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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Loma Los Colorados Landfill Gas Project
Version 2
27 January 2006.

A.2. Description of the project activity:

The objective of Loma Los Colorados Landfill Gas Project is to develop a landfill gas collection system. This will involve investing in and operating a system for landfill gas collection and flaring. Landfill gas flaring involves methane combustion leading to greenhouse gas (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 uses of landfill gas (LFG) for energy include electricity generation for use at the landfill site and for sale to users elsewhere. LFG could also be used as a fuel for leachate evaporation.

Landfill gas may also be sent to users outside the landfill. In this case, emissions reductions associated with methane combustion are included within the project boundary and would lead to creditable GHG emissions reductions. Carbon dioxide emissions reductions associated with LFG use outside the project boundary do not form part of the proposed CDM project. Such energy applications of LFG outside the landfill project boundary could form part of a separate CDM project.

The Loma Los Colorados Landfill is a Municipal Solid Waste (MSW) landfill located in the community of Til-Til, 63.5 km north of Santiago, Chile, near a village named Montenegro. The site operations are managed by KDM, and are generally considered to be the most modern of landfill operations in Chile. In May 2003, construction of a railway access was completed and operation of a train was initiated to transport MSW to the Landfill from the transfer station located in the community of Quilicura, Santiago. It is reported that more than 90 percent of the MSW deposited at the Landfill is delivered by rail.

Loma Los Colorados is the biggest landfill in Chile; the site comprises a total of about 800 hectares (ha), of which 200 ha are planned for landfill development. The area around the Landfill may be considered semi-arid, with an average annual precipitation of 340 mm, with poor vegetation and animal life. Water is located deep in the soil, which generally consists of very low permeability clay, with measured permeability in the range of 10^{-5} to 10^{-7} cm/s. The lack of water and the presence of clay make this site appropriate for landfill operations.

The Landfill began accepting waste in April 1996. To date, more than 13.6 million tonnes of waste have been filled over 44 of the Landfill's 200 hectares. Upon completion, maximum waste thickness is expected to be about 80 meters; current maximum landfill height is about 60 meters. The capacity of the Landfill is approximately 130 million tonnes. Currently, the Landfill is filling at a rate of about 5,000 tonnes per day, or greater than 1.7 million tonnes per year. Assuming an increase in current filling rates of about 2.5 percent per year, the Landfill is anticipated to reach capacity around 2045. In December 2004, KDM started receiving the sludge coming from the largest wastewater treatment plant in Santiago, which will be finally disposed mixed with the MSW. The duration of this contract is expected to be 18 months, starting from December 2004, and the average amount of sludge to be disposed is estimated at 380 tonnes per day.

Currently, there are 55 landfill gas wells installed over an area of 44 hectares; of these, 12 are connected to a flare station, through an active gas extraction system. The rest of the wells are currently venting landfill gas to the atmosphere. The current flare station has been burning the gas since 1998, with some long interruptions in system operation. The total amount of gas burnt at this flare has been recorded daily by KDM, and would determine the baseline.

Following the implementation of the proposed CDM project, the predicted LFG recovery rate for the Landfill in 2006 is 6,507 m^3/h (assuming 50% capture of LFG generated), increasing to 34,026 m^3/h (50% capture) in 2026. The overall predicted recovery rate will continue to increase until the landfill closes, which is anticipated to occur in 2045, after which the rate will decrease as the organic fraction is degraded.

Some electricity might be generated using biogas for on-site use. It is estimated that KDM would need a 0.8 MW installed capacity for satisfying its own electricity demand, which will be mainly used at the leachate treatment plant. For fuelling such a power plant, around 550 m^3/h LFG (with 50% methane content) will be needed.

Another possible energy application for landfill gas is at an industry off-site. Insofar as the methane is equally destroyed by off-site energy use as on-site flaring or electricity generation, emissions reductions associated with methane recovery and destruction remain unchanged. However, any emissions reductions associated with replacement of fossil fuels at the industrial site are not part of this CDM project.

The proposed project would increase the current capture, treatment and flaring or otherwise burning landfill gas, which is typically about 50% methane.

Besides climate change mitigation, the project would have important local environmental benefits. Most of 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.

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)	KDM 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.:

Metropolitan Region

A.4.1.3. City/Town/Community etc:

Administrative district ("Comuna"): Til-Til
Village: Montenegro

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

The Loma Los Colorados Landfill is located in the administrative district ("Comuna") of Til-Til, 63.5 km north of Santiago, Chile, near a village named Montenegro. Til-Til is located 578 meters above sea level. According to the last census, it has a population of 18,000 covering an area of 667.3 square kilometers (km^2). The distance between the landfill and the nearest settlement, Montenegro, is 3 km. Montenegro has a population of about 600.

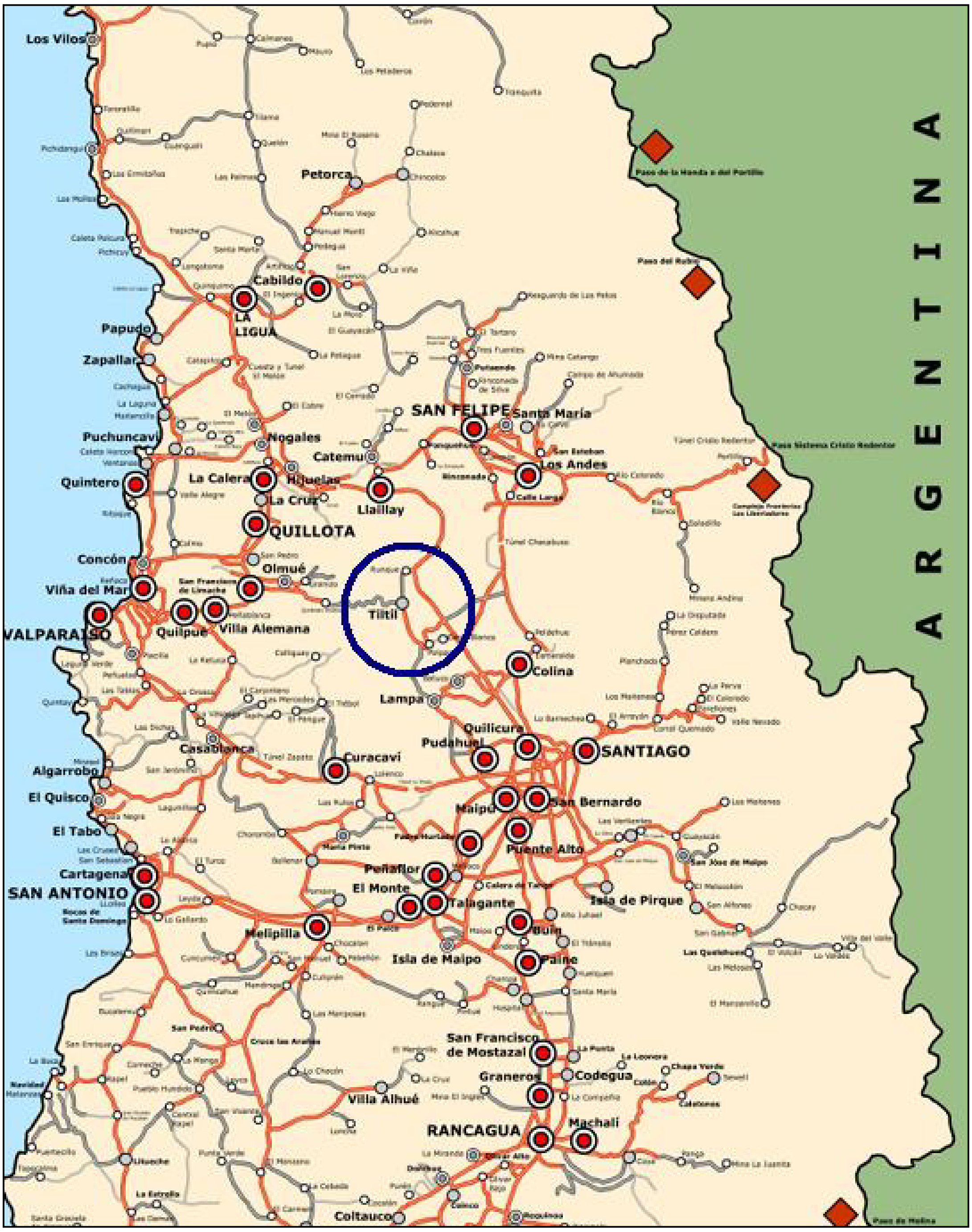

Figure 1 – Til-Til location.

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

According to the "Sectoral Scope" classification the project category is "13. Waste handling and disposal".

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

The Landfill is currently operating a small LFG collection and flaring system. The existing collection system currently consists of connection to a total of 12 wells. Some of these 12 wells are currently not being well operated due to elevated leachate levels. Site personnel also report that, historically, interruptions in system operation have been common, and are primarily due to disruptions in electrical service. Data on the amount of LFG collection and flaring are available since start of operation of the existing system in March 1998.

In order to maximize LFG recovery rates, and thus GHG emission reductions, the existing collection system will need to be expanded, and some existing elements improved. The LFG collection system will consist of a series of vertical extraction wells interconnected by header piping. The LFG will be extracted from the landfill using a vacuum system and conducted to a single point for flaring. Some LFG may be burnt to produce electricity or put to another energy use. The essential characteristics of the LFG collection and flaring system improvements are listed below:

- Expansion of the existing piping network to include connection to additional extraction wells. 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.

- Removal and replacement of approximately 350 meters of existing 160-mm piping currently serving the blower/flare station with larger diameter piping more suitable for the higher flow rates anticipated with a full-scale LFG collection system.

- Installation of a leachate dewatering system.

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

- Expansion of the flow capacity of the blower and flaring station. The existing blower and flaring station could be incorporated into the new station to provide additional capacity or backup utility capacity, or could be removed and relocated to another site.

- Improving the reliability of electrical service to the blower and flaring station, either by repairing or upgrading elements of the existing interconnection (if appropriate), or installing backup power capacity (e.g., diesel generator). Installation of a LFG-fuelled power generator is being considered.

When biogas recovery starts, electricity could be generated using biogas for on-site power generation. It is estimated that KDM would need a 0.8 MW installed capacity for satisfying its own electricity demand, which will be mainly used at the leachate treatment plant. For operating such a power plant, around 550 m^3/h LFG (with 50% methane content) will be needed. Commercially available equipment are available from several manufacturers for power generation using landfill gas.

Once LFG recovery starts, the project proponent would consider additional energy applications for the LFG, in particular (a) generation of electricity in excess of site demand for supply into the power grid; and (2) use as a fuel at an industry near the landfill site. In the latter case, the landfill gas would require some treatment to remove moisture and hydrogen sulfide and be compressed and injected into a dedicated pipeline conveying the gas to one or more industrial users.

Until recently, there were no projects to capture and flare (or otherwise use) landfill gas in Chile. Only in 2005, four other projects have been presented, for implementation under the CDM. Once this PDD is validated, engineering studies would be conducted and detailed designs made by a landfill gas specialty company from an Annex 1 country. Some of the key equipment: flares, blowers, LFG treatment, flow measurement devices, gas analysers, etc. will be provided by specialty manufacturers from Annex 1 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. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

This project comprises the collection and flaring of landfill gas, thus converting its methane content into CO_2, reducing its greenhouse gas effect. Some of the captured biogas may be used for energy, where it may offset GHG emissions from fossil fuel combustion.

The baseline scenario is defined as the most likely future scenario in the absence of the proposed CDM project activity. Establishing this future scenario requires an analysis and comparison of possible future scenarios using a comparison methodology that is justified for the project circumstances. Based on this analysis (see sections B.3. and B.4. below), the baseline scenario is the historical flow rate of LFG burnt at the existing flare station in recent years. This value is 245 tonnes of methane per year.

Sectoral policies and circumstances. To date there are no national or regional law requiring landfill gas capture and flaring.

