed flare. For conservativeness, the ex-ante estimations assume a default flare efficiency of 90%, as recommended in the Methodological *"Tool to determine project emissions from flaring gases containing methane"* (Version 1: EB28, Annex 13).

The project activity involves LFG recovery, which requires a blower for gas pumping, and electricity is needed for this purpose. If the project does not generate electricity, or until the power plant is operational, this electricity will be purchased from the grid and will constitute $PE_{EC,y}$ in Eq. (11). In case of electricity generation using the methane collected in the project, emissions reductions would be determined by the sum of the amount of electricity exported from the project site to the grid and the amount of electricity used on-site unrelated to the project activity –as it would have been imported in the absence of the project activity–. This will constitute $EL_{LFG,y}$.

Other assumptions related to electricity generation, made for the ex-ante estimations, are as follows:

- **Operation of the power plant:** It is expected that the electricity generation facility will operate 8,000 h/yr (91.3% of the year).
- **Operation of the flare station:** It was assumed that the flare station will operate 8,600 h/yr (98.2% of the year).
- **Blower electricity consumption:** Based on manufacturer's information, it is assumed that a blower will use 75 HP or about 56 kW to pump 5,000 m^3/h of LFG (@ 50% methane).

Emissions from this power consumption from the grid in the project activity will also depend on the emissions factor for electricity generation, which is estimated in Annex 3, according to the *"Tool to calculate the emission factor for an electricity system",* ver. 1. A value of 0.392 tCO_2/MWh (combined margin) was used in this project for imported electricity. This CO_2 emissions factor for power generation was determined using the same procedure indicated in the tool which allows for $EF_{grid,y}$ to remain fixed for each crediting period.

Fundo Las Cruces Landfill project contemplates thermal generation, by the possibility of using the LFG for leachate evaporation. Considering that the existing leachate treatment system uses electricity for operation, no fossil fuel based thermal energy is considered to be displaced in this PDD, thus $CEF_{ther,BL,y}$ is not applicable here.

For ex-ante calculation purposes, there will be no fossil fuel consumption at project scenario ($PE_{FC,j,y}$), but any eventual fossil fuel consumption will be accounted. $PE_{FC,j,y}$ will depend on the fossil fuel consumed and its value will be taken from IPCC default emission factors, in case no other data is available.

As ACM0001 covers a broad spectrum of methane utilization options, there are several calculation details and assumptions which can be better expressed in a spreadsheet. All the equations and main assumptions were presented above and are used to estimate project emissions reductions. The results are shown in the next page.

$BE_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y}$ (1)		2008	2009	2010	2011	2012	2013	2014	2015
BE_y	*Baseline emissions (tCO_2e).*	18,543	34,986	41,496	50,478	56,924	63,830	69,814	18,848
$MD_{project,y}$	*Amount of methane destroyed/combusted during the year, in project scenario (tCH_4)*	883	1,666	1,976	2,344	2,636	2,935	3,205	864
$MD_{reg,y}$	*Amount of methane that would have been destroyed/combusted during the year y in the absence of the project due to regulatory and/or contractual requirement (tCH_4)*	0	0	0	0	0	0	0	0
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21
$EL_{LFG,y}$	*Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y (MWh)*	0	0	0	3,200	4,000	5,600	6,400	1,795
$CEF_{elec,BL}$	*CO_2 emissions intensity of the baseline source of electricity displaced (tCO_2e/MWh).*	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
$ET_{LFG,y}$	*Quantity of thermal energy produced utilizing LFG, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year y (TJ)*	0.0	77.1	77.1	77.1	77.1	77.1	77.1	19.2
$CEF_{ther,BL}$	*CO_2 emissions intensity of the fuel used by boiler to generate thermal energy, which is displaced by LFG based thermal energy generation (tCO_2e/TJ)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$MD_{reg,y} = MD_{project,y} * AF$ (2)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{reg,y}$	*Amount of methane that World have been destroyed/combusted during the year y in the absence of the Project (tCH_4)*	0	0	0	0	0	0	0	0
$MD_{project,y}$	*Amount of methane that would have been destroyed/combusted during the year y (tCH_4)*	883	1,666	1,976	2,344	2,636	2,935	3,205	864
AF	*Adjustment factor*	0%	0%	0%	0%	0%	0%	0%	0%

$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}$ (3)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{project,y}$	*Quantity of methane that would have been destroyed/combusted during the year y (tCH_4)*	883	1,666	1,976	2,344	2,636	2,935	3,205	864
$MD_{flared,y}$	*Quantity of methane destroyed by flaring (tCH_4)*	883	125	435	14	109	13	85	37
$MD_{electricity,y}$	*Quantity of methane destroyed by generation of electricity (tCH_4)*	0	0	0	789	986	1,381	1,578	443
$MD_{thermal,y}$	*Quantity of methane destroyed for the generation of thermal energy (tCH_4)*	0	1,541	1,541	1,541	1,541	1,541	1,541	384
$MD_{PL,y}$	*Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)*	0	0	0	0	0	0	0	0

$MD_{flared,y} = (LFG_{flare,y}*w_{CH4,y}*D_{CH4}) - (PE_{flare,y}/GWP_{CH4})$ (4)		2008	2009	2010	2011	2012	2013	2014	2015
$LFG_{flare,y}$	*Quantity of landfill gas fed to the flare during the year (m^3)*	2,738,604	388,275	1,348,633	43,070	337,432	41,165	264,451	115,904
$w_{CH4,y}$	*Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)*	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	*Methane density (tCH_4/m^3CH_4)*	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream (tCO_2e) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane", ver. 1.*	2,061	292	1,015	32	254	31	199	87
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period (tCO_2e/tCH_4)*	21	21	21	21	21	21	21	21

$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4} * D_{CH4}$	(5)	2008	2009	2010	2011	2012	2013	2014	2015
$MD_{electricity,y}$	Quantity of methane destroyed by generation of electricity (tCH_4)	0	0	0	789	986	1,381	1,578	443
$LFG_{electricity,y}$	Quantity of landfill gas fed into the electricity generator (m^3)	0	0	0	2,201,600	2,752,000	3,852,800	4,403,200	1,235,007
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	Methane density (tCH_4/m^3CH_4)	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$MD_{thermal,y} = LFG_{thermal,y} * w_{CH4} * D_{CH4}$	(6)	2008	2009	2010	2011	2012	2013	2014	2015
$MD_{thermal,y}$	Methane destroyed by thermal generation (tCH_4)	0	1541	1541	1541	1541	1541	1541	384
$LFG_{thermal,y}$	Quantity of landfill gas fed into boiler (m^3)	0	4,300,000	4,300,000	4,300,000	4,300,000	4,300,000	4,300,000	1,072,055
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	Methane density (tCH_4/m^3CH_4)	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$MD_{PL,y} = LFG_{PL,y} * w_{CH4} * D_{CH4}$	(7)	2008	2009	2010	2011	2012	2013	2014	2015
$MD_{PL,y}$	Quantity of methane sent to the pipeline for feeding to the natural gas distribution network (tCH_4)	0	0	0	0	0	0	0	0
$LFG_{PL,y}$	Quantity of landfill gas sent to pipeline for feeding to the natural gas distribution network (m^3)	0	0	0	0	0	0	0	0
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured during the year y and expressed as a fraction (m^3 CH_4 / m^3 LFG)	50%	50%	50%	50%	50%	50%	50%	50%
D_{CH4}	Methane density (tCH_4/m^3CH_4)	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168	0.0007168

$MD_{project,y} = BE_{CH4, SWDS,y} / GWP_{CH4}$ (8)		2008	2009	2010	2011	2012	2013	2014	2015
$MD_{project,y}$	*Quantity of methane that would have been destroyed/combusted during the year y* (tCH_4)	1,428	2,445	2,946	3,413	3,854	4,273	4,677	1,264
$BE_{CH4, SWDS,y}$	*Methane generation from the landfill in the absence of the project activity* (tCO_2e)	29,993	51,346	61,864	71,677	80,929	89,741	98,214	26,536
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period* (tCO_2e/tCH_4)	21	21	21	21	21	21	21	21

$PE_{flare,y} = \sum TM_{RG,h} * (1 - \eta_{flare,h}) * GWP_{CH4} / 1000$ (T.15)		2008	2009	2010	2011	2012	2013	2014	2015
$PE_{flare,y}$	*Project emissions from flaring of the residual gas stream* (tCO_2e) *determined following the procedure described in the "Tool to determine project emissions from flaring gases containing methane", ver. 1*	2,061	292	1,015	32	254	31	199	87
$\sum TM_{RG,h}$	*Total mass flow rate in the residual gas (kg)*	981,516	139,158	483,350	15,436	120,936	14,754	94,779	41,540
$\eta_{flare,h}$	*Flare combustion efficiency*	90%	90%	90%	90%	90%	90%	90%	90%
GWP_{CH4}	*Global Warming Potential value for methane for the first commitment period* (tCO_2e/tCH_4)	21	21	21	21	21	21	21	21

$CEF_{elec,BL,y} = 3.6 * EF_{fuel,BL} / (\varepsilon_{gen,BL} * NCV_{fuel,BL})$ (9)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{elec,BL,y}$	*CO2 emissions intensity of the baseline source of electricity displaced* (tCO_2e/MWh)	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920
$EF_{fuel,BL}$	*Emission factor of baseline fossil fuel used, as identified in the baseline scenario identification procedure* (tCO_2*/mass or volume)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$\varepsilon_{gen,BL}$	*Energy efficiency of the thermal plant used in the absence of the project activity to generate the thermal energy*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$NCV_{fuel,BL}$	*Net calorific value of fuel, as identified through the baseline identification procedure (GJ/mass or volume)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.6	*Equivalent of GJ energy in a MWh of electricity*	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

