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 5.3
02 August 2012.

This revised and updated version of the PDD addresses the following post registration changes:

- Occurred and planned (yet to be fully implemented) permanent changes in the project design
- Permanent changes from the monitoring plan
- Corrections in information made available in the PDD (which does not affect the project design)

Occurred and planned (yet to be fully implemented) permanent changes in the project design:
These changes are related to the implementation and operation of the electricity generation component of the project activity and are summarized as follows:

- Occurred and planned (yet to be fully implemented) gradual installation of electricity generation equipment (fuelled by collected landfill gas) with higher energy conversion efficiency than earlier forecasted.
- Occurred and planned (yet to be fully implemented) gradual installation of electricity generation equipment under a revised timeline/schedule[1].

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[1] Since the initial conceptualization of the design for the project activity, gradual and phased implementation schedule for the project's electricity generation component has been assumed as fully dependent on the following project design and operational aspects and requisites:

- (i) expected and projected relative increments in terms of LFG generation and LFG collection along the crediting period and
- (ii) high share of collected LFG being utilized as fuel for electricity generation (instead of flaring collected LFG)

Under these aspects and requirements, gradual capacity additions in related nameplate total installed capacity for power generation equipment (fuelled only by LFG) have thus been forecasted as part of the project design.

In the particular case of the initial registered version of the PDD, gradual phased increments in the total installed nameplate power generation capacity were estimated based on the following aspects/elements:

- (i) ex-ante estimations of LFG generation and collection by the project activity (by using the first order decay – FOD model as required by ACM0001 (version 4))
- (ii) by considering a maximum technical LFG utilization rate (as fuel for electricity generation) of total flow of LFG effectively collected of about 80% (due to expected variability in the flow rate, it was expected that not more than 80% of all collected LFG would end up being utilized as fuel for electricity generation)
- (iii) by considering an earlier assumed technical LFG-to-electricity conversion efficiency as follows: about 688 m^3/h of constant LFG flow (with 50% CH_4 content) was assumed as required for generating a constant power of 1.0 MW of electricity. This earlier assumed technical conversion efficiency for related equipment was obviously applicable under circumstances with power generation equipment operating continuously and under optimal operational conditions in terms of fuel supply (quality of fuel), fuel quality and conditions of the electricity grid)."

The occurred and planned revised implementation schedule for the project's electricity generation component is due to the following two main reasons:

- (i) better understanding and assurance by KDM S.A in terms of real flow of LFG collection in the project site. This is a direct outcome of gained operational experience and competence developments within all operational aspects of the project activity by the whole project operation team of KDM S.A. These aspects have actually promoted significant improvements in terms of flow of LFG actually collected and also significant improvements

In order to address in an appropriate manner such occurred and planned permanent changes in the project design, the investment analysis which is enclosed to the PDD (in the context of the assessment and demonstration of additionality) is thus revised by taking into account:

- Projected relative increments in amount of electricity to be generated by the project activity along the project's lifetime (which results in incremental revenues from exports of electricity through the grid). The forecasted increments in electricity generation to be resulted by the changes in the project design are specifically outcomes of both higher conversion efficiency of power generation equipment as well as higher installed capacity (when compared to earlier assumptions at the time of the project conceptualization).
- Modified schedule for the project implementation (which affects the timing for capital investment and expenses in gradual capacity additions (including incremental operation and maintenance costs as well as incremental revenues associated to such gradual capacity additions) along the gradual phased implementation schedule of the project's electricity generation component over the whole project activity lifetime[2]

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in terms of expected variability of collected LFG flow (LFG flow variability has decreased significantly). These two main operational aspects resulted in higher technical utilization potential for collected LFG (as fuel for electricity generation), making relative increments in terms of installed power generation capacity technically feasible. The higher availability of LFG thus also triggered increment in power generation installed capacity (when compared to earlier estimates and forecasts at the time of the project implementation decision making in mid 2006)."

- (ii) availability in the Chilean market of power generation equipment (fuelled by LFG) (engine-generator sets) with about 20% higher conversion efficiency than equipment specification previously considered in the earlier conceptualization of the project activity in mid 2006 (reflected in terms of continuous flow of LFG with 50% methane content required to generate 1.0 MW of power continuously).

[2] The revised implementation schedule for the project's electricity generation component is summarized as follows:

Initial phase of the project's electricity generation component (implementation of two GE Waukesha model APG1000 engine-generator sets): The starting of operation of the project's electricity generation component is dated 26 November 2009 when phase 1 entered into operation (electricity generation facility CLLC 1(*"Central Lomas Los Colorados 1*). Under this initial phase of the electricity generation component, two identical engine-generator sets (fuelled by LFG) of brand GE Waukesha, model APG1000 (with 1.0 MW of nameplate installed capacity each) started to operate.

Subsequent phases of the project's electricity generation component (implementation of sets of GE Jenbacher model J420 engine-generator sets): The power generation component of the project activity also encompasses the construction and operation of a second and larger electricity generation facility termed CLLC 2 ("*Central Loma Los Colorados 2"*) as part of its gradual implementation. The timeline and schedule for the implementation of the electricity generation facility CLLC 2 is as follows:

- On 20 Sep. 2011, a package of 7 identical engine-generator sets (fuelled by LFG) of brand GE Jenbacher, model J420 (with 1.4 MW of nameplate installed capacity each) finalized the installation and commissioning phases and started to operate continuously.

  Along year 2012 a new additional package of 4 identical engine-generator sets (fuelled by LFG) of brand GE Jenbacher, model J420 (with 1.4 MW of nameplate installed capacity each) are planned to be installed.

  Further capacity additions of identical GE Jenbacher units model J420 (or similar/equivalentequiment), are planned to occur as mentioned in Section B.2. By 2028 a total nameplate power generation capacity of 33.1 MW is expected to be in place, thus ensuring that high share of collected LFG be utilized as fuel for electricity generation (instead of being flared).

While based on specification and performance information (as published by equipment manufacturers), each engine-generator set GE Waukesha model APG1000 and each individual engine-generator set brand GE Jenbacher, model J420 requires a LFG flow of about 550 m^3/h of LFG (with about 50% CH_4 content) to generate continuous power of 1.0 MW; electricity generation figures as per the earlier registered version of the PDD (version 4) were however derived by assuming a slightly lower technical LFG-to-electricity energy conversion efficiency (where about 688 m^3/h of LFG (with about 50% CH_4 content) would be required for generating the same amount of power (1.0 MW of continuous net electricity generation)). This earlier considered LFG-to-electricity conversion efficiency value was based on specifications and performance of engine generator set GE Waukesha brand, model VHP-L7032GL. This equipment was the one

- Occurred installation of two additional backup captive off-grid electricity generators (fuelled by diesel) (for meeting emergency and safety operational requirements of the CLLC-2 electricity generation facility)[3]

Permanent changes from the monitoring plan:

This revised version of the PDD also incorporates a more appropriate approach for calculating and monitoring project emissions due to the consumption of electricity by the project (electricity supplied from the grid and/or electricity supplied by installed captive fossil fuel off-grid electricity generators) as well as project emissions due to the consumption of Liquefied Petroleum Gas (LPG) by the project activity (LPG is used for igniting the flares).

The revision of the monitoring plan also incorporates the option of performing measurements of CH_4 fraction in collected LFG by using a calibrated portable gas analyzer (only during temporary circumstances when the continuous CH_4 content gas analyzer unit is not available) as established by ACM00001 (version 4). As part of the operation of the project activity KDM S.A. has historically followed (whenever needed) the applicable instructions of the internal documented working procedure for the whole project activity (*I-RSL-013 – Instructivo Sistema de Captacion y Abatimiento de Biogas* [/25/]) which specifies that whenever the continuous CH_4 content gas analyzer is not functioning measurements

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expected to be used by the project activity at the time of the completion of the earlier registered version of the PDD). Thus, equipment GE Waukesha APG1000 and GE Jenbacher model J420 engine-generator sets are about 20% more efficient than equipment earlier considered in the context of the project design.

As the utilization of more efficient power generation equipment clearly results in relative increments in electricity generation, it is taken into account that this relative expected "gain" in terms of conversion efficiency has a positive impact over the overall economic attractiveness of the project activity (and thus resulting in adverse impact in terms of additionality of the project). In order to address this aspect as per the applicable CDM rules for post-registration changes in the project design, the assessment and demonstration of additionality is thus revised accordingly in this revised version of the PDD.