Since the proposed project involves additional investments and operating costs and does not generate revenues, compared to the current practice of burning a small amount of landfill gas, the latter is economically the most attractive course of action. Thus, the additional LFG capture and flaring or use at Loma Los Colorados Project is not part of the baseline scenario, and may be considered to be additional.

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

Year	Annual estimation of emission reduction in tonnes of CO_2e
2006	426,609
2007	501,725
2008	539,127
2009	575,746
2010	611,678
2011	659,023
2012	693,851
2013	728,253
2014	762,307
2015	796,085
2016	845,669
2017	879,102
2018	912,461
2019	945,803
2020	979,189
2021	1,024,681
2022	1,058,315
2023	1,092,150
2024	1,126,236
2025	1,160,620
2026	1,195,347
Total estimated reductions (tonnes of CO_2e)	**17,513,976**
Total number of crediting years	**21**
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**833,999**

These ex-ante estimates are based on modelling of landfill gas (LFG) capture and estimates of electricity generation based on captured LFG.

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 methodology

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

The baseline methodology to be applied for the proposed project activity is the approved consolidated baseline methodology ACM0001, ver. 2, 30 September 2005: ***"Consolidated baseline methodology for landfill gas project activities"***. For emissions reduction associated with electricity generation using landfill gas ACM0001 also incorporates ACM0002 "Consolidated Baseline Methodology for Grid-Connected Power Generation from Renewable Sources" and, for power generation below 15 MW, small-scale CDM methodology AMS I.D.

B.1.1. 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; or*
b) *The captured gas is used to produce energy (e.g. electricity/thermal energy), but no emission reductions are claimed for displacing or avoiding energy from other sources; or*
c) *The captured gas is used to produce energy (e.g. electricity/thermal energy), and emission reductions are claimed for displacing or avoiding energy generation from other sources. In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the "Consolidated Methodology for Grid-Connected Power Generation from Renewable". If capacity of electricity generated is less than 15MW, and/or thermal energy displaced is less than 54 TJ (15 GWh), small-scale methodologies can be used."*

The proposed project activity corresponds to the first and third of these three alternatives. The collected landfill gas will generally be flared (option a above) or would be used to generate electricity to meet power requirements of the project itself or for other applications at the landfill site. Since emissions reductions would be claimed for displacing or avoiding energy from other sources, option c above is also applicable.

B.2. Description of how the methodology is applied in the context of the project activity:

The approved baseline methodology used —ACM0001 *"Consolidated baseline methodology for landfill gas project activities"*— is directly applicable to the proposed project activity.

The methodology is based on the case where baseline is defined in terms of "Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment."

The first step in applying the methodology is an evaluation of project additionality using the "Tool for the demonstration and assessment of additionality" published by the CDM Executive Board (sec. B.3, below).

The methodology refers to the type of project activity where neither the baseline nor project emissions of GHGs associated with LFG capture can be determined with precision, but the emissions reductions can indeed be accurately measured. While this makes project monitoring straightforward, it requires that the ex-ante emissions reductions be estimated using a mathematical model for LFG emissions and capture.

Thus ACM0001 states:

> *"Project proponents should provide an ex ante estimate of emissions reductions, by projecting the future GHG emissions of the landfill."*

Indeed, a single-decay LFG model (described in Annex 3) is used in this PDD as the basis for ex-ante estimates of emissions reductions from landfill gas capture and flaring (or use). Landfill gas production at the landfill is characterised by an overall methane generation capacity (Lo), and a single decay constants for all components of the waste. The values of Lo and k are shown below and model results are shown in Annex 3.

Parameter	Value	Units
Lo (single-k model)	79.78	m^3 of methane (@ 1.0 atm and 0ºC) per tonne of total waste.
k	0.07	(1/yr)

A small amount of landfill gas has been collected and flared at the proposed landfill over the last eight years. The amount of gas flared was measured throughout. We propose the average LFG flared in the last three years (2002-2004) to define a baseline and to determine emissions reductions in the baseline scenario. The basic assumptions and data sources for this determination are shown in the table below:

Main assumptions in determining emissions reductions from LFG capture and flaring in the baseline scenario

Fraction of Methane in LFG	%	FM	Measured at flare station (upper end of typical values)	60%
Density of Methane at STP	kg/m^3	Dstp	standard value	0.7168
Standard Temperature	K	Ts	standard value	273
Actual Temperature	K	Ta	Measured at flare station near flow meter (middle of typical range)	323
Standard Pressure	mbar	Ps	standard value	1,013
Actual Atmospheric Pressure	mbar	Patm	Measured at landfill (typical value)	920
Gauge pressure of LFG	mbar	Pg	Measured at flare station near flow meter (mid-point of typical range)	70

Note that some of the parameters (such as methane density at standard temperature and pressure, 0ºC and 1 atmosphere) are standard values. Others are based on measurements made at the landfill. Average values of temperature and pressure are used to convert measured LFG flow rate to mass units. A high estimate of methane content in LFG of 60% is considered in order for this calculation to be conservative, insofar as baseline emissions reductions are increased. Measured flow rates and calculations are shown in Annex 3.

Additional emissions reductions take place if the captured landfill gas is used for generating electricity. The procedure described in ACM0002 is used. For ex-ante estimates, the amount of electricity generation is determined by the capture of landfill gas. Since generation equipment comes in standard sizes, while landfill gas generation and capture vary with time, reasonable schedule for addition or replacement of generating equipment is considered in estimating the amount of electricity actually generated. Actual electricity generation would be determined from monitored data following project implementation.

Emissions reductions from electricity generation also depend on the emissions factor for power production. For power generation below 15 MW, ACM0001 suggests that the small-scale methodology may be used, while for higher power generation, ACM0002 is required. The proposed project would generate less than 15 MW for several years, until LFG generation and capture reaches levels that would permit higher power generation. For consistency, we propose to use ACM0002 throughout.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

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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 2 of *Approved consolidated baseline methodology ACM0001* "Consolidated baseline methodology for landfill gas project activities" makes the following comment regarding additionality:

> *"The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board…".*

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

These tools consist of Steps 0 through 5.

Step 0 is applicable to project activities that have started before registration. The project has not started and will not start until the PDD has been validated. Assuming successful validation and depending on the time elapsed between validation and project registration, it is possible that the project activity gets under way. Thus, Step 0 might become applicable at some point in the future. Step 0 requires that evidence be publicly provided to show "that the incentive provided by the CDM was seriously considered in the decision to proceed with the project activity".

This is indeed the case. CDM has been the sole basis for considering this project, and such discussions have been ongoing since early 2003. Documentation can be provided to show the following events:

- MGM contact with potential project participant KDM.
- Decision of J-Power (Japanese electric company, possible Annex 1 participant) and MGM International (CDM project developer) to conduct a feasibility study to determine the feasibility of the project under the CDM.
- The realization of the feasibility by SCS Engineers assisted by MGM International from mid-2003.
- Negotiations involving KDM, J-Power, and MGM in order to develop a business plan to develop the project under the CDM.

Thus, this project easily meets the requirements of Step 0 of the additional tool.

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 project activity.

The proposed project activity involves landfill gas capture and flaring. Alternatives could include the following circumstances:

1. Continuation of current practice. A limited gas capture and flaring has been operational since 1998, and this would be continued.
2. Proposed project activity not undertaken as CDM. The proposed activity is the capture of landfill gas and use as energy. Note that there are many variants to the use of captured landfill gas. All these variants are considered to be alternative project scenarios. Undertaking any of these without the CDM constitutes alternative baseline scenarios. The analysis that follows is applicable to any of these alternative scenarios as the project activity.

Sub-step 1b. Enforcement with applicable laws and regulations

This sub-step requires that:

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

To date, there are no national or regional law requiring landfill gas capture and flaring.

The tool for demonstration of additionality further states that:

> *"If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration;"*

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 of landfill gas. Therefore, additionality is not lost from the application of Sub-step 1.b of the tool.

The additionality tool then offers two options: Step 2 (Investment Analysis) or Step 3 (Barrier Analysis), with a third option of applying both Steps.

We choose to apply Step 3 Barrier Analysis.

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 project activity

We are required to establish that there are barriers that would prevent the proposed project activity from being carried out if the project were not registered as a CDM activity. Such barriers may include, among others:

1) Investment barriers
2) Technological barriers
3) Barriers due to prevailing practice
4) Other barriers

That the proposed project activity involves landfill gas recovery with flaring or any possible energy use of landfill gas. This set of proposed project activities faces technological barriers as well as barriers due to prevailing practice.

According to the additionality tool, technological barriers could include, *inter alia*:

- Skilled and/or properly trained labor to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;
- Lack of infrastructure for implementation of the technology.

Both the mentioned barriers are applicable to the proposed project activity. The proposed project would be one of the first of its kind in Chile. In recent months, several other projects to capture landfill gas in Chile, all within the CDM context.

It is only the potential for developing this project under the CDM that encouraged a potential Annex 1 participant, J-Power to support a feasibility study of the project under the CDM. The feasibility study was conducted by SCS Engineers, based in the USA, a country with ample experience in LFG capture and flaring projects. If the project is validated under the CDM, again it will be SCS Engineers (or other Annex 1 consultant) that would have to provide technical expertise in order to conduct detailed engineering studies and support project implementation. That engineering study will recommend a possible energy application of recovered landfill gas. It is possible that the successful implementation of the proposed project and a few others in Chile would be key to breaking the technological barriers to this type of project.

The proposed project activity thus also faces barriers due to prevailing practice. There are no similar projects in Chile, and except for the small amount of LFG collected and flared at this landfill site, the uncontrolled release of landfill gas, is common practice.

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

> *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)*

Note again that the project activity can be any one of a set of alternatives involving landfill gas capture and flaring, with possible energy use of landfill gas recovered are several. One baseline alternative represents the uncontrolled venting of landfill gas, save for a small amount captured and flared. This is the business-as-usual scenario. The barriers would not be applicable to the business-as-usual scenario, involving the uncontrolled release of LFG. The barriers would be applicable to any variant of the second alternative listed in Sub-step 1.a: “Capture of landfill gas and use as energy”. Capturing landfill gas and any alternative energy application involve additional technological know-how as well as additional investments, and thus face technological barriers.

Thus, considering the barriers, the only viable alternative to the possible set of project activities is the current practice at this and other landfills in Chile: the uncontrolled release of LFG.

We can therefore conclude that the proposed project activity meets the requirements of Step 3 (Barriers analysis) for the demonstration of additionality.

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

Step 4 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)."*

This step ensures that the stated barriers indeed have prevented similar projects from taking place. It is a credibility test on the validity of the barriers to project implementation. Step 4 comprises two Sub-Steps, which are discussed below.

> Sub-step 4a. Analyse other activities similar to the proposed project:
>
> *"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 we have stated in the context of Step 3 above, there are no other activities currently operating in Chile that are similar to the proposed project activity.

Sub-step 4b: "Discuss any similar options that are occurring" does not apply since no similar activities exist.

The final step for demonstrating additionality is Step 5. Impact of CDM Registration

The additionality tool states:

> "Explain how the approval and registration of the project as a CDM activity, and the attendant benefits and incentives derived from the project activity, will alleviate the economic and financial hurdles (Step 2) or other identified barriers (Step 3) and thus enable the project to be undertaken."
>
> The tool provides the following examples of benefits and incentives:

- Anthropogenic greenhouse gas emission reductions;
- The financial benefit of the revenue obtained by selling CERs,
- Attracting new players who are not exposed to the same barriers, or can accept a lower IRR (for instance because they have access to cheaper capital),
- Attracting new players who bring the capacity to implement a new technology, and
- Reducing inflation /exchange rate risk affecting expected revenues and attractiveness for investors.

Through CDM registration, the proposed project activity would benefit from revenues from CER sales, which would not otherwise be possible. This is by far the most important impact of CDM registration leading to project viability.