$CEF_{therm,BL} = EF_{fuel,BL} / (\varepsilon_{boiler,BL} * NCV_{fuel,BL})$ (10)		2008	2009	2010	2011	2012	2013	2014	2015
$CEF_{therm,BL}$	*CO_2 emissions intensity of the fuel used by thermal plant to generate thermal energy, which is displaced by LFG based thermal energy generation (tCO_2e/TJ)*	0	0	0	0	0	0	0	0
$EF_{fuel,BL}$	*Emission factor of the fuel, as identified through the baseline identification procedure, used in the thermal plant to generate the thermal energy in the absence of the project activity (tCO_2/mass or volume)*	0	0	0	0	0	0	0	0
$NCV_{fuel,BL}$	*Net calorific value of fuel, as identified through the baseline identification procedure, used in the thermal plant to generate the thermal energy in the absence of the project activity (TJ/mass or volume)*	0	0	0	0	0	0	0	0
$\varepsilon_{gen,BL}$	*Energy efficiency of the thermal plant used in the absence of the project activity to generate the thermal energy*	0	0	0	0	0	0	0	0

$PE_y = PE_{EC,y} + PE_{FC,j,y}$ (11)		2008	2009	2010	2011	2012	2013	2014	2015
PE_y	*Project emissions in year y (tCO_2e/yr)*	14.4	267.4	272.4	19.3	19.6	19.9	20.2	5.1
$PE_{EC,y}$	*Emissions from consumption of electricity in the project case (tCO_2e/yr)*	14.4	267.4	272.4	19.3	19.6	19.9	20.2	5.1
$PE_{FC,j,y}$	*Emissions from consumption of heat in the project case (tCO_2e/yr)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$PE_{EC,y} = EC_{PJ,y} * EF_{grid} * (1+TDL_y)$ (TE.1)		2008	2009	2010	2011	2012	2013	2014	2015
$PE_{EC,y}$	*Project emissions from electricity consumption by the project activity during the year y (tCO2 / yr)*	14.4	267.4	272.4	19.3	19.6	19.9	20.2	5.1
$EC_{PJ,y}$	*Quantity of electricity consumed by the project activity during the year y (MWh)*	31	568	579	41	42	42	43	11
EF_{grid}	*Emission factor for the grid in year y (tCO2/MWh)*	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920	0.3920
TDL_y	*Average technical transmission and distribution losses in the grid in year y for the voltage level at which electricity is obtained from the grid at the project site.*	20%	20%	20%	20%	20%	20%	20%	20%

$PE_{FC,j,y} = \Sigma FC_{i,j,y} * COEF_{i,y}$	(TF.1)	2008	2009	2010	2011	2012	2013	2014	2015
$PE_{FC,j,y}$	*Emissions from consumption of heat in the project case (tCO_2e/yr)*	0	0	0	0	0	0	0	0
$FC_{i,j,y}$	*Quantity of fuel type i combusted in process j during the year y (mass or volume unit / yr)*	0	0	0	0	0	0	0	0
$COEF_{i,y}$	*CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)*	0	0	0	0	0	0	0	0

$COEF_{i,y} = NCV_{i,y} * EF_{CO2,i,y}$	(TF.4)	2008	2009	2010	2011	2012	2013	2014	2015
$COEF_{i,y}$	*CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)*	0	0	0	0	0	0	0	0
$NCV_{i,y}$	*weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)*	0	0	0	0	0	0	0	0
$EF_{CO2,i,y}$	*weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)*	0	0	0	0	0	0	0	0

$ER_y = BE_y - PE_y$	(12)	2008	2009	2010	2011	2012	2013	2014	2015
ER_y	*Emission reductions in year y (tCO_2e/yr)*	18,529	34,719	41,224	50,459	56,904	63,810	69,794	18,843
BE_y	*Baseline emissions in year y (tCO_2e/yr)*	18,543	34,986	41,496	50,478	56,924	63,830	69,814	18,848
PE_y	*Project emissions in year y (tCO_2e/yr)*	14	267	272	19	20	20	20	5

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

Table 7: Ex-ante estimation of landfill gas collected and flared/used at Fundo Las Cruces Project

Year	$LFG_{total,y}$ m^3LFG /yr	$LFG_{thermal,y}$ m^3LFG /yr	$LFG_{electricity,y}$ m^3LFG /yr	$LFG_{flare,y}$ m^3LFG/yr
2008 (from April)	2,738,604	0	0	2,738,604
2009	4,688,275	2,150,000	0	2,538,275
2010	5,648,633	2,150,000	0	3,498,633
2011	6,544,670	2,150,000	2,201,600	2,193,070
2012	7,389,432	2,150,000	2,752,000	2,487,432
2013	8,193,965	2,150,000	3,852,800	2,191,165
2014	8,967,651	2,150,000	4,403,200	2,414,451
2015 (up to March)	2,422,966	536,027	1,235,007	651,931

Table 8: Ex-ante estimation of net emission reduction by methane destruction at Fundo Las Cruces Project

Year	$MC_{thermal,y}$ tCH_4/yr	$MD_{electricity,y}$ tCH_4/yr	$MD_{flare,y}$ tCH_4/yr	$MD_{project}$ tCH_4/yr	MD_{reg} tCH_4/yr	*Net* ER by methane destruction tCO_2e/yr
2008 (from April)	0	0	883	883	0	18,543
2009	1,541	0	125	1,666	0	34,986
2010	1,541	0	435	1,976	0	41,496
2011	1,541	789	14	2,344	0	49,224
2012	1,541	986	109	2,636	0	55,356
2013	1,541	1,381	13	2,935	0	61,635
2014	1,541	1,578	85	3,205	0	67,305
2015 (up to March)	384	443	37	864	0	18,144

Table 9: Ex-ante estimation of net emission reduction by fossil fuels displacement, due to electricity and/or thermal energy generation using landfill gas at Fundo Las Cruces Project

Year	$EL_{LFG,y}$ MWh/yr	*Net* ER by electricity generation tCO_2e/yr	$ET_{LFG,y}$ TJ/yr	*Net* ER by thermal generation tCO_2e/yr
2008 (from April)	0	0	0.00	0
2009	0	0	77.08	0
2010	0	0	77.08	0
2011	3,200	1,254	77.08	0
2012	4,000	1,568	77.08	0
2013	5,600	2,195	77.08	0
2014	6,400	2,509	77.08	0
2015 (up to March)	1,795	704	19.22	0

Table 10: Ex-ante estimation of net emission reduction by fossil fuels displacement, due to electricity generation using landfill gas at Fundo Las Cruces Project

Year	BE_y (tCO_2e/yr)	PE_y (tCO_2e/yr)
2008 (from April)	18,543	14
2009	34,986	267
2010	41,496	272
2011	50,478	19
2012	56,924	20
2013	63,830	20
2014	69,814	20
2015 (up to March)	18,848	5

Table 11: Summary of ex-ante estimation of total emission reduction at Fundo Las Cruces Project

Year	Total ER tCO_2e/yr
2008 (from April)	18,529
2009	34,719
2010	41,224
2011	50,459
2012	56,904
2013	63,810
2014	69,794
2015 (up to March)	18,843
Total	**354,281**

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

B.7.1 Data and parameters monitored:

Note: The "Data /Parameter" includes the variable number as it appears in ACM0001, ver. 7.

Data / Parameter:	**1. $LFG_{total,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas captured at normal temperature and pressure.
Source of data:	HERA Ecobio.
Measurement procedures (if any):	Measured by mass flow meters. Data to be agregated monthly and yearly.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after.
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**2. $LFG_{flare,y}$**
Data unit:	m^3
Description:	Amount of landfill gas flared at normal temperature and pressure
Source of data:	HERA Ecobio.
Measurement procedures (if any):	Measured by mass flow meters. Data to be agregated monthly and yearly.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after.
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**3. $LFG_{electricity,y}$**
Data unit:	m^3
Description:	Amount of landfill gas combusted in power plant at normal temperature and pressure
Source of data:	HERA Ecobio.
Measurement procedures (if any):	Measured by mass flow meters. Data to be agregated monthly and yearly.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after.
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**4. $LFG_{thermal,y}$**
Data unit:	m^3
Description:	Amount of landfill gas combusted in boiler at normal temperature and pressure
Source of data:	HERA Ecobio.
Measurement procedures (if any):	Measured by mass flow meters. Data to be agregated monthly and yearly.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after.
QA/QC procedures:	Flow meters should be subject to a regular maintenance and testing regime to ensure accuracy. Also, an independent company, accredited by

	local authorities, will conduct contrasting and data checking in accordance with manufacturer specifications, to ensure accuracy.
Any comment:	Flow meter would adjust volume flow for temperature and pressure.

Data / Parameter:	**6. $PE_{flare,y}$**
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year *y*.
Source of data:	On-site measurements / calculations. Calculated as per *"Tool to determine project emissions from flaring gases containing methane"*, ver. 1.
Measurement procedures (if any):	As per the "*Tool to determine project emissions from flaring gases containing methane", ver. 1.*
Monitoring frequency:	The parameters used for determining the project emissions from flaring of the residual gas stream in year *y* (**$PE_{flare,y}$**) will be monitored as per the *"Tool to determine project emissions from flaring gases containing methane"*, ver. 1. *The parameters used for the determination of $PE_{flare,y}$ are $LFG_{flare,y}$, $w_{CH4,y}$, $fv_{i,h}$, $fv_{CH4,FG,h}$ and $t_{O2,h}$.*
QA/QC procedures:	Regular maintenance will ensure optimal operation of the flare. Analysers will be calibrated annually according to manufacturer's recommendations.
Any comment:	The value applied in ex-ante estimation is 10% of CH_4 in gas stream. Note: A determination of **$PE_{flare,y}$** using the methane flaring tool requires the measurements of a number of additional parameters. These are listed and described following the variables specifically mentioned in ACM0001.

Data / Parameter:	**7. w_{CH4}**
Data unit:	m^3 CH_4 / m^3 LFG
Description:	Methane fraction in the landfill gas.
Source of data:	To be measured continuously by HERA Ecobio using certified equipment.
Measurement procedures (if any):	Preferably measured by continuous gas quality analyser. Methane fraction of the landfill gas to be measured on wet basis.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically, and data will be kept during the crediting period and two years after. Data will also be aggregated monthly/yearly.
QA/QC procedures:	The gas analyser will be subject to a regular maintenance and testing regime to ensure accuracy. An independent company will contrast instruments with reference instruments, in accordance with manufacturer specifications.
Any comment:	For ex-ante estimations it was assumed to be 50%.