Reasons and rationale for the changes in specification of equipment:

- Due to market conditions and technology development, LFG-to-electricity power generation equipment currently available in the market is more advanced, modern and efficient (in terms of energy conversion efficiency) than equipment earlier considered at the time of the compilation of the initial version of the PDD in mid 2006. It is important to note that such relative "gain" in terms of energy conversion efficiency for the installed (and expected to be installed) power generation equipment (when compared with equipment earlier considered) purely reflects the recent technology/market development within the area of utilization of LFG as fuel for electricity generation (and not a willingness of project participant to adopt technology different than technology considered in the initial project design). it is also important to note that adopted technology concept was not changed at all: both as per the situation considered at the time of the compilation of the initial version of the PDD as well as in the context of the occurred and planned implementation of the project's electricity generation component, internal combustion engines (fuelled by LFG) which are coupled to alternate current generators are considered to be used. The occurred "gain" in efficiency is thus merely due to the improvements in the design of equipment: use of equipment with more advanced mechanics and electronics (better geometry of engine components, better design and control of fuel-air mixing valves, improved engine controls, etc.).

As the project activity also claims emission reductions due to electricity generation using LFG as fuel (displacing electricity generated by existing fossil fuel plants and new generation sources additions in the National Electricity Grid of Chile), ex-ante estimation of emission reductions are thus also affected by the occurred and planned post registration changes in the project activity. Due to that, ex-ante estimations of the emission reductions are recalculated.

[3] As part of the implementation of CLLC-2 power plant, two additional captive off-grid electricity generators (fuelled by diesel) were installed and became functional in September 2011. These electricity generators are installed for backup purposes (in order to supply electricity to the project activity during temporarily circumstances where the supply of grid electricity is interrupted). One captive electricity generator (fuelled by diesel) with 352 kW of power output is currently connected to Electricity generation facility 2 (CLLC-2). The other installed captive electricity generator (fuelled by diesel) with 80 kW of power output is connected to the power substation of the electricity generation facility 2 (SELLC-2).

of CH_4 fraction in collected LFG should be done by using a portable gas analyzer (with measurements being performed and recorded every 5 minutes). The description of the monitoring plan in the PDD is thus complemented. References to the "Guidelines to calculate the fraction of methane in the landfill gas from periodical measurements" are also included.

Corrections in information made available in the PDD (which does not affect the project design):
Previously existent minor typographical errors and mistakes of the initial registered version of the PDD in terms of general project description and application of applied baseline and monitoring methodologies (incl. grammar mistakes, errors in the calculation formulas, errors in references to measurement units, etc.).

A.2. Description of the project activity:

The objective of Loma Los Colorados Landfill Gas Project is to develop a landfill gas collection and utilization/destruction system. This involves investing in and operating a system for landfill gas (LFG) collection and electricity generation and/or flaring. Landfill gas flaring or its utilization for electricity generation involves methane combustion leading to greenhouse gas (GHG) emissions reductions.

As per the project design, collected landfill gas is to be used as fuel for electricity generation and additional GHG emissions reductions —from electricity generation using renewable energy source— are accrued and are to be credited within this project under the CDM (Clean Development Mechanism).

As per the project design, possible uses for collected landfill gas (LFG) are summarized as:

(i) Combustion of collected LFG in high temperature enclosed flares (flaring);
(ii) Utilization of collected LFG as fuel for electricity generation (to be consumed by the project activity and/or exported through the SIC (Central Interconnected Electricity Grid of Chile));
(iii) Utilization of LFG as energy source/fuel for use other than electricity generation at the landfill site

Utilization of LFG as energy source/fuel by users elsewhere is however not allowed in the applicable CDM methodology ACM0001 (version 4) and it is thus not considered in the context of the project design.

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 S.A. The Loma Los Colorados Landfill is 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. In mid 2006 it was reported that more than 90 percent of the MSW deposited at the Landfill is delivered by rail[4].

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

[4] In June 2012, the fraction of the total disposed MSW delivered (transported) by rail was about 90%.

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. In January 2006[5], more than 16.3 million ton of waste have been filled over 48.5 of the Landfill's 200 hectares. Upon completion, maximum waste thickness is expected to be about 120 meters; current maximum landfill height is about 60 meters. The total MSW disposal capacity of the Landfill is approximately 130 million ton. In January 2006, the landfill was being filled at a rate of about 5,000 ton per day, or greater than 1.7 million ton per year[6]. By assuming (in January 2006) an increase in current filling rates of about 2.5 percent per year, the landfill was anticipated to reach such total MSW disposal capacity around year 2045. In December 2004, KDM S.A. started receiving sludge coming from the largest wastewater treatment plant in Santiago, which has been disposed mixed with the MSW in the Loma los Colorados landfill. The average amount of sludge to be disposed in the site is estimated at 380 ton per day[7].

In January 2006, the MSW disposal service contract signed between the affected municipalities and KDM was expected to be valid until 2011 and it would be automatically renewed for additional 16 years more if none of the parties stated the contrary no later than August 2009[8]. The Loma Los Colorados landfill has the largest area in the Metropolitan Region available for waste disposal, with a total capacity of 130 million ton of waste (enough for at least 40 years more after year 2011). The landfill is also very well located, in a rural area, reducing potential problems with the community. Moreover, the railway link provides an excellent means for transporting waste from the city to the landfill site. For these reasons, waste is expected to be disposed at the landfill site for far longer than the longest possible CDM crediting period. In any case, waste availability and status of applicable contracts may be checked at the start of each renewal of the crediting period.

In mid 2006, prior to the implementation of the project activity, there were 79 active landfill gas wells installed over an area of 48.5 hectares; of these, 12 hectares were connected to an existent small-scale flaring station, through an active LFG extraction system. The rest of the wells were for venting landfill gas into the atmosphere. Such small-scale LFG flaring station had been burning LFG since 1998, with some long interruptions in system operation. The total amount of LFG burnt at this flaring system has been recorded daily by KDM S.A., and it is considered for the determination of amount of methane destroyed in the absence of the project (parameter MD_{reg}) in the context of determination of baseline emissions.

In mid 2006, the predicted LFG recovery rate for the landfill for 2007 was about 7,100 Nm^3/h (assuming 50% capture of LFG generated). The overall predicted recovery rate was expected to 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.

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[5] While data and facts used for the completion of the earlier registered version of the PDD (version 4) are dated January 2006 and/or mid 2006 respectively, this revised version of the PDD refers to "*January 2006*" and/or "*mid 2006*" when describing related data and design information used for completing of the first registered version of the PDD (and which is not required to be updated in this version). It is important to note that some of figures and facts related to Loma los Colorados landfill and aspects related to the implementation of the project activity which are included in the PDD were not any longer applicable or valid at the time of the elaboration of the revised version of the PDD. For all relevant cases, references to updated data, information and/or facts were added as footnote complementary information disclaimers.

[6] In June 2012, about 6,000 ton of MSW were being daily disposed in the landfill.

[7] In June 2012, about 150 ton of sludge from wastewater treatment were being daily disposed in the landfill.

[8] The renewal of this MSW disposal service contractual agreement was signed on 2009. As per this contractual agreement, MSW is expected to be disposed in the landfill under the terms and conditions specified by the contract until 2027.

As per the project design, before the power plant (project's electricity generation component) is commissioned and also when the installed project's electricity generation component is not under full operation, all collected LFG and/or any surplus or fraction of collected LFG (which is beyond the LFG maximum consumption by the project's electricity generation component) are to be flared at enclosed high temperature flares, thus assuring complete combustion of collected methane as well as destruction of air pollutants present in collected LFG even when LFG cannot be combusted in the engine-generator sets.

Other possible energy applications for collected landfill gas include using LFG as a gaseous fuel at an industry off-site, or/and injection of LFG into a natural gas pipeline (after purification collected LFG). Possible alternative energy applications for collected LFG might be analyzed to determine their technical and economic viability in the future.

Besides climate change mitigation, the project have important local environmental benefits. In the pre-project scenario most of the generated LFG was released into 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. Capturing and flaring and/or utilization of landfill gas under the project scenario greatly reduces 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.	No
Spain	Urbaser S.A.	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 demographic census, it has a population of 18,000 inhabitants 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 inhabitants. The exact geographic coordinates of the project site (in decimal geographical coordinates) are:

Latitude	Longitude
-32.9564	-70.8013

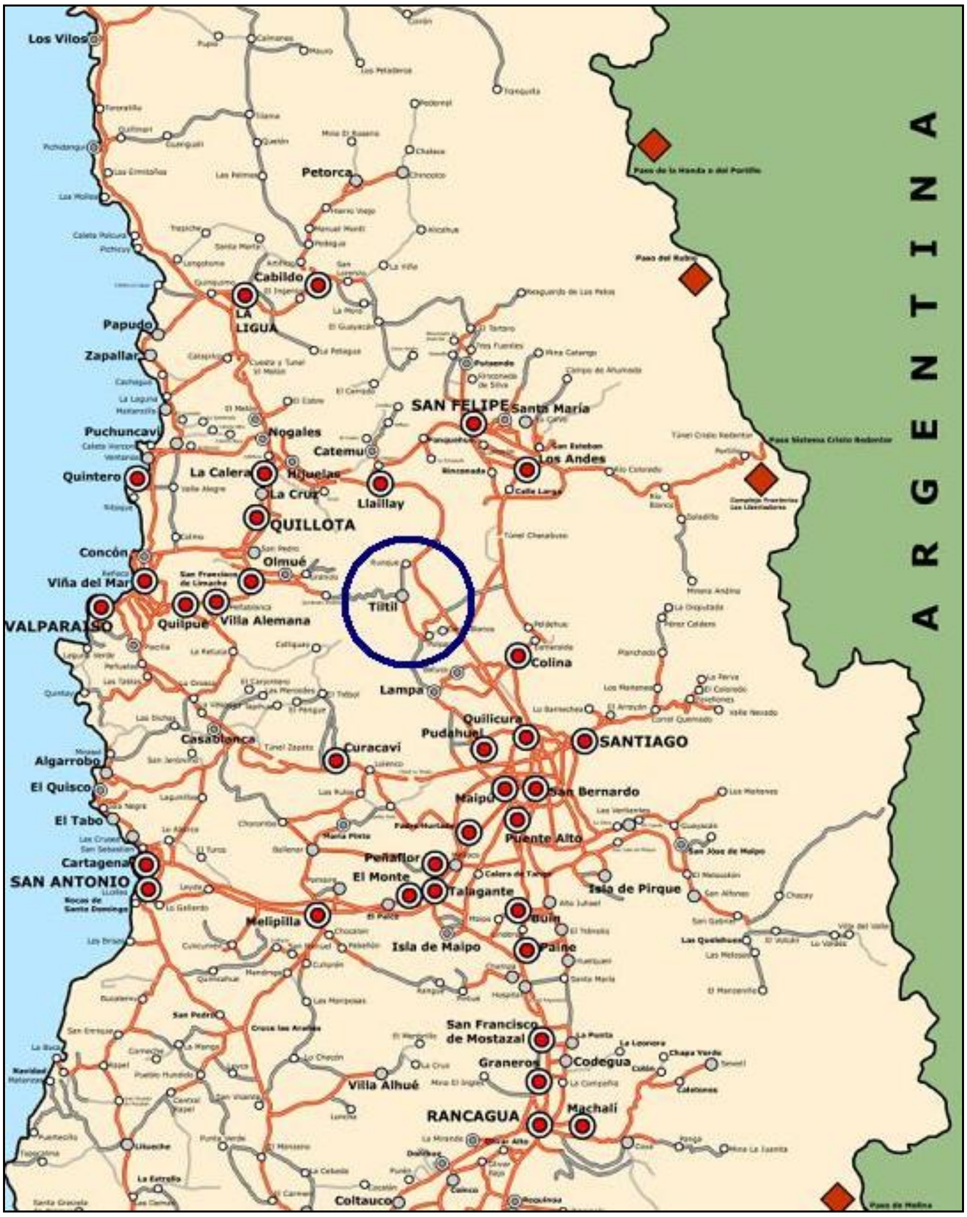

Figure 1 – Til-Til location.

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

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

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

In mid 2006, the Loma los Colorados landfill was operating with a small-scale active LFG collection and flaring system under operation. At that time, the existing pre-project active LFG collection system encompassed only a total of 12 LFG extracting wells. Some of these 12 wells were not being well operated due to elevated leachate levels. Site personnel also report that, historically, interruptions in system operation have been common, and these interruptions were primarily due to disruptions in electrical service. Historical data on the amount of LFG collected and flared by the pre-project small-scale active LFG collection and flaring system prior to the implementation of the project activity are available since start of its operation in March 1998.

In order to maximize LFG recovery rates, and thus GHG emission reductions, as part of the project design, the pre-project active forced LFG collection system is replaced and some existing elements are improved. The project LFG collection system consists of a series of vertical extraction wells interconnected by header piping. LFG is extracted from the landfill using a vacuum system and conducted to multiple enclosed flares[9]. Also as part of the project design, LFG is used as gaseous fuel to generate electricity or may be utilized as other energy source within the landfill geographical limits. The essential characteristics of the LFG collection and flaring system improvements (when compared to the pre-project small-scale LFG collection and destruction system) are listed below:

- Expansion of the existing piping network to include connection to a significant number of additional LFG extraction wells[10]. In general, connection should be made to those LFG 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 serving the pre-project blower/flare station by new larger diameter piping which are more suitable for the significantly higher LFG flow rates.

- Installation of a pneumatic leachate pumping system to extract the excess of leachate from the LFG collecting wells.

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

- Expansion of the LFG flow capacity by use of large scale blower and flaring station. As per the initially conceived project design, the pre-project blower and flaring station could eventually be incorporated into the new project's station in order to provide additional capacity or backup

[9] In June 2012, the project activity was operating with two enclosed high temperature flares with nameplate LFG destruction combustion capacity of 5,097 m^3/hour each.

[10] In June 2012, the project activity was under operation by encompassing about 300 LFG collection wells.

utility capacity, or could be removed and relocated to another site[11]. The project's flaring station includes high temperature enclosed flares which enables regular measurement of exhaust gas composition (sampling collection points for exhaust gas of the flares).

- Improving the reliability of electricity supply to the pre-project blower and flaring station[11], either by repairing or upgrading elements of the pre-project interconnection (if appropriate), or installing backup power capacity (e.g. backup captive off-grid electricity generator fuelled by diesel)[12]. Installation of a LFG-fuelled captive off-grid power generator was also considered.

As per the conceived project design, once LFG recovery volumes enable use of LFG as fuel for power generation, the project proponent considers additional energy related applications for the LFG, in particular electricity generation which would be exported to the National Interconnected Electricity Grid of Chile (SIC power grid). This LFG use alternative is considered in the context of the assessment and demonstration of additionality. In mid 2006, the landfill operator (project proponent) was granted with an environmental license to install and operate a power generation facility with nameplate installed capacity up to 3 MW. As per the project design, whenever increment in the power generation nameplate installed capacity becomes technically feasible, the corresponding permits would be requested to the Ministry of the Environment (former CONAMA).[13]

As per the conceived project design, the electricity generation facility most likely consist of:

- Internal combustion engines, 0.8 – 1.4 MW capacity each, in a number according to the biogas collection.
- Electric generator, 0.8 – 1.4 MW capacity each, installed and connected (coupled) to each engine.
- Power transformers (from 380 V to about 23 kV) with capacity as needed for allowing generated electricity to be exported and sold through the grid.

- LFG cleaning equipment (if needed, for hydrogen sulphide and other corrosive compounds).

[11] Since 2007, the pre-project LFG flaring station has not operated. It is still located in the project site but without any use and without any maintenance service. Since 2007 the pre-project small-scale LFG flaring station is not connected to any LFG well. This station is expected to be disassembled and sold as scrap material by KDM S.A.

[12] In June 2012, electricity demand of the project activity (which has not been met by the project's electricity generation component) has been met by imports of electricity from the grid and also by captive off-grid electricity generators fuelled by diesel. In June 2012 there were 3 captive off-grid electricity generators (fuelled by diesel) installed in the project site as follows:

- One diesel captive electricity generator with 276 kW of output (connected to project's LFG flaring station and installed in March 2007)
- One diesel captive electricity generator with 352 kW of output (connected to CLLC-2 and installed in September 2011)
- One diesel captive electricity generator with 80 kW of output (connected to the power substation of the CLLC-2 (SELLC-2) and installed in September 2011)

[13] The project activity was granted an environmental license enabling electricity generation with LFG as fuel with total equipment nameplate installed capacity up to 28 MW. This environmental permit for additional power generation installed capacity (beyond 3MW) was issued by CONAMA in May 2010 and it is registered under Resolution No. 344/2010.

- Building for housing the engines and generators.[14]

Regarding the electricity market, in mid 2006 Chile had one of the most liberalized, open-access electric power systems in the world. In mid 2006, there were two applicable laws, Law No. 20,018 and Law No. 19,940, which allow independent power producers (IPP) to sell energy and power. These laws guarantee the right of any power producer to sell surplus electricity to the Spot Market at a marginal spot price for energy and a node price for installed capacity[15]. Thus, in the context of the licensing of the electricity generation facilities, just sending a communication letter to the CDEC (central power grid operator) within 3 to 6 months in advance is required. Such communication should inform about starting of power generation and intention to sell generated net electricity through the SIC power grid. In mid 2006, there was no other requirements for KDM S.A. in order to obtain the right for connection to the electricity grid.