The possibility of CDM registration has already attracted new players into the field: SCS Engineers who have conducted a feasibility study of LFG capture and flaring, and are likely to conduct detailed engineering studies as well. The project attracted J-Power, a potential Annex 1 participant, as potential project investor in developing landfill gas recovery projects under the CDM. Moreover, J-Power and other potential Annex 1 participants have access to cheaper capital compared to local investors.

The project would lead to substantial reduction in anthropogenic greenhouse gas emission reductions. Without such a potential, no Annex 1 company would be interested in investing in this project.

Thus CDM registration would lead to many benefits and incentives, which would make project implementation possible.

Thus, we meet Step 5 of the additionality tool and, as the tool states: "*If Step 5 is satisfied, the proposed CDM project activity is not the baseline scenario.*".

Thus, we can assert that the proposed project activity is additional.

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

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As stated in the Baseline Methodology: "The project boundary is the site of the project activity where the gas is captured and destroyed."

Methane captured and flared as a part of the project activity determines the amount of methane destroyed by the project. GHG emissions from any fossil-fuel based energy used at the project site for collecting and flaring the landfill gas are considered as project emissions, and reduces overall GHG emissions reductions. GHG emissions from burning methane (fuel switching) are not considered. This may change pending future decisions of the CDM Executive Board, as stated by the Methodology Panel in the methodology used here:

> *"The Executive Board, at its twelfth meeting, requested the secretariat to prepare a technical paper, for consideration by the Panel on Methodologies of the Board, on the impact of oxidation of biogas in the calculation of emission reductions of methane (CH_4) for landfill gas project activities. The Board agreed that the Meth Panel shall prepare a recommendation on this issue to be presented to the Board, for its consideration, at its fifteenth meeting. This methodology might be revised in order to incorporate considerations by the Board on this issue. Any revisions shall not affect CDM project activities already registered using this current version of the methodology."*

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

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

Date of completion of the baseline study: 18/11/2005.

Baseline study prepared by Gautam Dutt and Ana Luisa Vergara, MGM International (not a project participant).

Contact information:

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Encomenderos 161, Of 2A
Las Condes, Santiago
Chile
gdutt@mgminter.com / avergara@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:

>>
The project is expected to be operational in 2006.

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

>> 21 years.

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

C.2.1. Renewable crediting period

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

>> 01/01/2006

C.2.1.2. Length of the first crediting period:

Seven years.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>NOT SELECTED.

C.2.2.2. Length:

>>

SECTION D. Application of a monitoring methodology and plan

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

Approved Consolidated monitoring methodology ACM0001: "Consolidated monitoring methodology for landfill gas project activities", version 2, 30 September 2005.

Note, however, that ACM0001 monitoring methodology requires:

> *"the methane content of the flare emissions should be analyzed at least quarterly, and where necessary more frequent, to determine the fraction of methane destroyed within the flare".*

We believe that a requirement to measure flare methane content is excessively burdensome and unnecessary. Moreover, methane emissions from the combustion of natural gas (over 90% methane) are not required to be measured at all in any of the approved methodologies involving natural gas combustion, including ACM0002. A flare is specifically designed to burn methane and as such a flare meeting standard LFG equipment specifications should be among the most effective in destroying methane. Note, further, that the IPCC default values for carbon oxidized in natural gas combustion is 99.5%.[1] Thus an appropriate conservative value for methane destruction in a flare might be 99%. Alternatively, flare effectiveness could be determined by temperature measurements. If the CDM EB decides to approve a monitoring methodology for landfill gas capture projects based on a default flare efficiency or temperature measurements, project sponsors reserve the right to use such a methodology in order to avoid the unnecessary expenses of measuring flare methane content four or more times each year.

The proposed project involves possible energy use of landfill gas collected. In this context the approved consolidated monitoring methodology, ACM0001 states:

> *"In this case a baseline methodology for electricity and/or thermal energy displaced shall be provided or an approved one used, including the ACM0002 "Consolidated Methodology for Grid-Connected Power Generation from Renewable". If capacity of electricity generated is less than 15MW, and/or thermal energy displaced is less than 54 TJ (15GWh), small-scale methodologies can be used."*

The proposed project would generate less than 15 MW up to 2015, and somewhat higher in subsequent years. While the small-scale methodology for renewable power generation would be applicable for the first few years, we propose to use the more general methodology ACM0002 for the entire crediting period.

[1] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Chapter 1 Energy, p. 1.29: Table 1-6. Fraction of carbon oxidized (recommended default assumptions)

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

The applicability of the methodology was listed in Sec. B.1.1, where it was shown that the proposed project fits within the conditions of applicability of the methodology.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

Option not selected.

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

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

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

Not applicable.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

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

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

Not applicable.

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

In landfill gas recovery projects, methane emissions in the baseline can only be estimated using a theoretical model, not measured directly. Similarly, remaining methane emissions (from incomplete coverage) after landfill gas capture system has been installed, cannot be measured either. However, the reduction in emissions from the project activity corresponding to what is actually captured can be determined with very high accuracy from monitoring. Thus Option 2 is applicable for landfill gas recovery projects, and is chosen here.

There are additional emissions reductions associated with energy use of landfill gas. This PDD considers the possibility that recovered landfill gas would be used to generate electricity. In this case the emissions reductions are given by the product of the electricity generated and the emissions factor for electricity generation, as described in ACM0001. Thus, this component of emissions reductions can also be determined by monitoring electricity generation. While the power output will be less than 15 MW for the first few years, we use ACM0002 (grid-connected electricity generation from renewable sources) for the entire crediting period.

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. $LFG_{total,y}$	Total amount of landfill gas captured	m^3	m	continuous	100%	electronic	Measured by a flow meter. Data to be aggregated monthly and yearly.
2. $LFG_{flare,y}$	Amount of landfill gas flared	m^3	m	continuous	100%	electronic	Measured by a flow meter. Data to be aggregated monthly and yearly.
3.$LFG_{electricity,y}$	Amount of landfill gas combusted in power plant	m^3	m	continuous	100%	electronic	Measured by a flow meter. Data to be aggregated monthly and yearly.
4.$LFG_{sold,y}$	Amount of landfill	m^3	m	continuous	100%	electronic	Measured by a flow meter. Data to be

	gas sold off site						aggregated monthly and yearly.
5. FE	Flare/combustion efficiency, determined by the operation hours (1) and the methane content in the gas exhaust gas (2)	%	m/c	(1) continuous (2) quarterly, monthly if unstable (see Comments)	n/a	electronic	(1) Continuous measurement of operation time of flare (e.g. with temperature) (2) Periodic measurement of methane content of flare exhaust gas
6. $w_{CH_4,y}$	Methane fraction in the landfill gas	m^3 CH_4/m^3 LFG	m	continuous /periodic	100%	electronic	Measured by continuous gas quality analyser
7. T	Temperature of the landfill gas	°C	m	continuous /periodic	100%	electronic	Measured to determine the density of methane D_{CH4}
8. p	Pressure of the landfill gas	Pa	m	continuous /periodic	100%	electronic	Measured to determine the density of methane D_{CH4}
9. (Regulatory Requirements)	Regulatory requirements relating to landfill gas projects	Text	n/a	annually	100%	electronic	Required for any changes the adjustment factor (AF) or directly $MD_{reg,y}$
10. EG_y	Electricity generated by the project	MWh	m	daily measurement and monthly recording	100%	electronic	Measured by electric meter.
11. EF_y	CO_2 emission factor of the grid	tCO_2/ MWh	c	yearly	100%	electronic	Calculated as a weighted sum of OM and BM emissions factors
12. $EF_{OM,y}$	CO_2 Operating Margin emission factor of the grid	tCO_2/ MWh	c	yearly	100%	electronic	Calculated as indicated in the ACM0002.
13. $EF_{BM,y}$	CO_2 Build Margin emission factor of the grid	tCO_2/ MWh	c	yearly	100%	electronic	Calculated as indicated in ACM002.

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Emissions reductions are determined directly in this option, and the corresponding formulae are shown in section D.2.4.

D.2.3. Treatment of leakage in the monitoring plan

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

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

"No leakage effects need to be accounted under this methodology" (from Approved baseline methodology ACM0001: "Consolidated baseline methodology for landfill gas project activities", version 2, September 2005.)

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Not applicable.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

We need to consider two greenhouse gases: methane (from landfill gas capture and destruction) and carbon dioxide (from electricity generation that would offset emissions from power plants elsewhere in the interconnected power grid. Any emissions reductions from replacing fossil fuels by LFG at an industrial facility off site is not considered in this CDM project and not counted in this PDD.

Methane

The GHG emission reduction associated with methane destruction achieved by the project activity during a given year "y" (ERM_y) is the difference between the amount of methane actually destroyed during the year $(MD_{project,y})$ and the amount of methane that would have been destroyed during the year in the absence of the project activity $(MD_{reg,y})$[2], times the approved GWP Global Warming Potential value for methane (GWP_{CH_4}).

$$ERM_y = (MD_{project,y} - MD_{reg,y}) \cdot GWP_{CH_4} \qquad (1)$$

Where:

ERM_y is measured in tonnes of CO_2 equivalent (tCO_{2e})

$MD_{project,y}$ and $MD_{reg,y}$ are measured in tonnes of methane (tCH_4)

GWP_{CH_4} = 21 tCO_2e/tCH_4

In the case where the $MD_{reg,y}$ is given/defined as a quantity that quantity will be used.

[2] Reg = regulatory and contractual requirements.

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.

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

For this project, there are no regulatory or contractual requirements to capture and flare landfill gas. In recent years a small amount of landfill gas has been collected and flared at this project site. In order to be conservative, we have considered the three-year average (2002-04) mass of methane captured and flared (245 tonnes methane per year) to be the baseline. The Adjustment Factor (AF) is considered to be zero for the first crediting period, since there are no legal requirements to capture and flare landfill gas in Chile. If any such requirements are introduced during the first crediting period, an appropriate value of AF may be included in the baseline for the second commitment period.

We provide an *ex ante* estimate of methane emission reductions, by projecting the future GHG emissions of the landfill, using a model. $MD_{project,y}$ will be determined *ex post* by metering the actual quantity of methane captured and destroyed once project activity is operational. The methane destroyed by the project activity ($MD_{project,y}$) during a year is determined by monitoring the quantity of methane actually flared or otherwise burnt (including any sold for use at an industry off site).

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

$$MD_{flared,y} = LFG_{flare,y} \cdot w_{CH_4,y} \cdot D_{CH_4} \cdot FE \qquad (4)$$

Where:

$MD_{flared,y}$ is the quantity of methane destroyed by flaring during the year measured in cubic meters (m^3)

$LFG_{flared,y}$ is the quantity of landfill gas flared or during the year measured in cubic meters (m^3)

$w_{CH_4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3CH_4/m^3LFG)

FE is the flare efficiency (the fraction of the methane destroyed)

D_{CH_4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4).

$$MD_{electricity,y} = LFG_{electricity,y} \cdot w_{CH_4,y} \cdot D_{CH_4} \quad (5)$$

Where:

$MD_{electricity,y}$ is the quantity of methane destroyed by generation of electricity during the year measured in cubic meters (m^3)

$LFG_{electricity,y}$ is the quantity of landfill gas fed into electricity generator during the year measured in cubic meters (m^3)

$w_{CH_4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3CH_4/m^3LFG)

D_{CH_4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4).

$$MD_{sold,y} = LFG_{sold,y} \cdot w_{CH_4,y} \cdot D_{CH_4} \quad 6)$$

Where:

$MD_{sold,y}$ is the quantity of methane destroyed from landfill gas sold during the year measured in cubic meters (m^3)

$LFG_{sold,y}$ is the quantity of landfill gas fed into the pipeline supplying other users (sold) during the year measured in cubic meters (m^3)

$w_{CH_4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3CH_4/m^3LFG)

D_{CH_4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4).