Data / Parameter:	**8. T**
Data unit:	ºC (Celsius degrees)
Description:	Temperature of the landfill gas.
Source of data:	Measured by HERA Ecobio.
Measurement procedures	Measured to determine the density of methane D_{CH4}.

(if any):	No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures:	Measuring instruments will be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. An independent company will contrast the thermometers used for measurements with certified equipment.
Any comment:	Value applied for ex-ante estimations: 0 (At STP conditions).

Data / Parameter:	**9. P**
Data unit:	Pa (Pascal)
Description:	Pressure of the landfill gas.
Source of data:	Measured by HERA Ecobio.
Measurement procedures (if any):	Measured to determine the density of methane D_{CH4} by pressure analyser. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters.
Monitoring frequency:	Continuous. Data will be measured at least once per hour, recorded electronically. Data will also be aggregated monthly/yearly. Records will be kept during the crediting period and two years after.
QA/QC procedures:	Measuring instruments will be subject to a regular maintenance and testing regime in accordance to appropriate national/international standards. An independent company will contrast the pressure analysers used for measurements with certified equipment.
Any comment:	Value applied for ex-ante estimations: 101,325 (1 atm at STP conditions).

Data / Parameter:	**9. EL_{LFG}**
Data unit:	MWh
Description:	Net quantity of electricity produced using landfill gas
Source of data:	Measured by HERA Ecobio, by electricity meter.
Measurement procedures (if any):	Electricity meter.
Monitoring frequency:	Continuous. Records will be kept during the crediting period and two years after.
QA/QC procedures:	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy.
Any comment:	Required to estimate the emission reductions from electricity generation from LFG, if credits are claimed.

Data / Parameter:	**10. ET_{LFG}**
Data unit:	TJ

Description:	Total amount of thermal energy generated using LFG.
Source of data:	Measured by HERA Ecobio.
Measurement procedures (if any):	- In case of steam meter: the enthalpy of steam and feed water will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by steam meter. - In case of hot air: the temperature, pressure and mass flow rate will be measured.
Monitoring frequency:	Continuous.
QA/QC procedures:	In case of monitoring of steam, it will be calibrated for pressure and temperature of steam at regular intervals. The meter shall be subject to regular maintenance and testing to ensure accuracy.
Any comment:	Required to estimate the emission reductions from thermal energy generation from LFG, if credits are claimed. In the case of Fundo Las Cruces Landfill Project, no credits will be claimed by fossil fuel displacement through the thermal generation component.

Data / Parameter:	**11. $CEF_{elec,BL,y}$**
Data unit:	tCO_2/MWh
Description:	Carbon emission factor of electricity
Source of data:	
Measurement procedures (if any):	In case the baseline source would have been grid, emission factor shall be estimated as described in “Tool for calculation of emission factor for electricity system”, ver. 1.
Monitoring frequency:	Annually.
QA/QC procedures:	The calculations will be made according to EB methodology or whenever new electric grid information is available to update values.
Any comment:	Value applied for ex-ante estimation: 0.392 (Combined Margin). CO_2 emissions factor for electricity generation in the Chilean grid connected to the project site, tCO_2e/MWh. Power generated using landfill gas would displace power generated in the interconnected power grid.

Data / Parameter:	**12. $EF_{fuel,BL}$**
Data unit:	tCO_2/mass or volume
Description:	CO_2 emission factor of fossil fuel
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain.
Measurement procedures (if any):	
Monitoring frequency:	Annually. The value will be taken from credible sources, preferably from IPCC recommended values. Data will be kept during the crediting period and two years after.
QA/QC procedures:	The value will be confirmed from the source each crediting period.

Any comment:	Fossil fuel that would have been used in the baseline captive power plant or thermal energy generation. In the project case, the value is zero.

Data / Parameter:	**13. $NCV_{fuel,BL}$**
Data unit:	GJ/mass or volume units of fuel
Description:	Net calorific value of fossil fuel
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain. Calorific value of the fossil fuel that would have been used in the baseline for thermal energy generation and/or electricity generation.
Measurement procedures (if any):	
Monitoring frequency:	Annually. Values of net calorific value of fossil fuels will be checked each crediting period. Data will be kept during the crediting period and two years after.
QA/QC procedures:	
Any comment:	For fossil fuel that would have been used in the baseline for thermal energy generation and/or electricity generation.

Data / Parameter:	**15. ε_{boiler}**
Data unit:	-
Description:	Efficiency of the baseline boiler for producing thermal energy.
Source of data:	Conservative approach taken from ACM0001 version 7.
Measurement procedures (if any):	To estimate thermal plant efficiency, project participants will use the highest value between measurement prior project implementation or during monitoring, or information from manufacturer, or at last a default efficiency of 100% should be considered.
Monitoring frequency:	Annually.
QA/QC procedures:	As per ACM0001 ver.7
Any comment:	Value applied for ex-ante estimations: 100%.

Data / Parameter:	**16. Operation of the energy plant**
Data unit:	hours
Description:	Operation of the energy plant.
Source of data:	Measured by HERA Ecobio.
Measurement procedures (if any):	
Monitoring frequency:	Annually. Records will be kept during the crediting period and two years after.
QA/QC procedures:	
Any comment:	Value applied for ex-ante estimations: 8,000.This is monitored to ensure methane destruction is claimed for methane used in electricity plant when

	it is operational.

Data / Parameter:	**17. Operation of the boiler.** For this project, it would be a leachate evaporation plant.
Data unit:	hours
Description:	Operation of the boiler.
Source of data:	Measured by HERA Ecobio.
Measurement procedures (if any):	
Monitoring frequency:	Annually. Records will be kept during the crediting period and two years after.
QA/QC procedures:	
Any comment:	Value applied for ex-ante estimations: 8,000.This is monitored to ensure methane destruction is claimed for methane used in thermal plant when it is operational.

Data / Parameter:	**Operation of the flare station**
Data unit:	hours
Description:	Operation of the boiler.
Source of data:	Measured by HERA Ecobio.
Measurement procedures (if any):	
Monitoring frequency:	Annually. Records will be kept during the crediting period and two years after.
QA/QC procedures:	
Any comment:	Value applied for ex-ante estimations: 8,600.

Data / Parameter:	$PE_{EC,y}$
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year *y*.
Source of data:	Calculated as per the “Tool to calculate project emissions from electricity consumption”, ver. 1.
Measurement procedures (if any):	As per the “Tool to calculate project emissions from electricity consumption”, ver. 1.
Monitoring frequency:	As per the “Tool to calculate project emissions from electricity consumption”, ver. 1.
QA/QC procedures:	As per the “Tool to calculate project emissions from electricity consumption”, ver. 1.
Any comment:	-

Data / Parameter:	$PE_{FC,j,y}$
Data unit:	tCO_2e

Description:	Project emissions from fossil fuel combustion in process *j* during the year *y*.
Source of data:	Calculated as per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", ver. 1.
Measurement procedures (if any):	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", ver. 1.
Monitoring frequency:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", ver. 1.
QA/QC procedures:	As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", ver. 1.
Any comment:	For ex-ante estimation purposes, there will be no fossil fuel consumption at project scenario, but any eventual fossil fuel consumption will be accounted.

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	Test (dimensionless)
Description:	The regulatory demands for gas collection and destruction are reflected in the adjustment factor (AF, for methane destruction in the baseline scenario).
Source of data:	National legislation and mandatory regulations.
Measurement procedures (if any):	
Monitoring frequency:	Although the methodology only requires recording at the renewal of the crediting period, the information related to all relevant policies and circumstances will be collected and recorded annually. Information will be kept during crediting period and two years after.
QA/QC procedures:	Legal documents.
Any comment:	AF=0%. The information, though recorded annually, is used for changes in the adjustment factor (*AF*) or directly $MD_{reg,\ y}$ at renewal of the crediting period.

The following variables are required to determine flare efficiency using the "Tool to determine project emissions from flaring gases containing methane", ver. 1. A fixed flare efficiency is assumed, so estimates of these data are not needed for ex-ante estimates.

Data / Parameter:	$\mathbf{FV_{RG,h}}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*.
Source of data:	On-site measurements.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of	Measured at least one per hour and electronically using a flow meter, and

measurement methods and procedures to be applied:	will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Flow meters will be periodically calibrated according to the manufacturer's recommendation.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

Data / Parameter:	**$fv_{i,h}$**
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour *h.*
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	As a simplified approach (see Eq. 3a), only methane content of the residual gas will be measured and the remaining part will be considered as N_2. Methane concentration would be measured at least once per hour using a continuous gas analyser, and data records will be kept during the crediting period and two years after.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	The same basis (dry or wet) is considered for this measurement when the residual gas temperature exceeds 60ºC.

If project operator decides to monitor emissions continuously, the following two variables should be monitored:

Data / Parameter:	**$t_{O2,h}$**
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust has of the flare in the hour *h*.
Source of data:	On-site measurements using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Measured at least once per hour and electronically using a continuous gas analyser, and will be kept during the crediting period and two years after. Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) will be in the upper section of the flare (80% of total flare height). Sampling will be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes).
QA/QC procedures to be	Analysers will be periodically calibrated according to the manufacturer's

applied:	recommendation. A zero check and typical value check to be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$fv_{CH4,FG,h}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*
Source of data:	Measurements by project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. 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). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Monitoring frequency: Continuously. Values to be averaged hourly or at a shorter time interval.
QA/QC procedures to be applied:	Analysers will be periodically 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:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10 000 ppmv.