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[14] In June 2012, the project's electricity generation component was implemented as two independent electricity generation facilities (CLLC-1 and CLLC-2) as per the following configuration:

- Electricity generation facility CLLC-1: 2 internal combustion engine-generator sets with nameplate installed capacity of 1.0 MW each. Both units are manufactured by GE-Waukesha and are of model APG1000. Generated electricity is sourced at 400 V/50 Hz then transformed to 23 kV/50 Hz and transmitted through a 800 meter length aerial transmission line to the power substation of the local electricity distribution company. All generated electricity is exported (no fraction of net generated electricity is consumed by the project activity or at the landfill site area). The LFG-to-electricity conversion efficiency of the engine generator sets are 550 Nm^3/h of LFG (with 50% CH4 content) for generating continuous power of 1 MW.
- Electricity generation facility CLLC-2: 7 internal combustion engine-generator sets with nameplate installed capacity of 1.4 MW each are installed and under operation. All units are manufactured by GE-Jenbacher and are of model J420. Generated electricity is sourced at 400 V/50 Hz then transformed to 110 kV/50 Hz and transmitted through a dedicated 21 km length aerial transmission line a power substation. About 0.8 MW of all installed power is consumed at the power plant. The J420 GE-Jenbacher engine-generator set is regarded as similar to the GE-Waukesha model APG1000 in terms of LFG-to-electricity conversion efficiency and investment costs per installed MW (for investment analysis purposes). Jenbacher engine-generator sets are widely known by experts in LFG to electricity area to have a more sophisticated control system than the GE-Waukesha APG1000 engine-generator. By using a more advanced control system (use of advanced electronics), it is possible to better set/adjust the fuel-air mix for the J420 GE-Jenbacher units when compared to the GE-Waukesha model APG1000, thus improving the working conditions for the engine-generator set especially under circumstances with lower methane fraction in the collected LFG (typically LFG with CH_4 content lower than 45%) and higher flow variability of collected LFG. When LFG with CH_4 content within the range of 50% is utilized (which has been the case of the project activity), the LFG-to-electricity energy conversion efficiency for both the J420 GE-Jenbacher unit and GE-Waukesha model APG1000 can be regarded as equal (The LFG-to-electricity conversion efficiency of the engine generator sets are 550 Nm^3/h of LFG (with 50% CH4 content) for generating continuous power of 1 MW). Note that while the nameplate capacity of the GE-Jenbacher model J420 is 1.4 MW, each engine generator unit is expected to more than 550 Nm of LFG (with 50% CH4 content) per hour.

[15] In June 2012, the following additional laws were also applicable for electricity generation by Independent Power Producers (IPPs) in Chile:

- Decree N° 244 – Bylaw for non-conventional and small-scale electricity generation sources. This bylaw established regulations for law N°19,940. It establishes requirements for grid connection as well as options for commercialization of electricity at a stabilized price and some fee exemptions for using the main transmission system.
- Law N° 20,257 - Introduces modifications to the General Electrical Services law, establishing as mandatory for the electric generation companies to comply with a minimum of 5% of their energy injections to be supplied by non-conventional renewable energy sources (ERNC), either directly or indirectly. This percentage will be gradually increased to reach 10% by year 2024.
- Resolution N° 1,278 – ERNC Law regulation. This resolution normalizes the implementation of Law N° 20,257, which requires power generation companies to inject in the grid a determined share of electricity being generated from non-conventional renewable energy sources.

As per the project design, LFG may also be used as a gaseous fuel at an industry near the landfill site or injected into a natural gas distribution network (after purification, if required). In the first case, collected 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. In the second case, LFG would need to be upgraded to natural gas quality through an appropriate technology, also removing the CO_2. If this alternative is chosen, the project would replace the flares with the installation of a gas upgrading facility. However, note that ACM0001 (version 4) does not allow off-site use of LFG. Therefore, prior to any such use, additional confirmation would be requested from the CDM Executive Board, including the demonstration of additionality, and for the purpose of crediting emissions reductions. Moreover, use of LFG as a fuel outside the landfill site or for injection into the natural gas network is not covered by the current Environmental License, so that such license must be obtained prior to undertaking any such activity.

In mid 2006, there were no other project based initiatives promoting LFG capturing and flaring (or otherwise use) in Chile. The current CDM project activity has been under analysis since 2003, when there were no landfill CDM projects in Chile. Since 2005, several other similar projects have been presented, for implementation under the CDM[16]. As per the project design, once registered under the CDM, engineering studies would be conducted and detailed designing made by a landfill gas specialty company from an Annex 1 country would be performed. As per the project design, some of the key project related equipment (flares, blowers, LFG treatment, flow measurement devices, gas analyzers, etc.) would be provided by specialty manufacturers from Annex 1 countries. Thus the project mean 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.

KDM S.A. is a company with its quality assurance and environmental management systems certified under ISO 9001 and ISO 14001 standards. This means that KDM S.A. is obliged to qualify its personnel under rigorous procedures at the beginning of the project and on a monthly basis afterwards. As per the project design, in the first phase of the project, KDM S.A. would count on supervision from the flare supplier for training, commissioning and start-up. In a second project implementation phase (i.e. when installing power generation equipment), KDM S.A. would also acquired and would continue to acquire training either from equipment supplier and/or specialist consultant for all the services needed for operation and maintenance of the electricity generation system fuelled by collected LFG. KDM S.A.'s staff to be trained are those persons with extensive experience at the landfill.

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. As part of the project activity, most of the captured LFG is to be used as fuel for electricity generation. By using LFG for electricity generation, GHG emissions are also resulted by displacement of an equivalent amount of electricity that would have been generated by the operation of grid-connected thermal power plants (connected to the SIC power grid) consuming fossil fuel and by the addition of new generation sources in the absence of the project activity.

[16] In June 2012, there were 9 registered CDM project activities encompassing LFG collection and destruction and/or utilization in Chile. Source: UNFCCC.

The baseline scenario for the project's methane destruction component 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 LFG production being emitted into the atmosphere by the Loma los Colorados landfill (minus the historical flow rate of LFG burnt at the pre-project flaring station). The pre-project LFG flaring station flared about 245 ton of methane per year, as an average[17].

The baseline scenario for the project's renewable energy component is equivalent amount of electricity being generated by the operation of grid-connected thermal power plants consuming fossil fuel and by the addition of new generation sources in the absence of the project activity.

Sectoral policies and circumstances:
In mid 2006, there were no national or regional law requiring landfill gas capture and flaring.[18]

Loma Los Colorados was the first landfill in Chile that voluntarily entered into the Environmental Impact Evaluation System (Sistema de Evaluación de Impacto Ambiental, SEIA) in 1995. As a result of this evaluation by the competent environmental authorities, the Environmental Impact Study (EIS) submitted by Kenbourne Ingeniería Ambiental S.A. (by then the owner of the landfill) stated their commitment of just collecting the landfill gas and venting it to the atmosphere but in no case flaring it. The real objective of this commitment was to prevent the migration of landfill gas to the ground water, and polluting it with the soluble parts of LFG. Moreover, the Resolution of Environmental Qualification (RCA, in Spanish) issued by the environmental authorities and the only mandatory document only required LFG monitoring at key points of the landfill e.g. the perimeter and the vent wells. Such monitoring has been conducted regularly every three months. On a voluntary basis, KDM has installed a limited active flaring system in 1998, and started its operation on a non-regular basis.
(Source: *http://www.e-seia.cl/documentos/documento.php?idDocumento=1506593* in item 1.1.7.b)

[17] This value represents MD_{reg}. For further information please refer to section D.2.4.

[18] In June 2012, there was still no legal or safety requirement requiring LFG to be collected applicable to the Loma Los Colorados Landfill.

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

Year	Annual estimation of emission reduction in tCO_2e
2007 (from March)	381,163
2008	494,454
2009	530,735
2010	573,960
2011	644,099
2012	698,694
2013	742,594
2014 (up to February)	130,182
First crediting period estimated reductions (tCO_2e)	**4,195,881**
Number of crediting years (first crediting period)	**7**
Annual average over the first crediting period of estimated reductions (tCO_2e)	**599,412**

This ex-ante estimation of emission reductions are based on modeling of landfill gas (LFG) capture and estimates of electricity generation using collected 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 project activity is the approved consolidated baseline methodology ACM0001 (version 4) issued on 28 July 2006: *"Consolidated baseline methodology for landfill gas project activities"*. For emissions reduction associated with electricity generation using landfill gas, ACM0001 also incorporates ACM0002 (version 6) "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[19].

Project emissions due to the consumption of grid electricity by the project activity as well as project emissions due to the consumption of electricity sourced by a captive off-grid electricity generator (fuelled by fossil fuel such as Diesel) are both determined as per applicable guidance of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 1)[20].

[19] The occurred and planned changes within the project's electricity generation component does not promote any impact over the scale of the project activity.

[20] The use of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"is not required as per ACM0001 (version 4). Anyhow, due to lack of applicable guidance in ACM0001 (version 4), this tool is applied to determine project emissions due to the consumption of grid electricity and also due to consumption of electricity sourced by a fossil fuel captive off-grid electricity generator.

Project emissions due to fossil fuel combustion by the project activity for use other than for electricity generation (i.e. consumption of LPG to ignite the flares) are determined as per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2)[21].

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

The selected methodology ACM0001 (version 4) 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. As per the project design, collected landfill gas will generally be flared (option a) above) or would be used as fuel to generate electricity to meet power requirements of the project itself or for other applications at the landfill site, and/or for being exported (sold) through the SIC power grid. Since emissions reductions would be claimed for displacing equivalent amount of electricity being generated by the operation of grid-connected thermal power plants connected to the SIC power grid and consuming fossil fuel; and by the addition of new generation 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 - ACM0001 *"Consolidated baseline methodology for landfill gas project activities"* (version 4) 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.