Carbon dioxide

There are reductions in carbon dioxide emissions from electricity generated using landfill gas, since this would replace emissions from power plants elsewhere. While the power output of the project will be below 15 MW for the first few years thereafter, we use ACM0002 for the entire crediting period.

Carbon dioxide emissions reductions during a given year (ERC_y) are given by:

$$ERC_y = EG_y \bullet EF_y \qquad (7)$$

where
ERC_y is measured in tonnes of CO_2 (tCO_{2e})
EG_y is the quantity of electricity generated during the year, MWh, and
EF_y is the emissions factor for electricity generation, tCO_2/MWh, given by:

$$EF_y = \frac{EF_{OM,y} + EF_{BM,y}}{2} \qquad (8)$$

where
$EF_{OM,y}$ is the operating margin emission factor, tCO_2/MWh, and
$EF_{OM,y} + EF_{BM,y}$ is the build margin emission factor, tCO_2/MWh.

Considering both methane and carbon dioxide emissions, total emissions reductions, ERT_y are given by:

$$ERT_y = ERM_y + ERC_y$$

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1-4 LFG_y	Low	Flow meters will be subject to a regular maintenance and testing regime to ensure accuracy
5. FE	Medium	Regular maintenance will be ensure optimal operation of flares. Flare efficiency will be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values. Note, however, if a new monitoring methodology is approved before and during project execution, replacing this requirement with an alternative, simpler, procedure, project sponsors propose to use the simplified procedure. See explanation in Section D.1
6. $w_{CH4,y}$	Low	The gas analyser will be subject to a regular maintenance and testing regime to ensure accuracy.
7. T	Low	Temperature measurement is very accurate. Data used only to correct for gas density.
8. p	Low	Pressure measurement is accurate.
9.(Regulatory requirements)	None	Legal document.
10 EG_y	Low	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically.
11-13. EF_y	Low	Emissions factor calculated from fuel use, carbon content of fuel and efficiency of power plants. All data are known and reported officially.

The landfill operator, KDM, has extensive experience in quality control procedures.

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

The overall management structure responsible for project monitoring is as follows. The KDM Technical Team who are responsible for the day-to-day operation of the landfill gas collection, flaring, and use system would also be responsible for monitoring key variables required for meeting the CDM monitoring requirements.

Data monitoring will be conducted by Landfill Gas Technical Operator supervised by the Landfill Gas Project Engineer,[3] both belonging to the Technical Department of KDM S.A., the project proponent. 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 KDM Technical Department.

One measurement involves the methane content of the flare combustion products, needed to determine what fraction of methane captured and sent to the flare did not indeed burn. Project proponent expects to acquire equipment to do these measurements in-house. However, if this is not feasible, then an outside laboratory would be contracted to undertake these measurements on a quarterly basis. The project developer does not agree with the current version of the methodology which requires measurements of flare stack methane content in order to determine flare efficiency, in part since such a requirement is not applicable to the landfill gas used for electricity generation. Indeed, no other methodology involving fuel consumption, which could involve natural gas combustion (natural gas is typically over 90% methane) requires a measurement of methane content of stack gases. For instance, no methodology involving the determination of the emissions factor for power plants (ACM0002 and other methodologies) requires measurements of methane content in stack gases. Boilers, furnaces and other combustion equipment such as those involved in thermal power generation equipment could also be emitting small amounts of methane in the exhaust gases. We expect that a future revision of ACM0001 would recognise this and offer an alternative procedure to ensure that the flare is indeed burning all the methane without the burdensome and discriminatory requirement for measuring stack methane content in the flare station. One such procedure could involve measuring stack gas temperature, whereby LFG combustion may be considered to be complete, provided the temperature is above a certain critical value. Since stack temperature measurements can be made on a continuous basis, this would be more complete indicator of flare effectiveness than spot measurements of stack methane content four times a year. An even simpler procedure would be consider a combustion efficiency such as indicated by IPCC for typical combustion devices, and assume (conservatively) that the part that is not fully burnt is methane (and not, say, carbon monoxide).

The determination of emissions factor for electric power generation requires a great deal of data on power plants recently built and in operation. This determination would be contracted to a consulting company specialising in such data collection and analysis. The consultant would be required to submit complete documentation so that the calculation procedure is transparent, and that the results can be independently verified. The procedure should be similar to that shown in Annex 3 of this PDD.

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.

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[3] Currently, these posts are occupied by Edgardo Araya and Camilo Silva Munizaga, the latter a Mechanical Engineer graduated from Santa Maria University of Viña del Mar.

All data would be subject to quality control procedures as described in Section D.3, above, and subject to Internal Audit from KDM Central Offices in Santiago.

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), on an annual basis. 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	Technical Department of KDM	Daily. Data will be entered into a spreadsheet on a daily basis, permitting continuous monitoring.	Yes	The data will be monitoring and filed by the KDM Technical 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 KDM Technical Department
3	Measurement of flare/combustion efficiency	Technical Department of KDM	Quarterly.	Yes	The measured value would be recorded in a file with the date of measurement. This file will be completed and filed by the person responsible for data filing and the Head of the Technical Department. This value would be used for estimating ERM until next measurement of flare efficiency.
4	Measurement of the methane content in the exhaust gas of flare	Technical Department of KDM (if feasible) or by external laboratory.	Quarterly, in order to determine flare efficiency, above.	Yes	The measured value would be recorded in a file with the date of measurement.. This file will be completed and filed by the person responsible for data filing and the Head of the Technical Department. This value would be used until next measurement of methane content of exhaust gas.

5	Measurement of methane fraction in the landfill gas	Technical Department of KDM or external laboratory	Continuous measurement.	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 the Technical Department.
6	Measurement of Pressure and Temperature	Technical Department of KDM	Daily. Data will be entered into a spreadsheet on a daily basis, permitting continuous monitoring.	Yes	Measured values will be used to determine methane density. 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 the Technical Department.
7	Sustainability indicators file	Technical Department KDM	Annual	Yes	This data file will be completed and filed by the person responsible for data filing and the Head of the Technical Department.
8	Monitoring of regulatory requirements relating to landfill gas projects	Technical Department KDM	Annual	No	The Head of the Technical Department will prepare the report on the current situation with respect to legal requirements.
9	Electricity generation data	Technical Department KDM	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 Technical Department.
10	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 KDM Technical Department.

11	Calculation of emissions factor for electric power generation in the interconnected grid.	Outside consultant	Yearly	No	Report showing the determination of emissions factor as the arithmetic mean of operating margin and build margin emissions factor will be filed by the Technical Department. This factor and the annual electricity generation will be used to determine CO_2 emissions reductions.
12	Internal Audit	KDM Central Office in Santiago.	Twice a year (July and December)	Yes	The internal auditor will prepare a report to the Manager of the landfill site and the Head of the Technical Department on the state of items 1 to 8. 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 Central Office and the Technical Department.

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

Monitoring methodology prepared by: Ana Luisa Vergara, Gautam Dutt, and Ignacio Barutta, MGM International (not a project participant).

Contact information:

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SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

Note that for this type of project activity, project emissions cannot be determined with precision, but the difference, representing emissions reductions from methane destruction can be measured as the amount of landfill gas captured due to the implementation of the CDM project, minus the amount of gas initially captured and burnt in the baseline scenario (considered as 245 tonnes of methane per year). In some cases, but not for this project activity, the measured values need to be adjusted (see ACM0001). Additional emissions reductions from power generation using landfill gas do not produce GHG emissions.

E.2. Estimated leakage:

Not applicable for this type of project activity (ACM0001).

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

Project emissions are not determined directly, see section E.3.

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

Note that for this type of project activity, baseline emissions cannot be determined with precision, for reasons explained in section E.1. However, emissions reductions can be directly determined.

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

Emissions reductions are directly measured in the approach used for this type of project activity (see section D.2.2).

A model for landfill gas (LFG) production determines total LFG recovery potential. The LFG model and its results for this landfill are shown in Annex 3. Actual LFG recovered depends on the effectiveness of the gas capture system, characterized by a collection efficiency, which is typically below 70%. A conservative value of 50% is considered for ex ante estimates. Also for conservative purposes, the sludge that is currently being disposed at the landfill was not considered as a source of gas generation, because of the limited period of that contract (18 months). It is important to consider that the sludge is one of the best raw materials for generating landfill gas and for accelerating the waste degradation process.

Ex ante GHG emissions reductions are determined from estimated LFG capture rates (m^3/h), assuming that 50% of LFG is methane, a methane density of 0.7168 kg/m^3 (0 degree Celsius and 1 atm.), and GWP of methane of 21. The ex ante estimates are shown in section E.6 below.

Following project implementation, emissions reductions associated with methane recovery and combustion would be determined from:

- actual LFG recovery rates (so that model predictions based on assumptions of gas production rates and collection efficiency will not be needed);
- measured methane fraction of LFG (from continuous gas analyser) so that this will not be estimated either; and
- methane density would be determined from measured pressure and temperature of LFG.

Thus actual emissions reductions are determined from monitored data without the need for any assumptions.

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

This PDD proposes three crediting periods of seven years each, starting in January 2006 and ending in December 2026. Baseline capture of methane emissions is assumed to be 245 tonnes of methane throughout. An emissions factor for electricity generation of 0.481 tCO_2/MWh has been used in this *ex-ante* estimate.

Emissions reductions in the *first* crediting period (tonnes CO_2 equiv/year)

year	year	Estimation of project activity emission reductions (tonnes of CO_2 e)	Estimation of baseline emission reductions (tonnes of CO_2 e)	Estimation of total emission reductions (tonnes of CO_2 e)
1	2006	431,754	5,145	426,609
2	2007	506,870	5,145	501,725
3	2008	544,272	5,145	539,127
4	2009	580,891	5,145	575,746
5	2010	616,823	5,145	611,678
6	2011	664,168	5,145	659,023
7	2012	698,996	5,145	693,851
Total		**4,043,773**	**36,015**	**4,007,759**

Emissions reductions in the *second* crediting period (tonnes CO_2 equiv/year)

year	year	Estimation of project activity emission reductions (tonnes of CO_2 e)	Estimation of baseline emission reductions (tonnes of CO_2 e)	Estimation of total emission reductions (tonnes of CO_2 e)
1	2013	733,398	5,145	728,253
2	2014	767,452	5,145	762,306
3	2015	801,230	5,145	796,084
4	2016	850,814	5,145	845,669
5	2017	884,247	5,145	879,102
6	2018	917,606	5,145	912,461
7	2019	950,948	5,145	945,803
Total		**5,905,695**	**36,015**	**5,869,678**

Emissions reductions in the *third* crediting period (tonnes CO_2 equiv/year)

year	year	Estimation of project activity emission reductions (tonnes of CO_2 e)	Estimation of baseline emission reductions (tonnes of CO_2 e)	Estimation of total emission reductions (tonnes of CO_2 e)
1	2020	984,334	5,145	979,189
2	2021	1,029,826	5,145	1,024,681
3	2022	1,063,460	5,145	1,058,315
4	2023	1,097,295	5,145	1,092,150
5	2024	1,131,381	5,145	1,126,236
6	2025	1,165,765	5,145	1,160,620
7	2026	1,200,492	5,145	1,195,348
Total		**7,672,552**	**36,015**	**7,636,539**

Estimates of emissions reductions summary

crediting period	tonnes of CO_2 equiv

7-year (January 2006 to December 2012)	4,007,758
14-year (January 2006 to December 2019)	9,877,438
21-year (January 2006-December 2026)	17,513,976

SECTION F. Environmental impacts

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

>>
Landfill gas collection, treatment and flaring are measures to improve the environmental management of solid wastes in landfills. The detailed design and engineering of the proposed project will be conducted by KDM and a leading consulting company on landfill gas management.