If project proponent decides to use the 90% default value for enclosed flares, the following two variables should be monitored:

Data / Parameter:	$\mathbf{T_{flare}}$
Data unit:	ºC
Description:	Temperature in the exhaust gas of the flare.
Source of data:	On-site measurements using a thermocouple.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	Not used in ex-ante estimates.
Description of measurement methods and procedures to be applied:	Continuous measurement of the temperature of the exhaust gas stream in the flare by a thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be	Thermocouples will be replaced or calibrated every year.

applied:	
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

Data / Parameter:	$\eta_{flare,h}$
Data unit:	Dimensionless
Description:	Flare efficiency in hour h
Source of data:	Values specified in **Tool to determine project emissions from flaring gases containing methane**, ver. 1.
Value of data applied for the purpose of calculating expected emission reductions in section B.6.3	0.9
Description of measurement methods and procedures to be applied:	Calculated as specified in Methane Flaring Tool as follows: ➢ 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*.
QA/QC procedures to be applied:	
Any comment:	

B.7.2 Description of the monitoring plan:

Unlike most methodologies that determine baseline and project emissions separately, and calculate emissions reductions as the difference between the two, the methodology ACM0001 determines emissions reductions directly. ACM0001 version 7 states:

"The monitoring methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform(s) and the electricity generating/thermal energy unit(s) to determine the quantities as shown in Figure 1 [of ACM0001, ver. 7]. *The monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are the quantity of methane actually destroyed* $MD_{project,y}$, *quantity of methane flared* ($MD_{flared,y}$), *the quantity of methane used to generate electricity* ($MD_{electricity,y}$)/*thermal energy* ($MD_{thermal,y}$), *the quantity of methane sent to the pipeline to the natural gas distribution network* ($MD_{PL,y}$) *and the quantity of methane*

captured ($MC_{total,y}$)[15]*. The methodology also measures the energy generated by use of LFG ($EL_{LFG,y}$, $ET_{LFG,y}$) and energy consumed by the project activity that is produced using fossil fuels."*

Since the proposed project involves flaring and electricity generation, Figure 1 of ACM0001 ver. 7 simplifies to Figure 3 below.

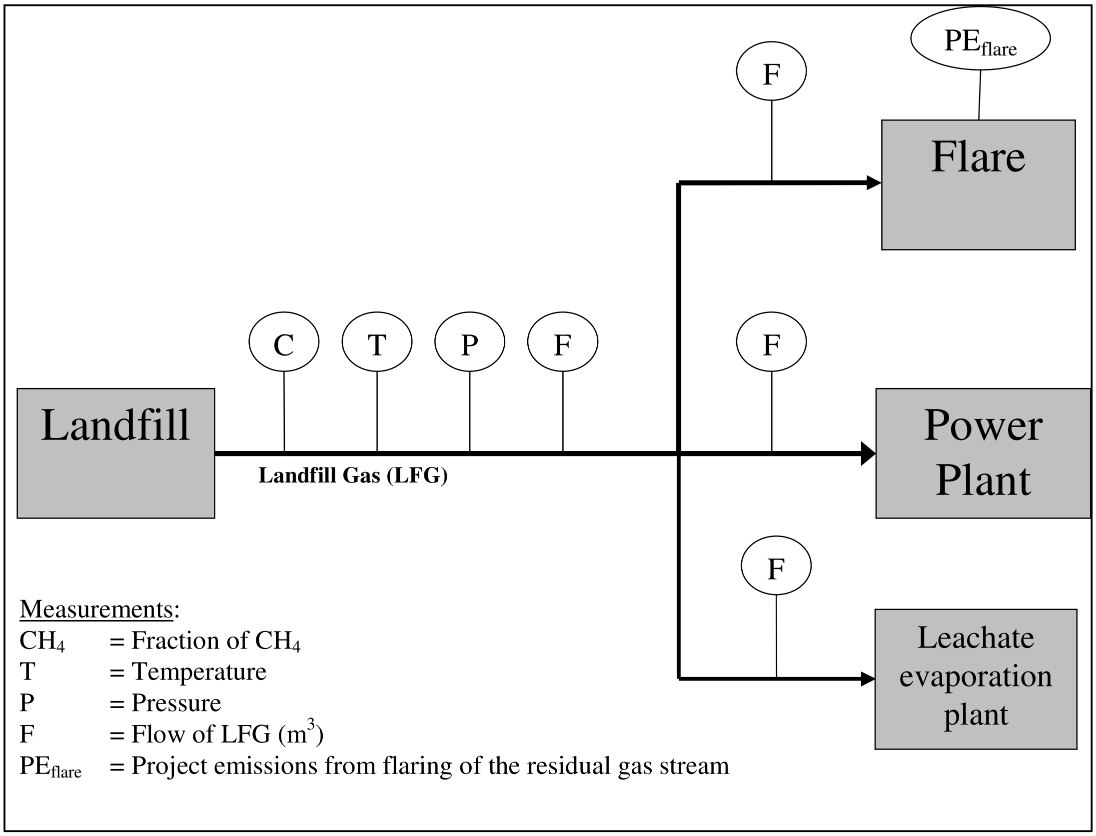

Figure 3: Schematic of the monitoring system at Fundo Las Cruces Landfill, according to ACM0001 version 7.

The variables to be monitored were all listed and described in Section B.7.1.

The overall management structure responsible for project monitoring is as follows:

[15] ACM0001 version 7 (and earlier versions) refers to the total quantity of methane generated, using the variable MD_{total}, but this is believed to be an error because it is not possible to monitor methane generation. This should be "methane captured". Then, as the symbol "MD" (methane destroyed) would be misleading, we renamed the variable as MC_{total}.

The landfill is owned and operated by HERA Ecobio S.A., part of the Spanish Group HERA Holding (hereinafter HERA). They would be involved in investments for gas collection and power generation, as well as additional operation, maintenance and monitoring costs.

The Technical Team of HERA will be responsible for the day-to-day operation of the landfill gas collection, flaring and use system. This Technical Team would also be responsible for monitoring key variables required for meeting the CDM monitoring requirements.

Data monitoring will be conducted by Landfill Gas Technical Operators supervised by the Landfill Gas Project Engineer, all of them belonging to the Operations Department of HERA. Other staff persons will be assigned by the Landfill Gas Project Engineer to assist in the monitoring tasks, as needed.

Certain activities (calibration of flow meters and electric meters) would be conducted by independent, outside laboratories, with the data archived by the HERA Operations Department.

HERA will count on supervision from the flare supplier for training, commissioning and start-up. If HERA decides to generate electricity or thermal energy using landfill gas, HERA will also acquire either from equipment supplier and/or specialist consultant all the services needed for training related to the operation of the LFG generation system. HERA staff to be trained will be selected from those with extensive experience at the landfill.

All data recorded would be transferred to and stored as electronic spreadsheets and other electronic files. Calibration certificates would be stored as paper copies, although scanned copies may also be stored electronically. HERA Operations Department will be responsible for oversight on all aspects involving monitoring and quality control. HERA Operations Department will maintain copies of all data collected, including calibration certificates for all instruments.

Following the internal audit, the electronic data would be used in a spreadsheet procedure in order to calculate emissions reductions. The original data, the calculation procedures and the resulting emission reductions will be verified by an independent Designated Operational Entity (DOE). The DOE would issue a Verification Report based on its findings and submit it to the CDM Executive Board for the issuance of CERs.

The operational and management structure for specific monitoring tasks is described in the following table:

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
1	Reading of landfill gas capture and gas flared/used	Operations Department of HERA	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring.	Yes	The data will be monitored and filed by the HERA Operations Department.
2	Calibration of the flow meters	External calibration laboratory	Every 2 years.	Yes	Calibration certificate will be issued by the Calibration Laboratory. This certificate will be filed by the HERA Operations Department.
3	Measurements related to the determination of flare efficiency	Operations Department of HERA	Continuous.	Yes	The data will be monitoring and filed by the HERA Operations Department.
4	Measurement of methane fraction in the landfill gas	Operations Department of HERA or external laboratory	Continuous measurement, recording on a weekly basis.	Yes	Measured value will be used, together with corresponding measurements of pressure, temperature and flow rate of landfill gas, and other parameters that are periodically upgraded. Measurement of methane fraction would be recorded in an appropriate computer file, which would indicate start and end time of measurements corresponding to each data file. The data records will be filed by the person responsible for data filing and the Head of HERA Operations Department.
5	Measurement of Pressure and Temperature	Operations Department of HERA	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring.	Yes	Daily data on pressure and temperature would be recorded in a spreadsheet file. The data records will be filed by the person responsible for data filing and the Head of HERA Operations Department.
6	Other environmental indicators (see below)	HERA	Annual	Yes	This data file will be completed and filed by the person responsible for data filing at HERA.

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
7	Monitoring of regulatory requirements relating to landfill gas projects	HERA	Annual	No	HERA will prepare the report on the current situation with respect to legal requirements.
8	Electricity generation and consumption from the grid	Operations Department HERA	Hourly	Yes	Data tables showing date, hour, and meter reading to be recorded in a spreadsheet file, and filed by the person responsible for data filing and the Head of the HERA Operations Department.
9	Thermal energy generation	Operations Department HERA	Hourly	Yes	Data tables showing date, hour, and meter reading to be recorded in a spreadsheet file, and filed by the person responsible for data filing and the Head of the HERA Operations Department.
10	Fossil fuel consumption (propane or others)	Operations Department HERA	Hourly	Yes	Data tables showing date, hour, and meter reading to be recorded in a spreadsheet file, and filed by the person responsible for data filing and the Head of the HERA Operations Department.
11	Operation of the flare station(s), power plant(s), thermal plants(s)	Operations Department HERA	Continuous	Yes	The data will be monitored and filed by the HERA Operations Department.
12	Electric meter calibration	External calibration laboratory	Twice a year	Yes	Calibration certificate will be issued by the Calibration Laboratory. This certificate will be filed by the HERA Operations Department.

13	Internal Audit	HERA Operations Department	Twice a year	Yes	The internal auditor will prepare a report to the Manager of the landfill site and the Head of HERA Operations Department on the state of items 1 to 9. In case of non-conformity, they will attempt to resolve problems prior to the annual Verification carried out by a Designated Operational Entity. A copy of this report should be filed in the HERA Operations Department and the Operations Department.

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)

Detailed baseline information is provided in Annex 3 to this PDD.

Date of completion of the baseline study: 30/11/2007.