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[21] The use of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" is not required as per ACM0001 (version 4). Anyhow, due to lack of applicable guidance in ACM0001 (version 4), this tool is thus applied to determine project emissions due to the consumption of fossil fuel by the project activity for use other than electricity generation (e.g. consumption of LPG to ignite the flares).

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 characterized 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)	80.64	m^3 of methane (@ 1.0 atm and 0ºC) per ton of total waste.
k	0.07	(1/yr)

A small amount of landfill gas had been collected and flared at the landfill over the last nine years prior to the implementation of the project activity by the utilization of a pre-project small-scale active (forced) LFG collection and destruction system. The amount of LFG flared was measured throughout. We propose that the average LFG flared throughout years (2002-2004) is used to define the amount of LFG flared in the absence of the project activity (MD_{reg}). Data from year 2005 was not considered, because some LFG recovery trials conducted by MGM International at a small area of the Landfill increased the amount of gas burnt during a three-month period. 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
Flare destruction efficiency	%	FE	To be conservative, as the current flare is enclosed type, the maximum efficiency was assumed.	100%

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 amount of methane destroyed in the baseline scenario 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 (version 6) is used.
For ex-ante estimates, the amount of electricity generation is determined by estimated availability of landfill gas and by considering:

1. Revised forecasts of amount of collected LFG to be utilized for electricity generation;
2. Revised gradual and phased implementation scheduled for the project's electricity generation component (incl. gradual additions in power generation capacity)
3. Updated LFG-to-electricity conversion efficiency for the project's electricity generation component.

Since electricity generation equipment is supplied in standard sizes, while the amount and quality (incl. fraction of CH_4) of LFG generated and captured may vary along the time, reasonable schedule for addition (or replacement) of power generation equipment is to be considered in estimating the amount of electricity actually generated[22]. The actual amount of net electricity generation thus depends on the performance of the project's LFG collection system (in terms of quantity, quality and flow stability of collected LFG) as well as the implementation schedule (capacity additions) and equipment specification for the project's electricity generation component.

Amount of generated electricity is determined will be monitored. This is a requirement for determining emission reductions associated with displacement of an equivalent amount of electricity that would otherwise be generated by fossil-fuel sources (power plants) and new additions in the absence of the project activity (baseline scenario). The determination of these emissions reductions also depend on the determination of CO_2 combined margin emission factor for the Interconnected National Electricity Grid of Chile (SIC power grid).

For power generation installed capacity below 15 MW, ACM0001 (version 4) requires that the provisions of the small-scale methodology AMS-I.D to be used. For higher installed power generation capacities (higher than 15 MW), ACM0002 guidance is to be followed. In mid 2006, the landfill operator (project

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[22] As per the available information dated June 2012, the occurred and planned (yet to be fully implemented) permanent changes for the first and sequential phases of the project's electricity generation component is as follows:

Post-registration occurred and planned configuration of the project's electricity generation component
(in number of operative engine generator sets and total nameplate installed capacity)

End of Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Number of operational GE-Waukesha APG1000 Units	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of operational GE-Jenbacher J420 Units	-	-	7	11	13	14	15	15	16	17	18	18	19	20	21	21	22	22
Total nameplate power generation capacity (in MW)	2.0	2.0	11.9	17.5	20.4	21. 8	23.2	23.2	24.6	26.0	27.4	27.4	28.9	30.3	31.7	31.7	33.1	33.1

proponent) had an environmental license to cover power generation up to 3 MW. As per the project design, whenever additional power generation comes to be implemented; applicable permission would be sought from Ministry of Environment (Chilean Environmental Agency, former CONAMA)[23].

ACM0002 (version 6) is applied for the determination of emission reductions for generation of electricity using LFG as a renewable energy source. In mid 2006, it was expected that the proposed project would be able to generate less than 15 MW up to 2015 and it would have a somewhat higher nameplate electricity generation capacity in subsequent years[24]. As it was assumed that KDM would be probably allowed to generate more than 3 MW power, the use the more general methodology ACM0002 (version 6) was thus selected.

All emission reduction calculation approaches (incl. equation formulas) for both the project's methane destruction and renewable energy generation components are presented in Section D.2.2.2.

The occurred and planned (yet to be fully implemented) permanent changes in the project design for the "Loma Los Colorados Landfill Gas Project" are related to the implementation and operation of the electricity generation component of the project activity do not affect the applicability and application of ACM0001 (version 4) nor ACM0002 (version 6). The scale of the project activity is also not affected.

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 4 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 (version 4), we apply the mentioned "Tool for the demonstration and assessment of additionality".

These tools consist of Steps 0 through 5.

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[23] In June 2012, the environmental compliance status of the project's electricity generation component was secured by the following granted environmental permits:

- Environmental license registered under Resolution N°344/2010, enabling power generation up to 28 MW of nameplate installed capacity. This environmental permit was issued by CONAMA in May 2010.

[24] In June 2012, the following configuration for electricity generation using LFG as fuel was available:

- Electricity generation facility CLLC-1: Since November 2009, 2.0 MW of installed nameplate electricity generation capacity were added (2 units of the engine-generator set GE-Waukesha APG1000 Units)
- Electricity generation facility CLLC-2: Since September 2011, additional 9.8 MW of installed nameplate electricity generation capacity were added (7 units of the 1.4 MW engine-generator set GE-Jenbacher J420)

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, so this step is not applicable.

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, its destruction (by flaring) and/or its utilization as fuel for electricity generation. Alternatives to the implementation of the project activity could include the following circumstances:

1. Continuation of pre-project practice, without utilization of LFG as fuel for electricity generation. A pre-project limited capacity small-scale LFG capture and flaring station has been operational since 1998, and this would have its utilization continued.
2. The proposed project activity not undertaken under the CDM. The proposed activity is a LFG capture and destruction and/or utilization of collected LFG as fuel for electricity generation. Note that there are many potential variants to the utilization of captured landfill gas. 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."*

In mid 2006, there were no national or regional law requiring landfill gas capture and flaring or its utilization[25].

The "Tool for assessment and 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. In mid 2006 there were no projects similar to that proposed here: the active collection and flaring of landfill gas, with the exception of projects under CDM structure which are happening due to carbon credits revenues[26]. Therefore, additionality is not lost from the application of Sub-step 1.b of the tool.

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[25] In June 2012, there was no national or regional law applicable for the Loma Los Colorados landfill requiring landfill gas capture and flaring or its utilization either.

[26] In June 2012, there were 9 registered CDM project activities encompassing LFG collection and destruction and/or utilization in Chile. All initiatives encompassing collection and destruction/utilization of LFG using active (forced) LFG collection systems are implemented as project activities registered (or under registration) under the CDM. Source: UNFCCC.

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

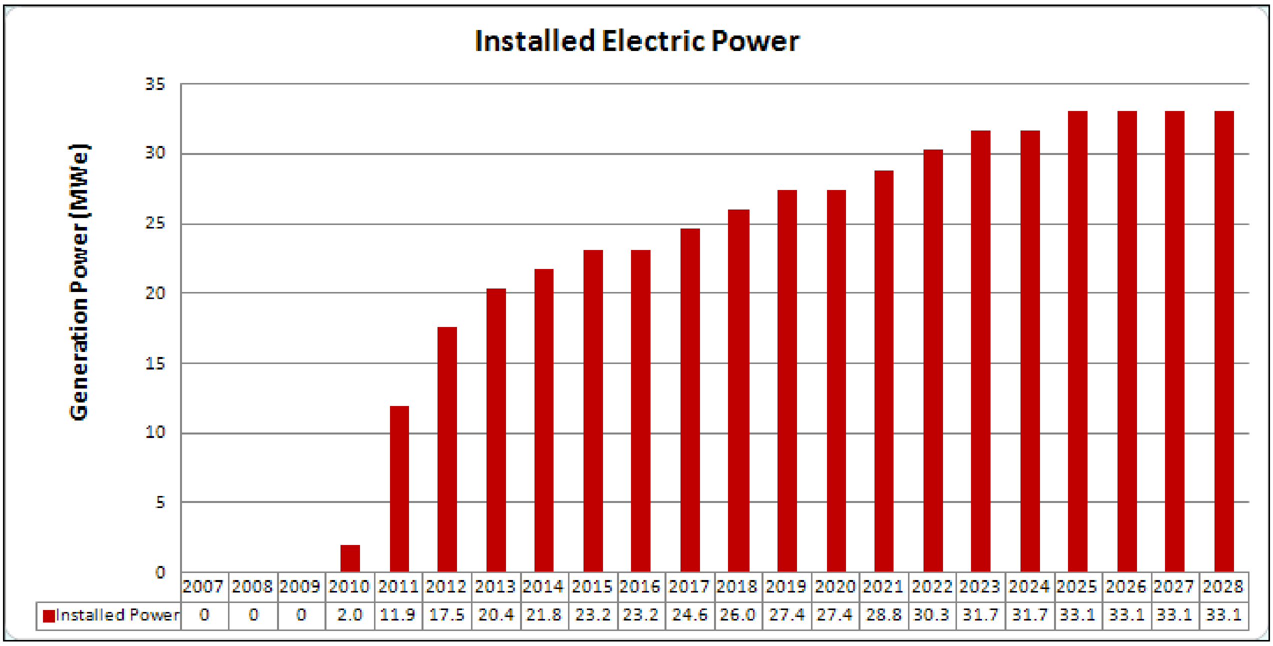
We apply both Step 2 (Investment Analysis) and Step 3 (Barrier Analysis).