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

- Destruction of non-methane hydrocarbons (NMOC) that contribute to photochemical smog in the local area. Moreover, volatile organic compounds are burnt in high-temperature flare, specially designed for this purpose.
- Destruction of air pollutants, such as hydrogen sulphide, that are sometimes present in landfill gas 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. LFG displaces oxygen in the soil, thereby harming the roots of plants. Plants on the landfill surface protect the cover soil from erosion. Erosion can lead to rainwater intrusion into the landfill and a consequent increase in leachate quantities. Erosion of the surface soil makes it more difficult for plants to grow. Plants promote transpiration of water, thereby minimizing both leachate and rainwater runoff.

Note that LFG combustion would produce small amounts of nitrogen oxides (NOx), particulate matter and carbon monoxide (CO), as would be the case in the kitchen stove or any other device burning natural gas. The emissions of such gases are regulated in order to maintain air quality, and the project would meet the relevant regulations. To this end, 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 (e.g. PM10) would be minimal. On the other hand a LFG flare is especially designed to operate at high temperature in order to burn the volatile organic compounds.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>
Project participants expect no significant negative environmental impact from the project activity.

SECTION G. Stakeholders' comments

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

Stakeholder comments for the Loma Los Colorados Landfill Gas Project are sought in two ways:

1) through a questionnaire survey sent to all potential stakeholders (see list below).
2) during two special public events that were held in August 2005 in an hotel in Santiago and at the landfill (Montenegro). Stakeholders invited in step 1 were invited to the event, which were also open to the public in general, permitting an opportunity of all persons and institutions who feel affected by the project to provide their input to the proposed project activity.

The following set of questions are presented to stakeholders, during this event:

1) With reference to climate change, the Kyoto Protocol and the Clean Development Mechanism, briefly express your opinion on the "Loma Los Colorados Landfill Gas Project".
2) 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?
3) Do you believe "Loma Los Colorados Landfill Gas Project" will contribute to the social, economic and environmental development (Sustainable Development) of Chile?
4) Do you believe that the project would contribute to the sustainable development of Til Til "Comuna"?
5) Are there any additional comments you would like to make?

The invitation process to participate in the stakeholder consultation was as follows:

1. At the end of July 2005, an e-mail was sent to the persons listed in the table below inviting them to participate at an event in Santiago on August 2, 2005. Invitees were requested to extend the invitation to anyone else that might be interested.
2. The August 2 meeting, held at a hotel en Santiago, was attended by about 40 persons from public and private institutions, universities, NGOs, companies interested in the energy use of landfill gas, companies related to the CDM, equipment suppliers, independent consultants, etc. The presentation included a brief description of CDM and a more detailed description of the proposed project. A brochure on the project was also distributed. Following the presentation, the audience was given the option of asking questions and providing opinion verbally; later the questionnaire with the questions mentioned above were also distributed. Some responses were received on the spot, while others sent them in by fax.
3. On August 5, 2005 an e-mail was sent to everyone originally invited and others that participated, and a web link was provided where they could download additional information on the project. They were give two weeks (until August 17) to provide additional comments. This constituted the first consultation process.
4. With respect to the consultation with the local community, landfill operator (KDM) staff contacted the head of the Community Association of Montenegro and invited participation at an event on August 12, at a meeting room located at the landfill site.
5. Twelve persons from the community participated at the event, which was conducted in a manner similar to that in Santiago, with the difference that e-mail was not used to send additional material, unless this was requested.

The following persons were invited to attend the meetings and to submit comments:

Name	Position	Company/Institution	Events Attendants
Marcela Main	Coordinadora Cambio Climático, Dirección Ejecutiva	CONAMA – Comisión Nacional de Medio Ambiente	
Javier García	Ingeniero Civil Industrial, Depto. Control de la Contaminación	CONAMA	Yes
Genaro Rodríguez	Area Residuos	CONAMA	
Joost Meijer	Area Residuos	CONAMA	
Pablo Badenier	Director CONAMA RM	CONAMA RM – Comisión Nacional de Medio Ambiente para Región Metropolitana	
Ivo Kovacic	Jefe de Area Evaluación de Impacto Ambiental	CONAMA RM	
Cristián Araneda	Area Evaluación de Impacto Ambiental	CONAMA RM	
Gonzalo Velásquez	Jefe de Area Residuos Sólidos	CONAMA RM	
Marcelo Fernández	Jefe de Area Calidad del Aire	CONAMA RM	Yes
		CONAMA RM	Yes
Juan Antonio Muñoz	Jefe de SEREMI Obras Públicas	MOP – Ministerio de Obras Públicas	Yes
Mirza Lemus		MOP	Yes
Benjamín Araneda		SAG - Servicio Agrícola Ganadero	
Cristián Calderón	Jefe Unidad de Residuos Sólidos	SEREMI Salud	
Marta Zamudio	Jefe (Subrogante) Depto. Acción Sanitaria	SEREMI Salud	
Yorka Retamal	Jefe Depto. Gestión Ambiental	SEREMI Salud	
Omar Cáceres	Jefe (Subrogante) Subdepto. Entorno Saludable	SEREMI Salud	
José Miguel Arriaza	Depto. Gestión Ambiental	SEREMI Salud	Yes
Rodrigo Rivera		SEREMI Salud	Yes
Alejandra Hernández		SEREMI Salud	
Magdalena Arancibia		SEREMI Salud	
Soledad Ubilla	Jefe División Políticas Públicas	MINSAL – Ministerio de Salud	
Jaime Bravo	Jefe del Area Medio Ambiente y Eficiencia Energética	CNE - Comisión Nacional de Energía	
Luis Cifuentes	Jefe Centro Medio Ambiente, Escuela Ingeniería	PUC - Pontificia Universidad Católica de Chile	
César Saez	Profesor Centro de Medio Ambiente, Escuela Ingeniería	PUC	
Enzo Sauma	Profesor Centro de Medio Ambiente, Escuela Ingeniería	PUC	
Juan de Dios Rivera	Profesor del Departamento de Ingeniería Mecánica y Metalúrgica	PUC	
Orelvis González	Jefe Sector Energía Sustentable	PUC	
Raúl O'Ryan		Universidad de Chile	

Leandro Herrera		Universidad de Chile	
José Hernández		Universidad de Chile	
Marcel Szantó	Ingeniería en Contrucción	UCV - Pontificia Universidad Católica de Valparaíso	
Juan Palma	Ingeniería en Contrucción	UCV	
Paola Conca	Gerente de Medio Ambiente	ProChile	Yes
Ana María Ruz	Director Programa Energía Sustentable	Fundación Chile	Yes
Javier Obach		Fundación Chile	Yes
Marcela Angulo	Director General	Fundación Chile	Yes
Jaime Dinamarca	Gerente de Medio Ambiente	SOFOFA – Sociedad de Fomento Fabril	
Manlio Coviello	Expert Natural Resources Division	CEPAL – Comisión Económica para América Latina	
Ignacio Vergara		Consultor Independiente	Yes
Andrés Gómez Lobo		Consultor Independiente	
Orlando Jiménez		CORFO – Corporación de Fomento	Yes
Francisco Albornoz		CORFO	Yes
Arturo Brandt		Poch Ambiental	
Ian Nelson	Gerente Area Grandes Clientes	Metrogas S.A.	Yes
Oscar Uribe	Subgerente de Estudios	Metrogas S.A.	
Gerardo Muñoz	Subgerente Area GNC y Climatización	Metrogas S.A.	Yes
Francisco Richards	Area Grandes Clientes	Metrogas S.A.	Yes
Sebastián Bernstein	Ingeniero de Estudios	Metrogas S.A.	
Matías del Río	Jefe Comunidades y Centrales Térmicas	Metrogas S.A.	Yes
Alejandro Sáez		Gas Atacama	Yes
Fernando Urrutia		Gas Atacama	Yes
Nicole Porcile		Cementos Polpaico	
Patricia Grüebler		SGS Chile	Yes
Mónica Aedo	Gerente de Sector Servicios Ambientales	SGS Chile	
Edgardo Devoto		DNV	
Manuel Antonio Pérez	Representante en Chile	LFG Specialties	Yes
Fernando Azofeifa		Banco Santander Santiago	
José Vargas	Ingeniero Proyectos	Pyros	Yes
Mario Solís	Area Negocios y Ventas	Pyros	Yes
Patricio Ossandón	Ingeniero de Proyectos	Pyros	Yes
Carlos Gebert		Sumitomo	
Alvaro Acevedo	Gerente General	Queulat	Yes
César Contreras		Gasco	
Alfredo Becerra	Gerente General	Geoandina	Yes
Jean Francois Bradfer	Gerente General	AS&D Consultores	Yes
Matías Errázuriz		Wetland	
Claudia Parra Q.		Montenegro	Yes
Eliana Ayala G.		Montenegro	Yes
María Elisa Tobar F.		Montenegro	Yes
Miriam Toro G.		Montenegro	Yes

Liliana González A.		Montenegro	Yes
Olga Berríos A.		Montenegro	Yes
Name unknown		Montenegro	Yes
Name unknown		Montenegro	Yes
Name unknown		Montenegro	Yes
Name unknown		Montenegro	Yes

G.2. Summary of the comments received:

All of the comments were made in Spanish. Following is a summary of translated comments.

Question 1: With few exceptions, the commenters expressed the opinion that the project should be implemented and that the project would be a positive development. A few commenters expressed the opinion that energy recovery should be emphasized in implementing a LFG recovery project. One expressed a preference for cogeneration.

One stakeholder expressed the following opinion: KDM's proposed activities are too limited. Landfill gas should not be burned in a flare. Instead the gas should be used to replace other fuels as a source of useful energy. The Kyoto Protocol does not provide proper incentives for energy recovery.

Question 2: Almost all commenters expressed support for the development of LFG recovery projects, such as the one proposed at the Loma Los Colorados Landfill. Several commenters included the condition that LFG recovery projects should be developed only if they are economically feasible or cost-effective. Several commenters expressed a preference that LFG recovery projects include energy recovery.

One commenter expressed unequivocal opposition to LFG recovery projects that do not include energy recovery.

Question 3: Most commenters agreed that the project would support the sustainable development of Chile in economic and environmental aspects. Several commenters expressed doubt or uncertainty that the project would promote social development. Other commenters specifically mentioned the social benefits of the project to the nearby community of Montenegro. They mentioned employment and reduction of odors as benefits the project would bring to the nearby community.

Some commenters said that including energy recovery as part of the project would increase the projects support for sustainable development. Electricity generation was supported by several commenters.

One commenter stated that the project would not contribute to sustainable development because the project would not properly use the energy in the LFG.

Question 4: Most commenters agreed that the project would support the sustainable development of the comuna of Til Til. Several commenters said that there should be focus on the benefits to the village of Montenegro. Montengro lies within Til Til.

One commenter expressed preference for a new industrial park that could use the LFG as fuel. One commenter said that the social aspects should be evaluated further. One commenter said that the landfill is already required to reduce emissions, so emission reductions from the project would not be additional. One commenter expressed a preference for using the best available technology. Some commenters said that electricity generation would improve the project's contribution to sustainable development, with one commenter suggesting that the provision of electricity to the local community would be a benefit.

One commenter said that burning LFG in a flare would not contribute to sustainable development of the local community but that energy recovery and the consequent generation of wealth would contribute to sustainable development.

Question 5: Some comments were complementary or supportive regarding the project, CDM, and the presentation at the stakeholders' meeting.

One commenter expressed regret that the project a) does not use the energy from the LFG in a more productive way; b) wastes energy and receives money for doing so; and c) illustrates how governmental incentives allow the waste of resources.

Several commenters expressed hope that the project would promote the development of the village of Montenegro. One commenter specified that some of the project profits should be used for schools, public transportation, sports, and cultural activities. One commenter mentioned job creation as a desirable benefit. Other commenters expressed the general sentiment that Montenegro, being very close to the landfill, should be given some favourable treatment.