Baseline and monitoring analysis prepared by: Ana Luisa Vergara, MGM International (not a project participant).

Contact information:

MGM International
Gautam Dutt
Junín 1655 1° B
Buenos Aires, C1111AAM
Argentina
T: 54.11.52191230
gdutt@mgminter.com

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/04/2008

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

21 years + 6 months

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

C.2.1. Renewable crediting period

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

01/04/2008

C.2.1.2. Length of the first crediting period:

7 years.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not selected.

C.2.2.2. Length:

Not selected.

SECTION D. Environmental impacts

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

Landfill gas collection, treatment and flaring are conducted to improve the environmental management of waste in landfills. The detailed design and engineering of the proposed project will be conducted by HERA Holding (Spain).

The project implementation would provide a number of local environmental benefits in addition to climate change mitigation:

- Destruction of air pollutants, such as hydrogen sulphide, that is present in trace quantities in LFG.
- Reduced fire and explosion risk through improved management of landfill gas.
- Reduced odour as landfill gas is captured and flared.
- Avoidance of methane leaking through the landfill cover, by the installation of a geomembrane as final cover of the waste.

Note that LFG combustion would produce small amounts of nitrogen oxides (NO_x), particulate matter and carbon monoxide (CO), as would be the case in a kitchen stove or any other device burning natural gas. The emissions of such gases are not regulated in Chile's VIII Region ("Region del Bio-Bio"). Nevertheless, the project would use enclosed flares specially designed to reduce these emissions to levels below that of an open flame. Note, however, that since the main fuel is methane, the emissions of particulate matter would be minimal. On the other hand an LFG flare is especially designed to operate at high temperature in order to burn the volatile organic compounds.

The landfill already has all the permits necessary to operate the landfill as well as for the proposed project activity:

- Environmental Impact Assessment (EIA), Resolution 337, November 22nd, 1999. This authorization was given by CONAMA Region del Bio-Bio and allows HERA to install and operate a municipal solid waste landfill at Fundo Las Cruces location, over an area of 28 hectares.
- Resolution 302, Concepcion, October 30th, 2007. This authorization was given by CONAMA Region del Bio Bio and states that there is no need for HERA Ecobio to enter into the

Environmental Impact Evaluation System ("SEIA", Sistema de Evaluación de Impacto Ambiental) to develop an LFG capture and flaring project at Fundo Las Curces Landfill.

Thus, the proposed project will meet all environmental regulations.

Note that possible uses of LFG discussed within this PDD are its use as fuel for leachate evaporation and/or for electricity generation (below 3 MW). The implementation of these options would depend on prior approval from the Regional CONAMA. Prior to such approval, any LFG recovered would be burnt in a flare.

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:

No significant impacts are applicable.

SECTION E. Stakeholders' comments

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

During the final days of October and the first days of September, 2007, persons representing the surrounding communities, from Llollinco and Quilmo sectors, were invited to attend the stakeholders' presentation meeting and to submit comments. Personnel from HERA that live in the surrounding sector were in charge of inviting the local community to the event and invitations were made personally.

This public event was held on September 4th at the landfill site. HERA's representatives were also invited to participate in this event. A total of 38 persons (not considered HERA's people) attended the meeting, of which 18 were school students. The stakeholders' comments presentation meeting was carried in the following way:

- Video, including a presentation of HERA Company and Fundo Las Cruces landfill facilities.
- Power Point, including a presentation con Climate Change and CDM general concepts, and Fundo Las Cruces Landfill Gas Recovery Project.
- Printed Brochure,
- Printed Questionnaire, to be filled by the participants after the meeting or during the week.

Additionally, on September 5th, letters were sent by mail with return receipt in order to invite other persons to submit comments about the project activity. Deadline for comments' submission was September 14th. Information sent by e-mail included:

- Invitations
- Executive Summary of the project
- Questionnaire
- A website link to download all the above mentioned documents, the PDD and a Power Point Presentation of the project.

The e-mail invitation was sent to a total of 59 persons from different sectors as follows:

(6) Non-governmental organizations and/or consultancies and academic sector
(40) Local government
(6) Private sector
(7) Other sectors

The following table lists all the people that were invited to participate in the stakeholders' consultation process and to submit any comment (not including HERA's personnel):

Name	Position	Company/Institution
Bolívar Ruiz Adaroz	Director	CONAMA
Deyanira Henríquez		CONAMA
German Oyola F.	Civil Engineer	CONAMA
Emilio Uribe Coloma		CORMA
Ivalu Astete		SISS
Miguel Carvacho	Regional Director of Ways	MOP (Ministry of Works)
Luís Cifuentes	Provincial Director of Ways	MOP (Ministry of Works)
Marcela López		MINSAL (Ministry of Health)
Hugo Castillo		MINSAL (Ministry of Health)
Ricardo Espinosa		MINSAL (Ministry of Health)
Hugo Rojas		MINSAL (Ministry of Health)
Arturo Bascuñan		MINSAL (Ministry of Health)
Julio San Martín	Mayor	Municipality of Chillan Viejo
Flavio Barrientos	Environmental Area	Municipality of Chillan
Jaime Bravo	Environment and Energy Efficiency Area	CNE (National Energy Commission)
Muriet Polett Salazar Flores	Chemical Department	Universidad Catolica Santisima Concepcion
Marcos Sandoval	Agronomy Department - Teacher	Universidad de Concepcion
Tania Junod López	Veterinary Department - Teacher	Universidad de Concepcion
Paola Conca	Environmental Manager	ProChile
Ana María Ruz	Sustainable Energy Department	Fundacion Chile
Marcela Angulo	Environmental Manager	Fundacion Chile
Jaime Dinamarca	Environmental Manager	SOFOFA
Nora Au	Vice Dean – Civil Engineering	UDD
Jaime Eriz	Commercial Manager	COPELEC
Guillermo Stevens Molla	Cooperative Manager	COPELEC
Paola Nelson		ANDES AMBIENTAL
Maria Elena Hurtado		PNUD
Javier García	Energy and CDM Coordinator	CORFO
Horacio Borquez	Manager	Carnes Ñuble
Paola Berdichevsky	Country Representative	Avina
Andrés Poblete	Chief of Preventions	Mutual Security
Mariano Ruiz Esquide	Senator of the Republic (District 41-46-47)	Senate
Víctor Pérez Varela	Senator of the Republic (District 41-46-47)	Senate
Carlos Abel Jarpa	Member of Parliament, Disctrict 41	Chillan Member of Parliament
Rosauro Martinez Labbe	Member of Parliament, Disctrict 41	Chillan Member of Parliament
María Soledad Tohá V.	Regional Intendant	Intendant
Ignacio Marín C.	Provincial Governor	Ñuble Government
Víctor Torres J.	S.R.M. Economy	S.R.M (Regional Ministerial Secretariat)

Name	Position	Company/Institution
Carlos Almanza L.	S.R.M. Mining and Energy	S.R.M (Regional Ministerial Secretariat)
Rodrigo Martínez F.	S.R.M. Education	S.R.M (Regional Ministerial Secretariat)
Omar Hernández A.	S.R.M. Works	S.R.M (Regional Ministerial Secretariat)
María Inés Csori G.	S.R.M. Agriculture	S.R.M (Regional Ministerial Secretariat)
Mauricio Ortiz S.	S.R.M. National Goods	S.R.M (Regional Ministerial Secretariat)
Marta Werner C.	S.R.M. Public Health	S.R.M (Regional Ministerial Secretariat)
Carlos Arzola B.	S.R.M. Housing and Town Planning	S.R.M (Regional Ministerial Secretariat)
Claudio Vásquez F.	S.R.M. Transport and Communication	S.R.M (Regional Ministerial Secretariat)
María Luz Gajardo S.	S.R.M. MIDEPLAN (Planification)	S.R.M (Regional Ministerial Secretariat)
Eduardo Araya P.	Councillor	Regional Government
Claudio Arteaga.	Councillor	Regional Government
Bernardo Daroch.	Councillor	Regional Government
Oscar Ferrel.	Councillor	Regional Government
Alvaro Riffo	Industry and Environment Area	TironiAscociados
Ricardo Jara	Secretariat	Regional Government
Elizabet Kock	Chilean Project Director	Private international consultant
Aldo Bernucci	Mayor	Municipality of Chillan
Julio Álvarez C.	Operations Manager	GASSUR
Mauricio Alegría	Environmental Sub-Manager	MASISA
Pedro Navarrete	Environmental Chief	CORMA
Andrés Ezquerra	Environmental Chief	Celulosa Arauco
Promas	N/A	PROMAS
Blanca Cortés	President of the Parents Committee	Llollinco School
Mauricio Acuña	Student	Llollinco School
María del Carmen Ortega	Teacher	Llollinco School
Alfonso Darech Manríquez	Teacher	Llollinco School
Juan Flores	Neighbour Committee	Llollinco
Sandro López	Plant Chief	Seaweed Plant
Aurora Fuentealba	President of Neighbour Committee	Llollinco
Miguelina Larrera	Teacher	Quilmo School
Jorge Monroy	Neighbour	Quilmo
Leonardo Sepúlveda	Neighbour	Llollinco
Víctor Bastías	Neighbour	Llollinco
Giovanni Navarrete	Neighbour	Llollinco
Julia Cortés	Neighbour	Llollinco
Eufemia Vásquez	Neighbour	Llollinco
Adriana Jiménez	Neighbour	Llollinco
Macarena Acuña	Neighbour	Llollinco
Karen Facuse	Teacher	Llollinco
Damián Paredes	Student	Llollinco
Ricardo Jara	Secretariat	Regional Government
Rodrigo Martínez	S.R.M. Education	S.R.M (Regional Ministerial Secretariat)
Whindy Figueroa Carter	Student	Quilmo School
Alejandro Rosales Utreras	Student	Quilmo School
Victor Pasten Carrasco	Student	Quilmo School
Alejandra Araya Sandoval	Student	Quilmo School
Víctor Elgueta Cea	Student	Quilmo School
Rosa Bastías Sandoval	Student	Quilmo School