Step 2. Investment Analysis

The currently considered further implementation schedule for the project's electricity generation component is forecasted based on on a revised phased implementation schedule for power generation equipment (gradual capacity additions), revised starting date for utilization of collected LFG as fuel for power generation (01/01/2010), expected LFG collection efficiency and revised LFG-to-electricity conversion efficiency[27]

Based in the aspects and factors above-described and by also considering the ex-ante estimation of LFG generation, as per the revised planned implementation schedule of the project's electricity generation component, the project activity is expected to gradually increase its installed nameplate power generation capacity along the project lifetime, thus reaching 33.1 MW of nameplate installed capacity for electricity generation at the end of the project's lifetime as follows:

As per the forecasted schedule presented below, the project activity is expected to reach 33.1 MW of nameplate installed capacity for electricity generation, according to the following estimation:



[27] LFG-to-electricity conversion efficiency for the project's electricity generation component is determined as the ratio between flow of LFG (in m^3/h of LFG with about 50% CH_4 content) which is continuously consumed by the one individual engine-generator set to generate a continuous power of 1 MW while operating under optimal operational conditions in terms of fuel supply (quality of fuel) and conditions of the electricity grid.

The revised technical LFG-to-electricity conversion efficiency for equipment already installed (and also planned to be installed) is about 550 m^3/h of LFG (with 50% CH_4 content) to generate 1 MW of power. Adopted conversion efficiency value is determined as per specification and performance details as informed by the equipment manufacturers for the engine generator-sets GE-Waukesha APG1000 and GE-Jenbacher G420.

Since LFG capture and flaring requires significant start-up investments (in equipment and construction); involves significant operational and maintenance costs (for personnel and equipment) but generates no revenues (apart of potential CDM revenues), this alternative is potentially less attractive (and less environmentally friendly) then using LFG as fuel for electricity generation or for other energy purposes. In the context of the assessment and demonstration of additionality, an investment analysis considering the utilization of LFG for electricity generation is presented.

The following table shows the forecasted electricity generation capacity and LFG specific consumption as per the currently considered implementation schedule for the project's electricity generation component. Estimated values for LFG generation and LFG-to-electricity conversion efficiency (for the engine-generator sets) are also considered.

Year	Projected amount of collected LFG (average LFG flow) (m^3/hour)	LFG-to-electricity energy conversion efficiency of the engine-generator sets (m^3/h of LFG (with 50% CH_4 content) for generating 1.0 MW of continuous power)	Total nameplate installed capacity for electricity generation (MW)[28]	Average load factor	Total forecasted annual electricity generation (MWh/year)	Average fraction of LFG flow used for electricity generation (considering equipment availability as 100% and the forecasted timeplan for the implementation of the steps of the sequential phases of the project's electricity generation component) (m^3/hour)	Average fraction of LFG flow directed to the flares (considering equipment availability as 100% and the forecasted timeplan for the implementation of the steps of the sequential phases of the project's electricity generation component) (m^3/hour)
2007	7,165	-	-	-	0	0	7,165
2008	7,739	-	-	-	0	0	7,739
2009	8,301	-	-	-	0	0	8,301
2010	8,853	550	2.0	0.8	14,016	880	7,973
2011	9,395	550	11.9	0.8	83,332	5,232	4,163
2012	9,930	550	17.5	0.8	122,941	7,719	2,211
2013	10,458	550	20.4	0.8	142,746	8,962	1,496
2014	10,980	550	21.8	0.8	152,648	9,584	1,396
2015	11,499	550	23.2	0.8	162,551	10,206	1,293
2016	12,014	550	23.2	0.8	162,551	10,206	1,808
2017	12,527	550	24.6	0.8	172,453	10,828	1,699
2018	13,039	550	26.0	0.8	182,355	11,449	1,590
2019	13,551	550	27.4	0.8	192,257	12,071	1,480
2020	14,063	550	27.4	0.8	192,257	12,071	1,992
2021	14,577	550	28.8	0.8	202,160	12,693	1,884
2022	15,093	550	30.3	0.8	212,062	13,314	1,779
2023	15,613	550	31.7	0.8	221,964	13,936	1,677

[28] The CLLC-1 electricity generation facility was installed in the end of year 2009 (with commissioning work staring in November 2009). During December 2009, the engine generator set operated under a very limited time and not under a continuous basis. Continuous operation of the CLLC-1 electricity generation facility initiated in 01/01/2010.

Year	Projected amount of collected LFG (average LFG flow) (m³/hour)	LFG-to-electricity energy conversion efficiency of the engine-generator sets (m^3/h of LFG (with 50% CH_4 content) for generating 1.0 MW of continuous power)	Total nameplate installed capacity for electricity generation (MW)[28]	Average load factor	Total forecasted annual electricity generation (MWh/year)	Average fraction of LFG flow used for electricity generation (considering equipment availability as 100% and the forecasted timeplan for the implementation of the steps of the sequential phases of the project's electricity generation component) (m^3/hour)	Average fraction of LFG flow directed to the flares (considering equipment availability as 100% and the forecasted timeplan for the implementation of the steps of the sequential phases of the project's electricity generation component) (m^3/hour)
2024	16,136	550	31.7	0.8	221,964	13,936	2,200
2025	16,664	550	33.1	0.8	231,867	14,558	2,106
2026	17,197	550	33.1	0.8	231,867	14,558	2,639

The following assumptions are considered in the context of the investment analysis for the collection and utilization of LFG as fuel for electricity generation:

- LFG collection: substantial investments are required to collect LFG. These investments include the construction of capture wells, a well field and blowers, etc. to collect LFG in order to make it available to destruction in high temperature enclosed flares and/or utilization as fuel for electricity generation. For this project, investment on a LFG collection system involves about US$ 4.15 million in 2006, another $ 1.42 million in 2007, and about $ 0.47 million yearly thereafter for well field expansion as the landfill expands. Note that this excludes the investment required for the installation of enclosed high temperature flares[29].
- Total annual operating costs for landfill gas collection is expected to be $ 0.44 million (in 2007), and such operation costs increase slowly as the landfill expands (and increments in terms of installed capacity for the project's electricity generation component occurs).
- The next table shows the forecasted total power generation installed capacity (under gradual capacity additions) and the occurred and planned investment in power generation.

[29] In the earlier version of the registered PDD (version 4), it was assumed in the context of investment analysis the installation and operation of a LFG collection and utilization project with no capital expenditures related to investment in enclosed flares. It was assumed in the context of such earlier developed investment analysis that, under circumstances where the power plant (fuelled by collected LFG) was not operating, LFG would not be collected at all or all collected LFG would be just vented. Regardless of the potential inappropriateness of such assumption from a technical or safety perspective, this assumption is conservative in the context of the investment analysis for the assessment and demonstration of additionality as since it represents a relative reduction in required investment and operational and maintenance associated costs for implementing and operating the project activity, thus making the proposed project more economically attractive.