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

In this section, comments are categorized according to subject. For each category, a description of how the project proponents have taken account of the comments is given.

Favourable Comments

Favourable comments are acknowledged. The project developer intends to proceed with the project as quickly as reasonably possible so that the benefits of the project will be realized.

Energy Recovery. Many comments relate to energy recovery. KDM intends to use some or all of the collected LFG to generate electricity, and possibly to supply landfill gas to industrial users off-site. The most likely beneficial use of LFG is to generate about 800 kW of electric power to serve the electricity requirements of the landfill.

The expected rate of LFG collection greatly exceeds the fuel requirements of an 800 kW generator. The project owner is very interested in making the LFG available to entities wishing to use it as a replacement for other fuels. The project owner is willing to consider reasonable offers from entities wishing to put the gas to beneficial use and will endeavour to contract with such entities so as to provide benefits to all involved parties, including the local community.

The project proponents recognize that a LFG energy recovery project generally requires a much larger investment than does the gas collection system associated with the energy recovery project and that certainty of fuel supply is generally a crucial prerequisite for justifying the investment in energy recovery. By moving forward with a gas collection and flaring system, the CDM project developer hopes to make certain the supply of fuel.

The project proponents believe that the project, even without any energy recovery, promotes the objectives of the CDM by decreasing emissions of greenhouse gases and by destroying minor components of LFG that cause local air pollution. The mitigation of global warming and local air pollution is part of sustainable development. Recovering useful energy from LFG is often a worthwhile activity. However, the objective of recovering energy should not be used as a reason to delay the development of a pollution-control project based on the flaring of LFG.

Social Benefits

Several commenters expressed concern that social benefits were not as clear as environmental and economic benefits. Ironically, several commenters from Montenegro specifically noted the social benefits of the project that they expected would impact on their community; such as the destruction of odorous gas, employment, and general improvement of landfill operations.

About three to five people will be directly hired to work full time on the project. Several people may be hired during construction. Money spent on supplies and services will indirectly contribute to the development of the local economy.

Benefits to the Village of Montenegro

Many of the landfill employees live in Montenegro. The project owner will make special efforts to find qualified people from Montenegro to work on the project. However, if qualified people are not found in Montenegro, they will be hired from wherever they may be found.

Following discussions with Mr. Juan Andrés Rivera, the Project Sponsor (KDM) has agreed to provide the following services to the village of Montenegro:

1. Fix the electrical system of the Montenegro rural school.
2. Expand the classroom in order to make room for a library.
3. Build bathrooms for pre-school children and for teachers of the Montenegro rural school.
4. Improve the water treatment system of the Montenegro rural school.
5. Provide eight 8 fire extinguishers to the Montenegro rural school.
6. Organize a Course on Risk Management for officials and teachers of the Montenegro rural school.
7. Provide two new computers for the Montenegro rural school.

In order not to limit the benefits to a single village, project proponent expects to provide improved services to a total of 14 rural schools all over the country.

Cost-Effectiveness

A few comments related to the cost-effectiveness of the project. The project proponent intends to develop the project because its analysis indicates that the value of the CERs exceeds the costs of producing the CERs. Similarly, if energy production for sale is cost effective in the sense that the cost of thermal energy production or electricity generation is less than the market price for thermal energy or electricity, then the project developers would pursue such options.

Additionality

The comment regarding additionality (see Question 4) is addressed in Section B of this PDD.

Best Available Technology

The project will use up-to-date technology, which in some cases will be the best that is available.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	KDM S.A.
Street/P.O.Box:	Alcalde Guzmán 0180, Quilicura
Building:	
City:	Santiago
State/Region:	
Postfix/ZIP:	
Country:	Chile
Telephone:	
FAX:	
E-Mail:	sdurandeau@guk.cl
URL:	www.kdm.cl
Represented by:	
Title:	Technical Manager
Salutation:	
Last Name:	Durandeau
Middle Name:	
First Name:	Sergio
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	sdurandeau@guk.cl

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 both from methane destruction resulting from the capture and burning of landfill gas. Additional emissions reduction take place if the landfill gas is used to generate electricity, thereby offsetting carbon dioxide emissions at power plants elsewhere in the interconnected grid. We first consider methane emissions.

Methane emissions reductions from landfill gas capture

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 and 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.

To estimate the potential LFG recovery rate for the Landfill, MGM utilized and updated version of the SCS Engineers in-house model that employs a first-order decay equation identical to the algorithm in the U.S. Environmental Protection Agency (EPA) landfill gas emissions model (LandGEM). Both models are described in detail below.

U.S. EPA Model

The EPA model requires that the site's waste disposal history (or, at a minimum, the amount of waste in place and opening date) be known. The model employs a first-order exponential decay function, which assumes that LFG generation is at its peak following a time lag representing the period prior to methane generation. The EPA model assumes a one-year time lag between placement of waste and LFG generation. After one year, the model assumes that LFG generation decreases exponentially as the organic fraction of waste is consumed.

For sites with known (or estimated) year-to-year solid waste acceptance rates, the model estimates the LFG generation rate in a given year using the following equation, which is published in Title 40 of the U.S. Code of Federal Regulations (CFR) Part 60, Subpart WWW.

$$Q_M = \sum_{i=1}^{n} 2k\,L_o\,M_i(e^{-k\,t_i})$$

where

$\sum_{i=1}^{n}$ = sum from opening year+1 (I=1) through year of projection (n);
Q_M = maximum expected LFG generation flow rate (m^3/yr);
k = methane generation decay rate constant (1/yr);
L_o = ultimate methane generation potential (m^3/Mg);
M_i = mass of solid waste disposed in the i^{th} year (Mg);
t_i = age of the waste disposed in the i^{th} year (years).

The above equation is used to estimate LFG 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).

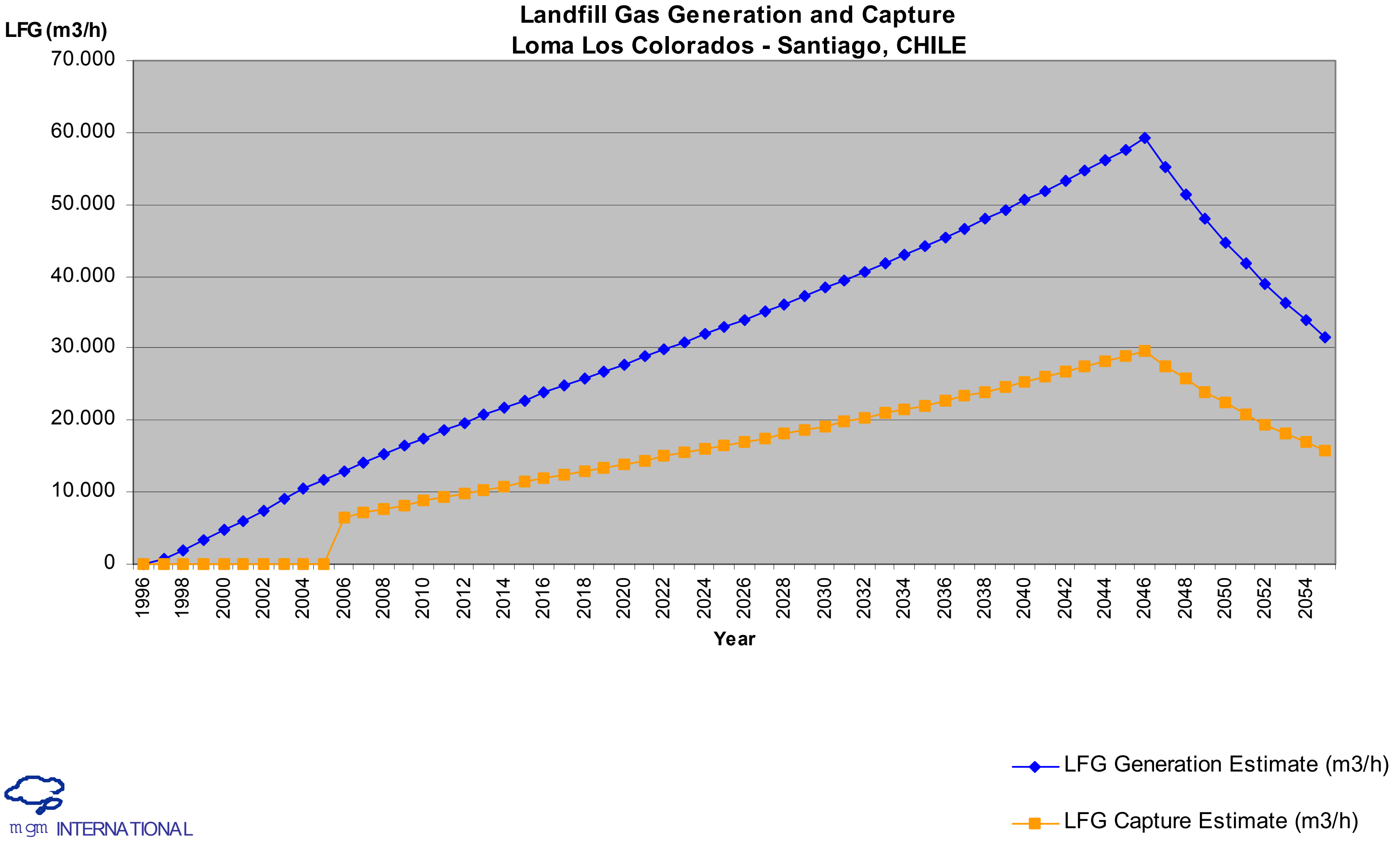
MGM used the model to estimate the projected LFG recovery rates for the Landfill through 2025 using the following criteria and assumptions:

- **Refuse Filling History -** The historical and projected future filling rates were provided by Landfill personnel. The landfill is projected to close in 2045, at which time it will have reached a capacity of approximately 130 million tonnes. For conservative purposes, the sludge that is currently being disposed at the landfill was not considered as raw material for gas generation, because of the limited period of that contract (18 months). It is important to consider that the sludge is one of the best matter for generating good quality landfill gas and for accelerating the waste degradation process.
- **Methane Content -** MGM estimates future methane content to be 50 percent.
- **Methane Generation Rate Constant [k] -** The decay rate constant is a function of refuse moisture content, nutrient availability, pH, and temperature.
- **Methane Generation Potential [Lo] -** 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
- **LFG System Coverage, or collection efficiency.** Considered as 50%.

For estimating the model parameters decay rate (k) and methane generation capacity (Lo) for the Landfill, the typical composition of waste buried in Loma Los Colorados Landfill was took into consideration.