Name	Position	Company/Institution
Cristopher Alvear	Student	Llollinco School
Victor Bastías Lagos	Student	Llollinco School
Paula Bastías	Student	Llollinco School
Fernando Cortes Cartes	Student	Llollinco School
Johanna Paredes	Student	Llollinco School
Nicol Acuña Riquelme	Student	Llollinco School
Eduardo Méndez	Student	Llollinco School
Hilda Navarrete Cortes	Student	Llollinco School
Jorge Jimenez Muñoz	Student	Llollinco School
Leonel Zapata Acuña	Student	Llollinco School
Leonardo Zapata Zapata	Student	Llollinco School

HERA Ecobio	**Fundo Las Cruces Landfill Gas Recovery Project** **QUESTIONNAIRE**	mgm INTERNATIONAL

YOUR OPINION IS IMPORTANT TO US

<table>
<tr><td colspan="2">Please, answer the following questions and include all the pertinent comments in the columns on the right.</td></tr>
<tr><th>Question</th><th>Answer/Comment/Opinion</th></tr>
<tr><td>With reference to climate change, the Kyoto Protocol and the Clean Development Mechanism, briefly express your opinion on the “Fundo Las Cruces Landfill Gas Recovery Project”.</td><td></td></tr>
<tr><td>Would you recommend private companies, government authorities and other organizations to develop projects of this nature: the capture and flaring and/or use of landfill gas?</td><td></td></tr>
<tr><td>Do you believe “Fundo Las Cruces Landfill Gas Recovery Project” will contribute to the social, economic and environmental development (Sustainable Development) of the VIII Region and Chile?</td><td></td></tr>
<tr><td>Are there any additional comments you would like to make?</td><td></td></tr>
<tr><td colspan="2">Please, write your personal data:
o Name and Last name:
o Institution/Organization that you represent:
o Position:
o E-mail:
o Telephone:
Signature:</td></tr>
</table>

Please, return this survey at the end of the meeting or send it back to the following addresses. Do not hesitate to consult us if you have any doubts. Thank you very much.

René Figueroa (renefigueroa.hcl@heraholding.com)
HERA Ecobio S.A.
Operations Director
Tel: 56.42.1971352

Ana Luisa Vergara (avergara@mgminter.com)
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HERA Ecobio S.A. Variante Cruz Parada Km 1.5 Camino a Yungay Comuna Chillan Viejo / Chillan Tel: 56.65.293345 / Fax: 56.65.277485 E-mail: renefigueroa.hcl@heraholding.com www.heraholding.com	MGM INTERNATIONAL Encomenderos 161 Of 2A Las Condes, Santiago Tel: 56.2.2317056 / Fax: 56.2.2317057 E-mail: avergara@mgminter.com www.mgminter.com

E.2. Summary of the comments received:

In general, the comments obtained regarding to the project presentation were positive. Some remarkable aspects mentioned were the contribution of this type of projects for improving waste management and reducing odours, benefiting the surrounding communities. The surrounding community emphasized their interest in new employment opportunities and in the beneficial use of landfill gas as a renewable energy. Some participants expressed their interest in replicating these greenhouse gas emission reduction projects in the VIII Region.

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

During the questions and answers session in the event held at the landfill, participants expressed concern about several issues. Some additional comments were received by e-mail. Below we provide a list of the questions raised and answers given by HERA's representatives:

Q – HERA must fix the road.

A – As it was informed to both the community and authorities, HERA Ecobio is willing to contribute for the construction of a definitive road; however, the institution responsible for the maintenance of public roads, the Ministry of Public Works (MOP), still maintains this as a project. Nevertheless, every year, HERA has contributed for the maintenance of these roads, whether it is by using its own machinery or providing granular material, and will continue to do so insofar no definitive solution is projected.

Q – New jobs posts for the Llollinco community.

A – From the construction stage of the project, HERA Ecobio has complied with its commitments to the neighboring community, by providing job posts for people of the area, particularly in the less qualified tasks. However, since the company is concerned about the development of capacities in accordance with the company's projections, HERA will continue to train and prepare the personnel academically, as it has been done so far.

Q – … If we talk about sustainable development and the benefits that this landfill gas plant can obtain regarding gas and electricity generation for domiciliary consumption, I believe that the sustainable contribution should involve the benefit of supplying these products at a lower cost, not only for schools but for the entire community where the plant is located.

A – Since energy generation using landfill is a stage subsequent to the landfill gas capture and flaring stage, the benefits for the community will initially involve the provision of computers and material for the schools of Llollinco and Quilmo. In case the electricity generation project is carried out, the contribution of energy generated from landfill gas, or any other renewable energy to be implemented, will be evaluated.

Q – Has this project enter the "SEIA" of CONAMA?

A – Given that the optimization proposed for the management of landfill gas corresponds to an improvement of the already approved project, it does not require to enter the Environmental

Impact Evaluation System ("Sistema de Evaluación de Impacto Ambiental, SEIA"). This has been ratified by CONAMA and the SEREMI (Regional Ministerial Secretariat) of Health.

Q – When is the construction projected?

A – The landfill gas flaring stage is projected for the first semester of 2008, the construction will start in January 2008.

Q – As it is mentioned below, apparently there was a meeting. When was it and who was invited?

A – The Stakeholders meeting was carried out on November 4^{th}. People leaving in the surrounding areas and people from the Llollinco and Quilmo schools, which did not have Internet access to know the project and express their opinions, were invited. In the case of local authorities, universities, institutions and companies related to environment and/or solid waste management, their participation via e-mail was thought as convenient, since most of them are located in Concepcion –regional capital– and not in the province of Ñuble, which makes it difficult to arrange a meeting. Besides, HERA Ecobio had previously planned another meeting with the same entities at the landfill site, which is scheduled for next December or January. The objective of this meeting is to inform about the landfill operations as well as about the operational units of its industrial waste management system which is in the start-up phase.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	HERA Ecobio S.A.
Street/P.O.Box:	
Building:	
City:	Chillan (Chillan Viejo)
State/Region:	VIII Region of Bio-Bio
Postfix/ZIP:	
Country:	Chile
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	Operations Director
Salutation:	
Last Name:	Figueroa
Middle Name:	
First Name:	Rene
Department:	
Mobile:	56.9.98171798
Direct FAX:	
Direct tel:	
Personal E-Mail:	renefigueroa.hcl@heraholding.com

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No funds from public national or international sources will be used in any aspect of the proposed project.

Annex 3

BASELINE INFORMATION

Emissions reductions result mainly from methane destruction resulting from the capture and burning of landfill gas. Additional emissions reductions take place when offsetting fossil fuel from thermal plant and if the landfill gas is used to generate electricity, thereby offsetting carbon dioxide emissions at power plants elsewhere in the interconnected grid.

This Annex contains two items:

1. A derivation of the parameters used to estimate landfill gas generation from solid waste using the *"Tool to determine methane emissions from dumping waste at a solid waste disposal site"* ver. 1, from Executive Board 35th Meeting Report, Annex 10. These parameters are only used in the ex-ante estimation of emissions reductions; and
2. A calculation of the emissions factor for power generation in the interconnected power grid in Chile, using the "*Tool to calculate the emission factor for an electricity system*", ver. 1, from Executive Board 35th Meeting Report, Annex 12.

<u>Methane emissions reductions from landfill gas capture</u>

Landfill gas is generated by the anaerobic decomposition of solid waste within a landfill. It is typically composed of approximately 40 to 60 percent methane, with the remainder primarily being carbon dioxide.

The rate at which LFG is generated is largely a function of the type of waste buried, the moisture content and age of the waste. It is widely accepted throughout the industry that the LFG generation rate generally can be described by a first-order decay equation.

The k-parameters needed as input in the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site", ver. 1, are based on IPCC recommendations (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5). The Tool is described in detail below.

The Tool states:
"The amount of methane that would in the absence of the project activity be generated from disposal of waste at the solid waste disposal site ($BE_{CH4,SWDS,y}$) is calculated with a multi-phase model. The calculation is based on a first order decay (FOD) model. The model differentiates between the different types of waste j with respectively different decay rates k_j and different fractions of degradable organic carbon (DOC_j). The model calculates the methane generation based on the actual waste streams $W_{j,x}$ disposed in each year x, starting with the first year after the start of the project activity until the until end of year y, for which baseline emissions are calculated (years x with x=1 to x=y)."

The amount of methane produced in the year y ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j(y-x)} \cdot (1-e^{-k_j})$$

Where:

$BE_{CH4,SWDS,y}$	=	Methane emissions avoided during the year y from preventing waste disposal at the solid waste disposal site (SWDS) during the period from the start of the project activity to the end of the year y (tCO_2e)
φ	=	Model correction factor to account for model uncertainties (0.9)
f	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
GWP_{CH4}	=	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
OX	=	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering waste)
F	=	Fraction of methane in the SWDS gas (volume fraction) (0.5)
DOC_f	=	Fraction of degradable organic carbon (DOC) that can decompose
MCF	=	Methane correction factor
$W_{j,x}$	=	Amount or organic waste type j prevented from disposal in the SWDS in the year x (tonnes)
DOC_j	=	Fraction of degradable organic carbon (by weight) in the waste type j
k_j	=	Decay rate for the waste type j
j	=	Waste type category (index)
x	=	Year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year y for which avoided emissions are calculated (x=y)
y	=	Year for which methane emissions are calculated

The Tool used is usually for project activities that would avoid methane avoiding waste disposal at landfills. But in the same way, the methane generation can be estimated for landfills, only taking into account different years: the first year is the year of landfill opening and the last year is the last year of the project activity.

Hence, the above equation is used to estimate methane generation for a given year from all waste disposed up through that year. Multi-year projections are developed by varying the projection year and re-applying the equations. The year of maximum LFG generation normally occurs in the closure year or the year following closure (depending on the final year's disposal rate).