End of Year	No. of installed GE-Waukesha APG1000 units	No. of installed GE-Jenbacher J420 units	Total nameplate power generation installed capacity [MW]
2009	2	-	2.0
2010	2	-	2.0
2011	2	7	11.9
2012	2	11	17.5
2013	2	13	20.4
2014	2	14	21.8
2015	2	15	23.2
2016	2	15	23.2
2017	2	16	24.6
2018	2	17	26.0
2019	2	18	27.4
2020	2	18	27.4
2021	2	19	28.8
2022	2	20	30.3
2023	2	21	31.7
2024	2	21	31.7
2025	2	22	33.1
2026	2	22	33.1

Investments							
End of Year	**Generation Equipments**	**Generation Civil Works**	**Substation & Trans. Line Equipments**	**Substation & Trans. Line Civil Works**	**Trans. Line Land Easment**	**Other Services**	**Total Investment**
2009	2,499,785	52,537	-	-	-	98,974	2,651,296
2010	11,066,662	2,703,169	620,233	3,618,308	1,476,845	295,377	19,780,594
2011	6,360,207	-	-	-	-	-	6,360,207
2012	3,180,103	-	-	-	-	-	3,180,103
2013	1,590,052	1,125,718	620,233	82,057	-	-	3,418,060
2014	1,590,052	-	-	-	-	-	1,590,052
2015	-	-	-	-	-	-	-
2016	1,590,052	-	-	-	-	-	1,590,052
2017	1,590,052	-	-	-	-	-	1,590,052
2018	1,590,052	-	-	-	-	-	1,590,052
2019	-	-	-	-	-	-	-
2020	1,590,052	-	-	-	-	-	1,590,052
2021	1,590,052	-	-	-	-	-	1,590,052
2022	1,590,052	-	-	-	-	-	1,590,052
2023	-	-	-	-	-	-	-
2024	1,590,052	-	-	-	-	-	1,590,052
2025	-	-	-	-	-	-	-
2026	-	-	-	-	-	-	-
Total	37,417,223	3,881,424	1,240,466	3,700,365	1,476,845	394,351	48,110,675

Remarks about investments and operation and maintenance costs:

- The schedule for investment capital expenditures does not precisely and proportionally match with schedule for equipment capacity additions as there are capital investments in LFG treatment

and cooling stations, edifications, power transmissions, main power transformers, etc, which are are designed for the final total installed capacity and are thus built/installed in advance. From 2011 onwards, further power generation capacity additions are made by adding modules of engine-generator sets (coupled with power transformers) in the existing infrastructure.

- Total average operation and maintenance costs (for the whole project's lifetime) are calculated as $0.0231 USD per generated kWh of electricity (or $23.10 per MWh). Engine-generator sets powered by LFG are known to have high operation and maintenance costs (lube oil draining, preventive maintenance, spare parts, etc.). In mid 2006 there was no experience in Chile with power generation using LFG equipment.[30]

- Equipment lifetime is estimated in 20 years (this is high, therefore conservative, since it increases project cost effectiveness).

- Electricity sale price (levelized) is assumed as $0.05 per kWh for electricity being exported and sold through the SIC power grid. At the time of the project's implementation decision making process (in mid 2006), there was no official projections for electricity prices, which were determined by market forces in Chile. In mid 2006 a long range marginal cost for power made available to the grid was estimated from the cost of power generation using new, coal-fired power plants, as about $0.037 per kWh. While at mid 2006 wholesale power prices were higher, since there was power shortages, it is assumed that $0.05 is a deemed conservative value over the life of the project.

- Tax rate of 17% is considered.

- A discount rate of 10% is considered. Note that in mid 2006, 10-year bonds of the Chilean government were offered at an interest rate of 5.25% (http://www.bcentral.cl/esp/infoeconomica/referencial/index.htm, on 8 Dec. 2006).
  It is assumed that for a small or medium-sized company borrowing a relatively small amount of money, the applicable interest rate per year was likely to be about 5% higher. Considering the risks of this new technology as well as the risks in effective biodegradation of waste and effective methane capture, another 2% may be added. Thus an appropriate benchmark rate for this type of investment is assumed as being 12.25%. The selected benchmark discount rate of 10% was thus assumed as conservative.

The detailed investment analysis is presented in the electronic workbook which is enclosed to this PDD[31].

The Internal Rate of Return (IRR) for project's LFG capture and electricity generation initiative (without consideration of CDM revenues is calculated as 2.50%[32],. The electronic workbook also includes a sensitivity analysis with respect to the key assumptions, electricity sale price, O&M costs and investment requirements, in each case considering values ± 20% with respect to the assumptions above. Even if the

[30] In June 2012 there was still lack of experience and expertise with operation and maintenance of engine-generator sets fuelled by LFG in Chile. In June 2012, the Loma Los Colorados Landfill Gas Project was still being the only initiative in Chile involving generation of electricity from LFG.

[31] An additional workbook including detailed break-down of all assumed required investment capital expenditures and operation and maintenance costs for the project's electricity generation components is also enclosed to the PDD. This work book was elaborated in the context of the revised investment analysis for the occurred and planned changes in the project design.

[32] Value determined by merely changing selected values in the IRR calculation spreadsheet enclosed to the earlier registered version of the PDD (version 4).

assumed electricity sale prices were 20% higher, the IRR would be 6.21%, which is still considerably below the benchmark discount rate. Similarly, if O&M costs or investment requirements were 20% lower, the IRR would increase to 4.46% and 3.42% respectively. These values are considerably below the adopted benchmark discount rate of 10%.

Thus, the flaring-only case (which does not generate any income other than CDM revenues), and the power generation case (which is demonstrated to be not economically attractive) can not be economically justified without the benefits of the CDM.

Note that the enclosed investment analysis considers the overall potential for power generation using LFG as the only fuel.

With the internal rate of return result of 2.50%, it is clearly demonstrated that the project would not be implemented without the support of the CDM revenues.

Sensitivity Analysis

Power Price Variation	**-20%**	**-10%**	**0%**	**10%**	**20%**
IRR	2.1%	2.31%	2.50%	2.70%	2.89%

Electricity sale price variation	**-20%**	**-10%**	**0%**	**10%**	**20%**
IRR	-2.01%	0.38%	2.50%	4.43%	6.21%

O&M Variation	**-20%**	**-10%**	**0%**	**10%**	**20%**
IRR	4.46%	3.51%	2.50%	1.45%	0.34%

Investment Variation	**-20%**	**-10%**	**0%**	**10%**	**20%**
IRR	3.42%	2.95%	2.50%	2.08%	1.67%

Also, when analyzing the variations needed to cross the 10% benchmark we have the following results:

	Parameter variation needed to reach Benchmark			
	Power Price	**Energy Price**	**Investments**	**O&M**
IRR	454.2%	44.2%	-115.9%	-86.8%

It can be noted that in the cases when the project's IRR reaches the benchmark is only in the occurrence of significantly higher power prices and/or significantly lower required investment. Both cases are highly unlikely. In the case of electricity sale prices, it would be required an increase out of any possible variation estimates. On the other hand, the investment should decrease considerably to cross the 10% benchmark, which is very unlikely as most of the investment in landfill site adaptation, pumping, extraction, wells, and flaring equipment has already been made. Therefore, the remaining non-fixed

investments amounts would need to decrease out of a logical range to make the total investment figures drop so that the benchmark is crossed.

Step 3 (Barrier Analysis) is also applied.

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

The proposed project activity involves landfill gas recovery with flaring or with some 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. Although, in mid 2006, several other projects to capture landfill gas in Chile, have been registered within the CDM, they were in the early part of the learning curve, and it will be several years before LFG collection with or without power generation is a well established technology in Chile.

It is only the potential for developing this project under the CDM that encouraged an Annex 1 company, 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. It is possible that the successful implementation of the proposed project and a few others in Chile would be the key to breaking the technological barriers to this type of project.

The proposed project activity thus also faces barriers due to prevailing practice. In mid 2006, there were no similar projects currently operational 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 "Tool for assessment and demonstration of additionality" also provides guidance for the application of 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. The only baseline alternative is uncontrolled venting of landfill gas with a small amount of captured LFG being combusted in the pre-project flaring station. 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 with no investment in LFG capture and destruction/utilization being made.

It is reasonable to 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. Common practice Analysis
The tool states:

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

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. Analyze 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 outlined in Step 3 above, in mid 2006, there were no other activities currently operating in Chile that were similar to the proposed project activity.

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

Does not apply since no similar activities existed in mid 2006.

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 Cornerstone Environmental Group who is conducting detailed engineering studies as well. The project attracted J-Power, an Annex 1 company, as a 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. the 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.

The occurred and planned permanent post-registration changes in the project design for the "Loma Los Colorados Landfill Gas Project" which are related to the implementation and operation of the electricity generation component of the project activity do not compromise the additionality. As per the revised investment analysis, the impact of the occurred and permanent post-registration changes on additionality consist in changing the IRR of the project activity (without considering CDM revenues) from 1.01 % to 2.22% when the affected key parameters in the original investment analysis spreadsheet are changed.

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

>>

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

Measurements of the amount of methane captured and flared and/or utilized as fuel for electricity generation as a part of the project activity determine 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 and/or utilizing landfill gas are considered as project emissions, and reduce overall GHG emissions reductions. GHG emissions from burning methane for energy/thermal purposes besides electricity generation (fuel switching) are not considered. In mid 2006, this was assumed as an issue which could change pending in 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. Modified 28 September 2006.

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

Contact information:

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Details about the baseline and monitoring plan was updated, by:

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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 on January 31st, 2007.[33]

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:

>> 01/03/2007

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:

>>

[33] The project starting date as per its definition in the UNFCCC's "Glossary of CDM Terms" is 07 February 2006 (date when purchase order of the first enclosed flare was issued and approved by KDM S.A.)

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 4) of 28 July 2006.

ACM0001 (version 4) states:
"The flare efficiency shall be calculated as product of (i) fraction of time the gas is combusted in the flare; and (ii) the efficiency of the flaring process. Efficiency of the flaring process is defined as fraction of methane completely oxidized by the flaring process.