Loma Los Colorados Estimated Landfill Gas Generation, Capture & Emissions Reduction											
Year	Total Disposal Rate (tonnes/yr)	Total Refuse In-Place (tonnes)	LFG Generation (m^3/h)	LFG Capture Efficiency (%)	Project LFG Capture (m^3/h)	Baseline LFG capture (tonnes methane per year)	**Emissions reductions from LFG capture (tonnes CO_2-e/year)**	Max. electricity generation potential (MW)	Possible scenario for power generation (MW)	**Emissions reductions due to Power Generation (tonnes CO_2/year)**	**Total emissions reduction (tonnes CO_2-e/year)**
1996	544,867	544,867	0	0%	0	0	0	0	0	0	0
1997	1,118,610	1,663,478	648	0%	0	0	0	0	0	0	0
1998	1,284,802	2,948,280	1,934	0%	0	0	0	0	0	0	0
1999	1,346,151	4,294,431	3,330	0%	0	0	0	0	0	0	0
2000	1,409,470	5,703,900	4,706	0%	0	0	0	0	0	0	0
2001	1,534,759	7,238,659	6,063	0%	0	0	0	0	0	0	0
2002	1,771,241	9,009,900	7,478	0%	0	0	0	0	0	0	0
2003	1,689,504	10,699,403	9,078	0%	0	0	0	0	0	0	0
2004	1,730,062	12,429,465	10,473	0%	0	0	0	0	0	0	0
2005	1,675,812	14,105,277	11,821	0%	0	0	0	0	0	0	0
2006	1,718,210	15,823,487	13,014	50%	6,507	245	423,407	9.5	0.8	3,202	426,609
2007	1,761,681	17,585,168	14,177	50%	7,089	245	461,696	10.3	10.0	40,029	501,725
2008	1,806,251	19,391,419	15,313	50%	7,657	245	499,098	11.1	10.0	40,029	539,127
2009	1,851,949	21,243,368	16,425	50%	8,213	245	535,717	11.9	10.0	40,029	575,746
2010	1,898,804	23,142,172	17,516	50%	8,758	245	571,649	12.7	10.0	40,029	611,678
2011	1,946,843	25,089,016	18,589	50%	9,295	245	606,986	13.5	13.0	52,037	659,023
2012	1,996,099	27,085,114	19,647	50%	9,824	245	641,814	14.3	13.0	52,037	693,851
2013	2,046,600	29,131,714	20,692	50%	10,346	245	676,216	15.0	13.0	52,037	728,253
2014	2,098,379	31,230,093	21,726	50%	10,863	245	710,269	15.8	13.0	52,037	762,307
2015	2,151,468	33,381,561	22,752	50%	11,376	245	744,047	16.5	13.0	52,037	796,085
2016	2,205,900	35,587,461	23,771	50%	11,886	245	777,620	17.3	17.0	68,049	845,669
2017	2,261,709	37,849,170	24,787	50%	12,393	245	811,053	18.0	17.0	68,049	879,102
2018	2,318,931	40,168,101	25,800	50%	12,900	245	844,412	18.7	17.0	68,049	912,461
2019	2,377,599	42,545,700	26,812	50%	13,406	245	877,754	19.5	17.0	68,049	945,803
2020	2,437,753	44,983,453	27,826	50%	13,913	245	911,140	20.2	17.0	68,049	979,189
2021	2,499,428	47,482,881	28,843	50%	14,422	245	944,623	21.0	20.0	80,058	1,024,681
2022	2,562,663	50,045,545	29,864	50%	14,932	245	978,257	21.7	20.0	80,058	1,058,315
2023	2,627,499	52,673,043	30,892	50%	15,446	245	1,012,092	22.5	20.0	80,058	1,092,150

2024	2,693,975	55,367,018	31,927	50%	15,964	245	1,046,178	23.2	20.0	80,058	1,126,236
2025	2,762,132	58,129,150	32,971	50%	16,486	245	1,080,562	24.0	20.0	80,058	1,160,620
2026	2,832,014	60,961,164	34,026	50%	17,013	245	1,115,290	24.7	20.0	80,058	1,195,347
2027	2,903,664	63,864,828	35,092	50%	17,546	245	1,150,405	25.5	20.0	80,058	1,230,463
2028	2,977,127	66,841,955	36,172	50%	18,086	245	1,185,951	26.3	24.0	96,069	1,282,020
2029	3,052,448	69,894,403	37,266	50%	18,633	245	1,221,970	27.1	24.0	96,069	1,318,039
2030	3,129,675	73,024,078	38,375	50%	19,188	245	1,258,502	27.9	24.0	96,069	1,354,572
2031	3,208,856	76,232,933	39,501	50%	19,751	245	1,295,588	28.7	24.0	96,069	1,391,657
2032	3,290,040	79,522,973	40,646	50%	20,323	245	1,333,266	29.5	24.0	96,069	1,429,335
2033	3,373,278	82,896,251	41,809	50%	20,904	245	1,371,575	30.4	24.0	96,069	1,467,644
2034	3,458,622	86,354,872	42,993	50%	21,496	245	1,410,553	31.2	28.0	112,081	1,522,633
2035	3,546,125	89,900,997	44,198	50%	22,099	245	1,450,236	32.1	28.0	112,081	1,562,317
2036	3,635,842	93,536,839	45,425	50%	22,713	245	1,490,662	33.0	28.0	112,081	1,602,743
2037	3,727,829	97,264,668	46,677	50%	23,338	245	1,531.867	33.9	28.0	112,081	1,643,948
2038	3,822,143	101,086,810	47,953	50%	23,976	245	1,573,887	34.8	28.0	112,081	1,685,968
2039	3,918,843	105,005,653	49,255	50%	24,627	245	1,616,759	35.8	32.0	128,092	1,744,851
2040	4,017,990	109,023,643	50,584	50%	25,292	245	1,660,517	36.8	32.0	128,092	1,788,609
2041	4,119,645	113,143,287	51,941	50%	25,970	245	1,705,199	37.7	32.0	128,092	1,833,291
2042	4,223,872	117,367,159	53,327	50%	26,663	245	1,750,839	38.8	35.0	140,101	1,890,940
2043	4,330,736	121,697,895	54,743	50%	27,371	245	1,797,474	39.8	35.0	140,101	1,937,574
2044	4,440,303	126,138,198	56,190	50%	28,095	245	1,845,139	40.8	35.0	140,101	1,985,240
2045	4,552,643	130,690,841	57,670	50%	28,835	245	1,893,871	41.9	35.0	140,101	2,033,972
2046	0	130,690,841	59,184	50%	29,592	245	1,943,706	43.0	35.0	140,101	2,083,807
2047	0	130,690,841	55,183	50%	27,591	245	1,811,952	40.1	35.0	140,101	1,952,053
2048	0	130,690,841	51,452	50%	25,726	245	1.689,105	37.4	28.0	112,081	1,801,185
2049	0	130,690,841	47,973	50%	23,987	245	1,574,563	34.9	28.0	112,081	1,686,644
2050	0	130,690,841	44,730	50%	22,365	245	1,467,765	32.5	24.0	96,069	1,563,834
2051	0	130,690,841	41,706	50%	20,853	245	1,368,187	30.3	20.0	80,058	1,448,245
2052	0	130,690,841	38,886	50%	19,443	245	1,275,341	28.3	20.0	80,058	1,355,399
2053	0	130,690,841	36,258	50%	18,129	245	1,188,773	26.3	17.0	68,049	1,256,822
2054	0	130,690,841	33,806	50%	16,903	245	1,108,056	24.6	13.0	52,037	1,160,094
2055	0	130,690,841	31,521	50%	15,760	245	1,032,797	22.9	13.0	52,037	1,084,835



mgm INTERNATIONAL

Historical data on landfill gas capture and flaring and resulting estimate of emissions reductions in the baseline scenario

	Units	Symbol	Source or Equation	1998	1999	2000	2001	2002	2003	2004	2005
LFG Flared											
January	m^3		Reported by KDM	-	127.380	5.125	18.742	6.405	0	102.656	119.377
February	m^3		Reported by KDM	-	107.500	555	22.856	8.435	0	109.644	107.359
March	m^3		Reported by KDM		147.688	552	2.688	8.450	9.740	107.026	44.758
April	m^3		Reported by KDM		118.276	6.002	39.227	9.700	15.084	108.118	47.725
May	m^3		Reported by KDM	4.638	106.856	17.227	42.325	9.370	13.842	120.166	87.444
June	m^3		Reported by KDM	13.385	68.230	39.417	7.974	9.471	13.597	98.609	102.130
July	m^3		Reported by KDM	31.131	84.713	7.149	6.520	8.160	102.606	99.530	105.236
August	m^3		Reported by KDM	37.787	88.573	108.261	7.491	8.200	102.292	108.725	
September	m^3		Reported by KDM	38.499		45.732	5.921	9.290	129.379	104.545	
October	m^3		Reported by KDM	36.911	47.277	35.712	5.804	9.460	102.500	108.878	
November	m^3		Reported by KDM	107.105	21.746	5.493	7.605	9.490	103.126	108.729	
December	m^3		Reported by KDM	131.391	24.031	6.218	7.030	2.560	81.755	117.229	
Total LFG Flared	m^3	LFG	Sum of monthly flows	400.847	942.270	277.443	174.183	98.991	673.921	1.293.855	614.029
Volume of Flared Methane	m^3	VM	FM x LFG	240.508	565.362	166.466	104.510	59.395	404.353	776.313	368.417
Temperature Adjustment	none	Tadj	Ts/Ta	0,845	0,845	0,845	0,845	0,845	0,845	0,845	0,845
Pressure Adjustment	none	Padj	(Patm + Pg)/Ps	0,977	0,977	0,977	0,977	0,977	0,977	0,977	0,977
Adjusted Density of Methane	kg/m^3	Dadj	Dstp x Tadj x Padj	0,592	0,592	0,592	0,592	0,592	0,592	0,592	0,592
Mass of Flared Methane	kg	MMkg	VM x Dadj	142.401	334.742	98.562	61.879	35.167	239.411	459.643	218.134
Mass of Flared Methane	**ton**	**MM**	**MMkg/1000**	**142**	**335**	**99**	**62**	**35**	**239**	**459,64**	**218**
								Use last three years as baseline			
								Average: 245 tonnes per year			

Additional assumptions used in the calculation of baseline emissions reduction from historical data on LFG capture and flaring are given in the table below:

Fraction of Methane in LFG	%	FM	Measured at flare station (upper end of typical values)	60%
Density of Methane at STP	kg/m^3	Dstp	standard value	0.7168
Standard Temperature	K	Ts	standard value	273
Actual Temperature	K	Ta	Measured at flare station near flow meter (middle of typical range)	323
Standard Pressure	mbar	Ps	standard value	1013
Actual Atmospheric Pressure	mbar	Patm	Measured at landfill (typical value)	920
Gauge pressure of LFG	mbar	Pg	Measured at flare station near flow meter (mid-point of typical range)	70

Baseline data for electricity

Insofar as captured LFG is used to generate electricity in the project scenario, and this generation replaces electricity generated elsewhere in the Chilean grid, additional emissions reductions would result from the proposed project activity. These emissions reductions are determined by the amount of electricity generated in each future year and the emissions factor for power generation. The emissions factor is determined using the approved consolidated methodology ACM0002, requiring a determination of the Build Margin, the Operating Margin and a Combined Margin.

The data used for the calculations and results are shown below. The data correspond to the Central Interconnected System of the Republic of Chile (SIC), which corresponds to the location of the project activity and also includes the capital city of Santiago. The SIC provides electricity to 92.7% of the Chilean population.

Build Margin estimation:

The five most recent power plants making up 20% of the power generation are shown in the Table below.

Power Plants Comprising the Build Margin

Plant Identification	Fuel Type	Year online	Generation (GWh/yr)	Emissions (ton CO_2 / yr)
Valdivia	Black liquour/Biomass/Diesel	2004	155.7	0
Lincanten	Biomass	2004	21.4	0
Horcones	Natural Gas	2004	12.1	5,750
Lag. Verde TG	Diesel	2004	8.7	7,339
Ralco	Hydro	2004	1,332.3	0
Nehuenco II	Natural Gas	2003	1,996.3	776,620
Cholguán	Biomass	2003	93.2	0
Nehuenco 9 B	Natural Gas/Diesel Petroleum	2002	107.6	71,631
S. F. de Mostazal	Diesel Petroleum	2002	9.4	10,040
Taltal 1 & 2	Natural Gas	2000	988.8	642,645
Mampil	Hydro	2000	174.2	0
Peuchén	Hydro	2000	262.3	0
Petropower	Petroleum derivates	1998	526.2	560,261
Nehuenco	Natural Gas/Diesel	1998	1,847.9	719,730
Total			**7,536.1**	**2,794,017**

Note: Since Chacabuquito hydro is considered as CDM, it was excluded from the build margin scope.

From this information, one can determine that:

$\langle E \rangle_{BM} = 0.371$ t-CO_2/MWh.

Operating Margin estimation:

The data are shown in the Table below.