The selected values used for each variable according to the Tool recommendations are the following:

Table 3.1: *Variables and values chosen for methane generation at Fundo Las Cruces Landfill Gas Project*

Variable	Value	Justification
φ	0.9	Default value recommended
f	70%	Conservative value according to observation to other landfills with LFG active extraction systems in place. As an impermeable cover over the waste mass of Fundo Las Cruces Landfill is considered, the overall gas collection efficiency is expected to be at least 70%, based on the experience of other similar technology in USA.
GWP_{CH4}	21	Global Warming Potential (GWP) of methane, valid for the relevant commitment period
OX	0	Oxidation factor in a well managed landfill with a good cover is not considerable and can be estimated as zero.
F	50%	Most waste in SWDS generates a gas with approximately 50 percent of CH_4. Only material including substantial amounts of fat or oil can generate gas with substantially more than 50 percent of CH_4. Taking into account the IPCC default value, MGM estimates future methane content in landfill gas to be 50 percent.
DOC_f	0.5	The decomposition of degradable organic carbon does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. IPCC recommends that values should vary from 0.5 to 0.77. Default value recommended is 0.5.
MCF	1.0	Fundo Las Cruces is a technically well-managed landfill, which includes bottom impermeabilisation, levelling of waste, waste compaction and daily cover, leachate drainage and treatment system, among other things. Moreover the depth of the waste mass is currently about 12 metres and will increase up to 30 meters. The value is chosen according to IPCC table:

MCF value	Type of site
1.0	For anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.
0.5	For semi-aerobic managed solid waste disposal sites. These must have controlled placement of waste and will include all of

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<tr><td></td><td>the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating poundage; and (iv) gas ventilation system.</td></tr>
<tr><td>0.8</td><td>For unmanaged solid waste disposal sites – deep and/or with high water table. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.</td></tr>
<tr><td>0.4</td><td>For unmanaged-shallow solid waste disposal sites. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.</td></tr>
</table>
</td>
</tr>
<tr>
<td>$W_{j,x}$</td>
<td>
<table>
<tr><th>Year</th><th>Waste input in Fundo Las Cruces Landfill (tonnes)</th></tr>
<tr><td>2002</td><td>30,000</td></tr>
<tr><td>2003</td><td>61,896</td></tr>
<tr><td>2004</td><td>77,491</td></tr>
<tr><td>2005</td><td>99,234</td></tr>
<tr><td>2006</td><td>103,203</td></tr>
<tr><td>2007</td><td>152,833</td></tr>
<tr><td>2008</td><td>174,720</td></tr>
<tr><td>2009</td><td>181,709</td></tr>
<tr><td>2010</td><td>188,977</td></tr>
<tr><td>2011</td><td>196,536</td></tr>
<tr><td>2012</td><td>204,398</td></tr>
<tr><td>2013</td><td>212,574</td></tr>
<tr><td>2014</td><td>221,077</td></tr>
<tr><td>2015</td><td>229,920</td></tr>
<tr><td>2016</td><td>239,116</td></tr>
<tr><td>2017</td><td>248,681</td></tr>
<tr><td>2018</td><td>258,628</td></tr>
<tr><td>2019</td><td>268,973</td></tr>
<tr><td>2020</td><td>279,732</td></tr>
<tr><td>2021</td><td>290,922</td></tr>
<tr><td>2022</td><td>302,559</td></tr>
</table>
</td>
<td>The historical and projected future filling rates were provided by landfill personnel. It is expected that the 28-hectare area will be available to accept waste until the year 2031. At that time it would have reached a capacity of more than 7 million tonnes.</td>
</tr>
</table>

	<table><tr><td>2023</td><td>314,661</td></tr><tr><td>2024</td><td>327,247</td></tr><tr><td>2025</td><td>340,337</td></tr><tr><td>2026</td><td>353,951</td></tr><tr><td>2027</td><td>368,109</td></tr><tr><td>2028</td><td>382,833</td></tr><tr><td>2029</td><td>398,146</td></tr><tr><td>2030</td><td>414,072</td></tr><tr><td>2031</td><td>430,635</td></tr></table>	
DOC_j	<table><tr><th>Waste type j</th><th>DOC_j (% wet waste)</th><th>Fraction of Waste Type j</th></tr><tr><td>A. Wood and Wood Products</td><td>43%</td><td>1.14%</td></tr><tr><td>B. Pulp, Paper & Cardboard (other than sludge)</td><td>40%</td><td>12.66%</td></tr><tr><td>C. Food, Food Waste, Beverages & Tobacco (other than sludge)</td><td>15%</td><td>50.60%</td></tr><tr><td>D. Textile</td><td>24%</td><td>0.65%</td></tr><tr><td>E. Garden, Yard & Park Waste</td><td>20%</td><td>5.62%</td></tr><tr><td>F. Leather and Rubber (other than natural rubber)</td><td>39%</td><td>0.00%</td></tr><tr><td>G. Nappies (disposal diapers)</td><td>24%</td><td>0.00%</td></tr><tr><td>H. Sludge</td><td>9%</td><td>6.00%</td></tr><tr><td>TOTAL</td><td></td><td>76.67%</td></tr></table>	Waste composition at Fundo Las Cruces Landfill. IPCC (2006) provides DOC default values for each type of waste *j*, as shown in the table.
K_j	<table><tr><th>Type of k</th><th>Tropical (MAT ≤ 20°C) Wet (MAP/PET > 1)</th></tr><tr><td>Slow k1 - Pulp, Paper, Cardboard / Textiles</td><td>0,060</td></tr><tr><td>Slow k2 - Wood & Straw</td><td>0,035</td></tr><tr><td>Medium k3 - Garden & Park / Other Organics</td><td>0,100</td></tr></table>	The decay rate constant is a function of refuse moisture content, nutrient availability, pH, and temperature. The methane generation rate constant, k, that appears in the landfill gas production model is related to the time taken for the DOC in waste to decay to half its initial mass (the 'half life' or $t_{½}$). The rate constant k has dimensions of "per year". Based on measurements in the USA, the United Kingdom and the Netherlands, IPCC supports values of k in the range of 0.03 per year (dry conditions) to 0.20 per year (high temperature and humidity condition). IPCC provides default

	Fast k4 - Food waste/sewage sludge	0,185	values or a range of values for k, depending on the weather conditions. The precipitation at Fundo Las Cruces Landfill is about 1,100 mm/yr and the average temperature is 13ºC. The IPCC recommended default values for each waste category under these weather conditions are presented on the table.
j			According to IPCC recommendations and for the categories in DOC_j
x	2002		Beginning of landfill operations
y	2008 - 2029		Years for which methane emissions are calculated

Methane Generation Potential [L_0]:

The methane generation potential is the total amount of methane that a unit mass of refuse will produce given enough time. The L_0 is a function of the organic content of the waste, water content and precipitation data.

The amount of methane released from solid waste, L_0, is given by the following formula:

L_0 = MCF x DOC x DOC_f x F x 16/12 **(Eq. 1)**

Applying these values in Eq. 1, we obtain:

L_0 = 0.0499 tonne CH_4/ tonne waste

Or, alternatively,

L_0 = 69.59 Nm^3 CH_4/ tonne waste, considering CH_4 density of 0.7168 kg/Nm^3 (P = 1atm, T = 0 C).

Emission Factor for Electricity Generation in the Chilean Grid ($EF_{elec,BL}$ and EF_{grid})

ACM0001 ver.7 recommends calculating the grid emission factor using the *"Tool to calculate the emission factor for an electricity system"*. We use version 1 of this Tool.

The Tool states that: *"This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "combined margin" (CM). The operating margin refers to a cohort of power plants that reflect the existing power plants whose electricity generation would be affected by the proposed CDM project activity. The building margin refers to a cohort of power units that reflect the type of power units whose construction would be affected by the proposed CDM project activity."*

Moreover:

'This tool may be referred to in order to estimate the OM, BM and/or CM for the purpose of calculating baseline emissions for a project activity substitutes electricity from the grid, i.e., where a project activity supplies electricity to a grid or a project activity that results in saving of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects). Note that this tool is also referred (…) for the purpose of calculating project and leakage emissions in case where a project activity consumes electricity from the grid or results in increase of consumption of electricity from the grid outside the project boundary".

Hence, the combined margin calculated with this tool will be used for two cases: when Fundo Las Cruces Landfill Project is consuming energy from the grid in order to meet project energy demand and/or when the electricity generated with LFG is supplied to the grid and emission reductions will be claimed for energy displacement.

In order to calculate the emission factor so-called "combined margin", the tool establishes the following six steps:

STEP 1. Identify the relevant electric power system.
STEP 2. Select an operating margin (OM) method.
STEP 3. Calculate the operating margin emission factor according to the selected method.
STEP 4. Identify the cohort of power unites to be included in the build margin (BM).
STEP 5. Calculate the build margin emission factor.
STEP 6. Calculate the combined margin (CM) emission factor.

STEP 1. Identify the relevant electric power system.

The Fundo Las Cruces Landfill is currently connected to the SIC (Interconnected Central System). The SIC is the main electrical system from Chile, providing electricity to about 90% of the Chilean population. The geographic and system boundaries include all the geographic area and infrastructures between Taltal (in the north) and Isla Grande de Chiloé (in the south).

The grid emission factor is calculated based on data provided by CNE (National Energy Commission) and by CDEC-SIC, through its report "Estadísticas de Operación 1997-2006 (Anuario 2007)".

STEP 2. Select an operating margin (OM) method.

Four different procedures are indicated for determining the operating margin emission factor ($EF_{grid,OM,y}$). These are denominated:

(a) Simple Operating Margin.
(b) Simple Adjusted Operating Margin.
(c) Dispatch Data Analysis Operating Margin.
(d) Average Operating Margin.

Of the methodological choices provided, the tool states the following:

"…Any of the four methods can be used, however, the simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

For the simple OM, the simple adjusted OM and the average OM, the emissions factor can be calculated using either of the two following data vintages:

- ***Ex ante option:** A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factor during the crediting period, or*
- ***Ex post option:** The year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year (y-1) may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year proceeding the previous year (y-2) may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods."*

As stated in Section B.7.2 of the PDD, this project chooses an *ex-ante* vintage for each crediting period (ex-ante option above). Of the three applicable ex-ante procedures, the Simple Adjusted Operating Margin is chosen since low cost/must run sources constitute more than 50% of total generation. Data available for the Chilean SIC power grid supports this approach, which is followed here.