Power plants included in the determination of the operating margin

Plant Identification	Fuel Type	Generation (GWh/yr)	Emissions (ton CO2 / yr)
Ventanas 1	Coal	413.5	406,713
Ventanas 2	Coal	1,050.7	1,032,083
Renca	Coal/Diesel	6.6	4,257
Nueva Renca	Natural Gas/Diesel Petroleum	2,275.6	887,858
L.Verde	Coal	38.5	69,819
Lag. Verde TG	Diesel	8.7	7,339
Bocamina	Coal	300.1	297,648
Huasco Vapor	Coal	4.1	10,437
Huasco TG	Diesel Petroleum	29.1	34,155
Guacolda 1	Coal	1,240.8	1,212,048
Guacolda 2	Coal	1,238.3	1,207,383
D. de Almagro	Diesel Petroleum	6.2	7,276
S. F. de Mostazal	Diesel Petroleum	9.4	10,040
Nehuenco	Natural Gas/Diesel Petroleum	1,847.9	719,730
Nehuenco 9 B	Natural Gas/Diesel Petroleum	107.6	71,631
Nehuenco II	Natural Gas	1,996.3	776,620
San Isidro	Natural Gas	2,706.0	1,046,005
Taltal 1 & 2	Natural Gas	988.8	642,645
Valdivia	Black liquour/Biomass/Diesel	155.7	0
Celco	Black liquour/Biomass/Diesel	132.5	0
Arauco	Black liquour/Biomass/Diesel	156.0	0
Petropower	Petroleum derivates	526.2	560,261
Horcones	Natural Gas	12.1	5,750
Total		**1,5250.7**	**9,013,162**

From these data we determine that:

$\langle E \rangle_{OM} = 0.591$ t-CO_2/MWh.

The combined margin emissions factor is given by the arithmetic mean of build margin and operating margin emissions factors:

$\langle E \rangle_{CM} = (\langle E \rangle_{BM} + \langle E \rangle_{OM}) / 2 = (0.371+0.591)/2 = 0.481$ t-CO_2/MWh.

Data sources

- Operational Statistics, "Anuario 2004" (www.cdec-sic.cl)

Annex 4

MONITORING PLAN

The monitoring methodology used for this project is ACM0001, with minor adjustments for application to the conditions of this project.

The project involves landfill gas capture and flaring. Some gas will be used for power generation at the landfill site. ACM0001 provides guidance and equations for these applications. ACM0001 also provides for the case that LFG is used to generate thermal energy (e.g. in a boiler) at the landfill site.

Figure A.4.1 shows the overall monitoring scheme as presented in ACM0002.

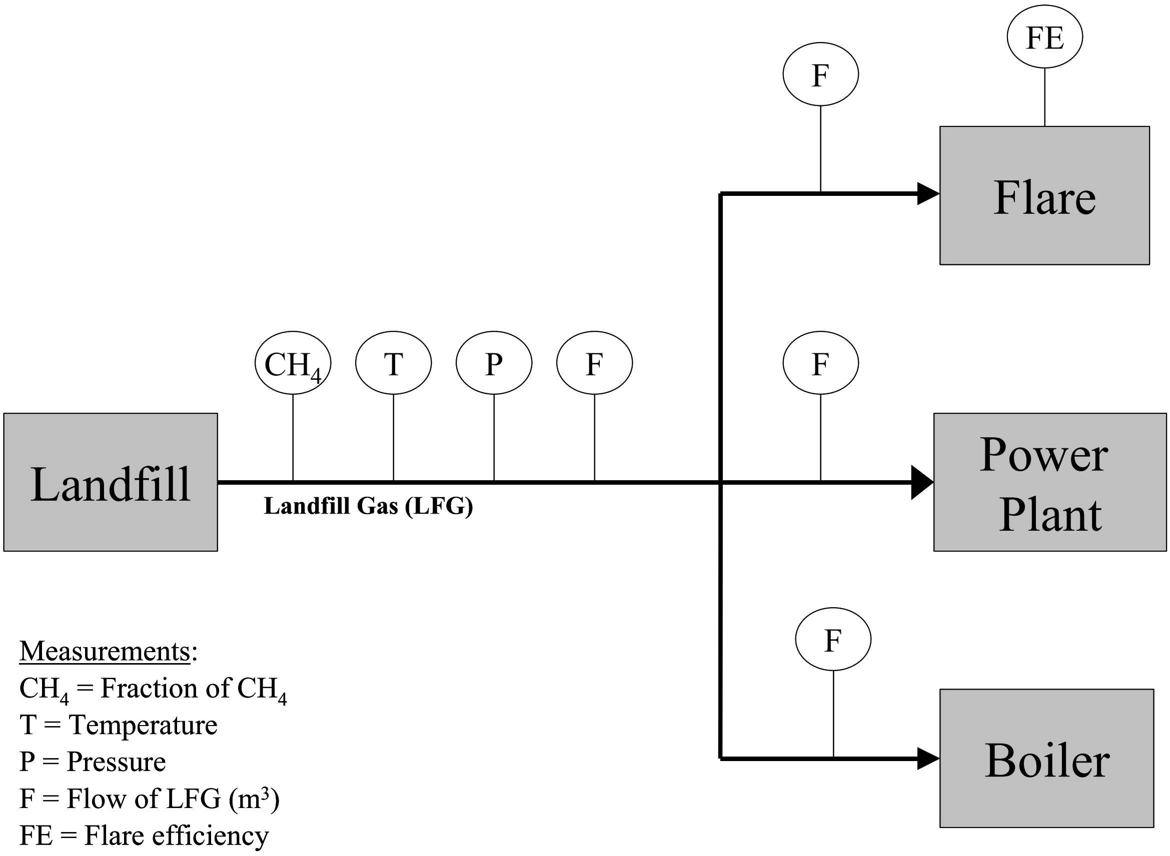


Figure A.4.1: Key Data Points for Monitoring (from ACM0001)
(Note: In this project, "Boiler" indicates users of LFG as fuel off-site)

The specific project is not expected to involve LFG use to generated thermal energy use on site. A more likely alternative is the treatment and supply of landfill gas to industrial users off site. Off site energy use of LFG also leads to methane destruction. However, since the energy used is outside the project boundary, any emissions reductions resulting from the use of LFG off site would not be creditable in the proposed project.

The monitoring procedure, including relevant equations, are summarised in Section D of the PDD. Here we provide some additional details on how the procedure would be applied to the specific project activity.

The monitoring requirements for estimating methane and carbon dioxide emissions reductions are considered separately.

Methane

Ex ante estimates of methane emissions reductions shown in this PDD were based on a model of landfill gas production and assumptions on how much of the total production would be captured for flaring or energy use. Actual emissions reductions would be based on monitored data on methane actually captured and burnt.

The monitoring plan requires direct measurement of the amount of landfill gas captured and the amount of landfill gas destroyed in one of three ways: at the flare platform, for electricity generation, and sold for use as fuel off-site. Thus four measurements of methane flow rate are involved, shown as "F" in Figure A.4.1. Each flow rate is measured as a volume flow rate, compensated for temperature and pressure in order to measure and record flow rate at standard temperature (0 C) and pressure (1.013 bar). The methane content of landfill gas collected is measured at a point in the landfill gas extraction system where all of the collected gas passes. The compensated flow rates of landfill gas at the four measurement points (total LFG collected, and LFG sent to flare, electricity generation, and injected to pipeline for sale) are multiplied by the methane fraction of landfill gas and methane density at standard temperature and pressure (0.7168 kg/m^3) in order to determine the mass flow rates of methane at each of the four locations.

Note that Eq. 4 of Section D.2.4 (based on ACM0001) states the following:

$$MD_{flared,y} = LFG_{flare,y} \cdot w_{CH_4,y} \cdot D_{CH_4} \cdot FE$$

Where:

$MD_{flared,y}$ is the quantity of methane destroyed by flaring during the year measured in cubic meters (m^3)

$LFG_{flared,y}$ is the quantity of landfill gas flared or during the year measured in cubic meters (m^3)

$w_{CH_4,y}$ is the average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^{3}CH$_4$/m^{3}LFG)

FE is the flare efficiency (the fraction of the methane destroyed)

D_{CH_4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH$_4$/m^{3}CH$_4$).

There are similar equations (5 and 6) in Section D.2.4 for methane used for electricity generation and sold for use off site.

Here all the measured variables are shown as their annual average values. This is not strictly the correct way of determining the total amount (mass) of methane destroyed annually. Rather, the annual mass of methane destruction should be determined as the sum of the hourly mass flows of methane destruction, i.e.

$$MD_{flared,y} = (\sum_{i=1}^{8760} LFG_{flare,i} \cdot w_{CH_4,i}) \cdot D_{CH_4} \cdot FE \qquad (A.4.1)$$

where
$LFG_{flare,i}$ is the flow rate at standard temperature and pressure of LFG sent to the flare during hour "i",
$w_{CH_4,i}$ is the average methane concentration of LFG collected during the same hour "i"

The mass of methane used to generate electricity ($MD_{electricity,y}$) and the mass of methane sold to users off-site ($MD_{sold,y}$) each year are determined similarly, by summing hourly values over the year.

In the above equation, a single value of flare efficiency (FE) is shown. Since ACM0001 requires FE to be measured quarterly, the mass flow of methane flared also would need to be determined on a quarterly basis. The mass of methane flared during each quarter would be determined by summing hourly values as indicated above, using value of FE as measured at the start of each quarter.

Once the components of methane destroyed in any of the three ways have been determined, the total mass of methane destroyed in each year can be determined using Eq (3) of Section D.2.4:

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{sold,y} \qquad (A.4.2)$$

The emissions reductions associated with methane destruction is then determined by Eq (1) of Section D.2.4:

$$ERM_y = (MD_{project,y} - MD_{reg,y}) \cdot GWP_{CH_4} \qquad (A.4.3)$$

Where:
ERM_y is measured in tonnes of CO_2 equivalent (tCO_{2e})
$MD_{project,y}$ and $MD_{reg,y}$ are measured in tonnes of methane (tCH_4)

For reasons explained in Section D.4.2, $MD_{reg,y}$ is zero for the first crediting period of this project , while GWP_{CH_4} = 21 tCO_2e/tCH_4, again for the first commitment period of the Kyoto Protocol (until 2012).

In order to determine if an adjustment needs to be made for the second and third crediting periods, KDM would monitor relevant regulations for LFG project activities periodically, and make modifications on the value of $MD_{reg,y}$, accordingly.
Note that the measurement equipment for gas quality (humidity, particulate, etc.) is sensitive, so a strong QA/QC procedure for the calibration of this equipment is needed.

Carbon dioxide

In this project, carbon dioxide emissions reductions result from power generation using landfill gas (which is a renewable fuel and therefore produces no net carbon dioxide emissions). The electricity produced here offsets emissions from power plants elsewhere in the system.

Here, the key variable to be measured is the net electricity output of the LFG generation system, which would be measured using an electric meter. This meter will be calibrated periodically, e.g. annually.

The determination of emissions reductions also requires a determination of the emissions factor for power generation in the interconnected power grid. This emissions factor would be calculated yearly from the most recent data available of the Chilean power system. The procedure to be used, based on the approved consolidated methodology ACM0002 "Consolidated monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources", is as shown in Annex 3.

Once the annual net electricity generation and the emissions factor for the interconnected power grid have been determined, carbon dioxide emissions reductions during a given year (ERC_y) are given by Eq (7) of Section D.2.4:

$$ERC_y = EG_y \cdot EF_y \qquad \text{(A.4.4)}$$

where

ERC_y is measured in tonnes of CO_2 (tCO_{2e})

EG_y is the quantity of electricity generated during the year, MWh, and

EF_y is the emissions factor for electricity generation, tCO_2/MWh.

Monitored data used to determine methane and carbon dioxide emissions reductions would be recorded in spreadsheets wherever possible (except for such information as regulations), showing calculation procedures. These data should be compiled on an annual basis, be subject to internal audit (see Section D.4) and be available to the Designated Operational Entity in charge of Verification.