STEP 3. Calculate the operating margin emission factor according to the selected method.

As shown in STEP 2, the operating margin calculation method chosen was Simple Adjusted Operating Margin (method b).

For calculating the operating margin emission factor, the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system excluding the low-cost/must run generation units is considered.

Also, the tool gives three different options to calculate OM emission factor, as follows:

- Option A. Based on data fuel consumption and net electricity generation of each power plant / unit.

- Option B. Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit or
- Option C. Based on data on the total net electricity generation of all power plants serving the system and the fuel consumption of the project electricity system.

This is a variation of the Simple Operating Margin, where the power sources are separated in low-cost/must-run power sources and other power sources. We are required to determine what fraction of time; the low-cost/must-run power plants are on the margin.

$$EF_{grid,OM-adj,y} = (1-\lambda_y)\frac{\sum_{i,j} FC_{i,j,y} \times NCV_{i,y}\ x\ EF_{CO2,i,j}}{\sum_j EG_{j,y}} + \lambda_y \frac{\sum_{i,k} FC_{i,k,y} \times NCV_{i,y}\ x\ EF_{CO2,i,j}}{\sum_k EG_{k,y}}$$

(T.EF.6[16])

Where

$EF_{grid,OM-adj,y}$	=	Simple adjust operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,y}$	=	Amount of fossil fuel type i consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y	=	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants / units, in year *y* (MWh)
i	=	All fossil fuel types combusted in power sources in the project electricity system in year *y*
y	=	Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

Net electricity imports must be considered low-cost / must-run plants.

λ_y is defined as follows:

$$\lambda_y(\%) = \frac{Number\ of\ hours\ low-\cos t/must-run\ sources\ are\ on\ the\ m\arg in\ in\ year\ y}{8760\ hours\ per\ year} \qquad (8)$$

Lambda (λ_y) is calculated by using the following steps and the graph provided in page 10 of the Tool.

Step i) Plot a load duration curve. Collect chronological load data (typically in MW) for each hour of the year y, and sort the load data from the highest to the lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Collect power generation data from each power plant / unit. Calculate the total annual generation (in MWh) from low-cost/must-run power plants / units (i.e. $\Sigma_k EG_{k,y}$).

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[16] Equation numbers from the "Tool to calculate the emission factor for an electricity system" are prefixed with the letter "T.EF" to distinguish them from equations from the ACM0001 methodology.

Step iii) Fill the load duration curve. Plot a horizontal line across the load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from low-cost/must-run power plants / units (i.e. $\Sigma_k EG_{k,y}$).

Step iv) Determine the "Number of hours for which low-cost/must-run sources are on the margin in year y". First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run sources are on the

As stated above, we select using the *ex-ante* vintage for each crediting period.

The simple adjusted operating margin was calculated for the most recent three years for which data were available: 2004, 2005, and 2006. The calculations are shown in the workbook: Chile_SIC Emission Factor (Sept2007).xls.

The results are summarised below:

	2004	2005	2006
∑FCij EFi,j (tCO_2/year) of NO LC/MR	6,449,702	5,712,405	6,030,306
∑FCij EFi,j (tCO_2/year) of LC/MR	2,307,781	2,077,358	2,302,471
NO LC/MR Generation (MWh)	12,977,054	10,315,300	9,803,967
LC/MR Generation (MWh)	24,989,132	29,846,425	30,469,313
Imports (MWh)	0	0	0
lambda	0.0043	0.0692	0.0307
fOM EF (tCO_2/MWh)	0.495	0.520	0.599
Average EF OM (tCO_2/MWh)	**0.539**		

STEP 4. Identify the cohort of power units to be included in the build margin.

For the purpose of determining the build margin emission factor, the spatial extent is limited to the project electricity system. According to the methodology, the build margin emission factor can be calculated using one of the following options:

- *Option 1: For the first crediting period, calculate the build margin emission factor ex-ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the requested for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emissions factor during the crediting period.*

- *Option 2: for the first crediting period, the build margin emission factor shall be updated annually, ex-post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emission factor shall be calculated ex-ante, as described in Option 1 above. For the third* *crediting period, the build margin emission factor calculated for the second crediting period should be used.*

In this particular case, the most recent data available would correspond to one or two years prior to the year in which project generation occurs, thus the Option 1 is selected among the two options proposed by the methodology. As a consequence, the build margin emission factor is calculated *ex-ante* and it is considered fixed along the first crediting period.

The sample group *m* consists of either:

(a) The five power plants that have been built most recently, or

(b) The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

According to the methodology, from these two options, the sample group that comprises the larger annual generation should be used. In this case, more than five power plants are needed to comprise 20% of the total generation. The 20% of the system generation during 2006 results to be 0.20 × 40,342,105 MWh = 8,068,421 MWh.

STEP 5. Calculate the build margin emission factor

The build margin emission factor is calculated as the generation-weighted average emission factor (tCO_2/MWh) of a sample of power plants, calculated in a similar way as the operating margin.
The equation is given below:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which power generation data is available

The CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) is determined according to what the tool recommends, i.e., *“as per guidance in step 3 (a) for the simple OM”*.

Power Plant	Generation (2006, MWh)	Cumulative Generation (MWh)	Start Year	Type	Fuel consumption (TJ)			CO_2 Emissions (tCO_2)	Cumulative CO_2Emisiones (tCO_2/year)
					Coal	Liquid	Gas		
Nueva aldea 2	229	229	2006	Diesel	0	0	0	0	0
Nueva aldea 3	10,781	11,010	2006	Diesel	0	0	0	0	0
Los Vientos	3,476	14,485	2006	Diesel	0	0	0	0	0
Candelaria 1 Diesel	1,896	16,381	2006	Diesel	0	218	0	16,132	16,132
Candelaria 2 Diesel	1,448	17,829	2006	Diesel	0	0	0	0	16,132
Campanario	4,553	22,382	2006	Gas - Diesel	0	55	0	4,108	20,240
Nueva aldea 1	111,311	133,692	2005	Gas - Diesel	0	0	0	0	20,240
Coronel_TG	87,852	221,544	2005	Gas	0	0	817	45,861	66,101
Coronel_Diesel	6,027	227,571	2005	Diesel	0	71	0	5,241	71,342
Antilhue TG	17,464	245,035	2005	Diesel	0	196	0	14,555	85,897
Candelaria 1	28,185	273,220	2005	Gas	0	0	775	43,490	129,386
San Isidro Diesel	40,781	314,001	2005	Diesel	0	0	11,976	671,891	801,278
Huasco_TG_IFO	30,092	344,093	2005	Diesel	0	563	0	41,714	842,992
Candelaria 2	37,366	381,459	2005	Gas	0	0	0	0	842,992
Valdivia	193,621	575,080	2004	Black Liquor - Biomass	0	0	0	0	842,992
Licantén	16,793	591,872	2004	Forest Residues	0	0	0	0	842,992
Ancud	256	592,128	2004	Diesel	0	0	0	0	842,992
Quellon	3,336	595,463	2004	Diesel	0	0	0	0	842,992
Horcones_TG	6,336	601,799	2004	Gas	0	0	86	4,812	847,804
Ralco	3,855,602	4,457,401	2004	Hydro (dam)	0	0	0	0	847,804
Cholguan	78,348	4,535,749	2003	Forest Residues	0	0	0	0	847,804
Nehuenco 2	2,126,032	6,661,781	2003	Gas	0	0	14,929	837,498	1,685,302
Sn. FCO. Mostazal	103	6,661,884	2002	Diesel	0	3	0	191	1,685,493
Nehuenco 9B	27,994	6,689,878	2002	Diesel	0	0	346	19,407	1,704,900
Chacabuquito	177,711	6,867,589	2002	Hydro (run of river)	0	0	0	0	1,704,900
Taltal	354,140	7,221,729	2000	Gas - Diesel	0	0	6,067	340,355	2,045,255
Taltal 2	217,603	7,439,332	2000	Gas - Diesel	0	164	38	14,277	2,059,533
Mampil	200,663	7,639,995	2000	Hydro (run of river)	0	0	0	0	2,059,533
Peuchén	304,559	7,944,554	2000	Hydro (run of river)	0	0	0	0	2,059,533
Petpower	484,527	8,429,081	1998	Petroleum derived fuel	0	0	0	0	2,059,533

Note: Green columns show the cumulative generation and the cumulative CO_2 emissions.

The results are summarized below. The build margin emissions factor for baseline power generation is **0.244 t CO_2/MWh**.

Total Generation 2006 (MWh)	40,342,105
20% of Total Generation 2006 (MWh)	8,068,421
Generation for BM calculation (MWh)	8,429,081
Total CO_2 Emissions (tCO_2)	2,059,533
EF_{BM} (tCO_2/MWh)	**0.244**

STEP 6. Calculate the combined margin emissions factor

In order to calculate the Combined Margin emission factor, the tool provides the following formula:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

The default values indicated to be used for w_{OM} and w_{BM} are:

- *Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispachable nature) for the first crediting period and for subsequent crediting periods, or*
- *All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and : w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology refers to this tool.*

Considering the operating margin and build margin emissions factors, we have:

Operating Margin Emission Factor (Average 2004, 2005 and 2006)	**0.539**	(t-CO_2/MWh)
Build Margin Emission Factor (2006)	**0.244**	(t-CO_2/MWh)
Combined Margin Emission Factor	**0.392**	(t-CO_2/MWh)

Then we have:

$$EF_{grid,CM-adj,y} = 0.539 \times 0.5 + 0.244 \times 0.5 = 0.392\ tCO_2 / MWh$$

Thus, the combined margin is **0.392 t CO_2/MWh**.

Data sources:

- Estadísticas de Operación 1997-2006 – CDEC-SIC (anuario2007)
- "Fijación de Precios Nudo 2003/2006 - Sistema Interconectado Central (SIC)" (Comision Nacional de Energía - Gobierno de Chile - www.cne.cl)

Annex 4

MONITORING INFORMATION

Detailed information is in section B.7.