"If an enclosed flare is used, the project participants shall measure and quantify the efficiency of the flare (% of methane completely oxidized by combustion in the flare) on a yearly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare shall be applicable for the period up to the next measurement. In case the yearly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used.

"For open flares, if the efficiency of the flare is not measured, a conservative destruction efficiency factor of 50% should be used."

The proposed project involves possible energy use of landfill gas collected. In this context the approved consolidated monitoring methodology, ACM0001 (version 4) 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."*

Applicable guidance of ACM0002 (version 6) is utilized for determining emission reductions from the renewable energy project's component. The proposed project would be able to generate less than 15 MW up to 2015, and higher in subsequent years. In mid 2006, KDM S.A. was authorized to generate up to 3 MW, but given that it was assumed in mid 2006, KDM S.A. would probably be allowed to generate more power in the future[34], thus the adoption of the more general methodology ACM0002 (version 6) for the entire crediting period was considered.

For project emissions related to electricity consumption, the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 1) is applied.

For project emissions related to consumption of fossil fuel by the project activity (for uses other than electricity generation), the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2) is applied.

[34] In June 2012, the project activity had the following status related to compliance with environmental permits and regulations:

- The project was granted with the Environmental license registered under Resolution N°344/2010, enabling power generation up to 28MW. This environmental permit was issued by CONAMA in May 2010.

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[35].

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.

[35] The occurred and planned changes in the design of the project's electricity generation component do not promote any impact over the level of accuracy and completeness in the monitoring of the project activity.

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 and destruction/utilization projects, methane emissions in the baseline scenario 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 achieved by the project activity corresponds to what the amount of LFG (rich in methane) actually captured can be determined by related measurements with a deemed acceptable accuracy level as part of the project's monitoring. Thus Option 2 is applicable for landfill gas recovery projects, and is chosen here.

There are additional emission reductions associated with use of the collected landfill gas as fuel for electricity generation. 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 amount of net electricity generated and exported and the determined CO_2 emissions factor for the electricity grid for which generated electricity is exported, as described in ACM0001 (version 4). Thus, this component of emissions reductions can also be determined by monitoring the net electricity generation. The present PDD uses ACM0002 version 6).

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)	For how long is archived data to be kept?	Comment
1. $LFG_{total,y}$	Total amount of landfill gas captured	Nm^3	m/c	Continuous measurement. Values are to be recorded and reported with frequency of at least every minute	100%	electronic	During the crediting period and 2 years after	Measured by a thermal mass flow meter. Data to be aggregated monthly and yearly.
2. $LFG_{flare,y}$	Amount of landfill gas flared	Nm^3	m/c	Continuous measurement. Values are to be recorded and reported with frequency of at least every minute	100%	electronic	During the crediting period and 2 years after	Measured by a thermal mass flow meter. Data to be aggregated monthly and yearly.
3.$LFG_{electricity,y}$	Amount of landfill gas combusted in power plant	Nm^3	m/c	Continuous measurement. Values are to be recorded and reported with frequency of at least every minute	100%	electronic	During the crediting period and 2 years after	Measured by a thermal mass flow meter. Data to be aggregated monthly and yearly.
4. FE	Flare/combustion efficiency	%	m/c	Flare operational hour is to be continuously monitored (1), Measurements and calculations required for the determination of FE (including measurement of residual CH_4 content	n/a	electronic	During the crediting period and 2 years after	Determined by the operation hours (1) and the methane content in the gas exhaust gas (2) 1) The flare operation shall be continuously monitored by continuous measurement of operation

				and O_2 concentration in the exhaust gas of the flares) shall be performed yearly (with the first year measurements and calculations to be made at the time of installation). (see Comments)				time of flare using a run time meter connected to a flame detector or a flame continuous temperature controller, irrespective of whether the flare efficiency is monitored. (2) Periodic measurement of residual methane content of flare exhaust gas (inter alia other related required measurements for the determination of FE). (3) The enclosed flares shall be operated and maintained as per the specifications prescribed by the flare manufacturer.
5. $w_{CH_4,y}$	Methane fraction in the landfill gas	m^3 CH_4/m^3 LFG	m	Continuous measurement. Values are to be recorded and reported with with frequency of at least every minute. During the temporarily utilization of portable CH_4 content gas analyzer, measurements and recording + reporting of measurements are to be done under a frequency of at least every 5 minutes.	100%	electronic	During the crediting period and 2 years after	Continuous gas quality analyzer , measures oxygen (O_2), methane (CH_4) and eventually carbon dioxide (CO_2) contents in LFG sent to the flares and for the electricity generation facility(ies). Alternatively, in case Continuous gas quality analyzer is temporarily not available, periodical measurements are to be performed at a 95% confidence level , using a calibrated portable gas meter by applying a

								statistically valid number of samples, Under such temporarily circumstances, the applicable guidance of the "Guidelines to calculate the fraction of methane in the landfill gas from periodical measurements" should be followed. The use of continuous gas analyzer is the preferred option.
6. T	Temperature of the landfill gas	°C	m	Continuous measurement. Values are to be recorded and reported with frequency of at least every minute	100%	electronic	During the crediting period and 2 years after	Measured to determine the density of methane D_{CH4}. No separate monitoring of LFG temperature is necessary if adopted LFG flow meters are able to automatically measure LFG flow by compensating temperature and pressure, thus expressing LFG flow measurements in normalized cubic meters per hour (Nm^3/h). Additional LFG temperature measurements to be performed by using appropriate LFG temperature sensor. .
7. P	Pressure of the landfill gas	Pa	m	Continuous measurement. Values are to be recorded and reported with	100%	electronic	During the crediting period and 2 years after	Measured to determine the density of methane D_{CH4}. No separate monitoring of LFG pressure is necessary

				frequency of at least every minute				if adopted LFG flow meters are able automatically measure LFG flow by compensating temperature and pressure, thus expressing LFG flow in normalized cubic meters per hour (Nm^3/h). Additional LFG pressure measurements to be performed by using appropriate LFG pressure sensor.
8. Regulatory Requirements	Regulatory requirements relating to landfill gas projects	-	n/a	At the renewable of crediting period	100%	electronic	During the crediting period and 2 years after	The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{reg,y}$ at renewal of the crediting period.
9. $EL_{EXP\ LFG,y}$	Total amount of net electricity exported out of the project	MWh	m	Continuous measurement. Accumulated values are to be recorded and reported at least once a week	100%	electronic	During the crediting period and 2 years after	Required to estimate the emission reductions for electricity generation using LFG as a renewable fuel.
10.Operational Hours	Operation of the power plant	Hours	m	annual	100%	electronic	During the crediting period and 2 years after	Measured by hour-meter or equivalent/suitable instrument or method. This is monitored to ensure methane destruction is

								claimed for methane used in electricity plant when it is operational.
11. $EC_{grid,y}$	Amount of grid electricity consumed by the project activity	MWh	m	Continuous measurement. Accumulated values are to be recorded and reported at least once a week	100%	electronic	During the crediting period and 2 years after	Measured by following applicable monitoring provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". Measured with electricity meter.
12. $EC_{captive,y}$	Amount of electricity sourced by the captive off-grid electricity generator (fuelled by Diesel) and consumed by the project activity	MWh	m	Continuous measurement. Accumulated values are to be recorded and reported at least once a month	100%	electronic	During the crediting period and 2 years after	Required to determine CO_2 emissions from consumption of electricity sourced by the captive electricity generator to operate the project activity. Measured by following applicable monitoring provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". Measured with electricity meter.
13. $EF_{EL,captive,y}$	Emission factor for electricity sourced by the captive off-grid electricity generator	tCO_2/ MWh	e (based on selection of default value)	-	100%	electronic	During the crediting period and 2 years after	This parameter will be monitored only if alternative approach 2 is selected for determining project emissions consumption of electricity sourced by the captive off-

								grid electricity generator ($PE_{EC,captive,y}$). As per Option B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is directly determined as 1.3 tCO_2/MWh. This conservative default value may be used as an alternative. In alternative approaches 1, 3 or 4 are used for determining project emissions due to the consumption of electricity sourced by the captive off-grid electricity generator (fuelled by Diesel) during the verification period in question, the value of $EF_{EL,captive,y}$ is not directly selected and $EF_{EL,captive,y}$ is thus not regarded as a monitoring parameter.
14. FC_{Diesel}	Quantity of fuel Diesel combusted by the captive off-grid electricity generator	liters	M	Continuous measurement. Accumulated values are to be recorded and reported at least once a week	100%	electronic	During the crediting period and 2 years after	Measurements using flow meters or volume meters. As an alternative measurements will be based on records of an integrated electronic system of the generator,

								which shows the percentage of stored fuel Monitoring will be made weekly, recording the operating hours and the percentage of fuel load of equipment, considering the consumption specified by the manufacturer. This parameter will be monitored only if alternative approaches 1 or 3 are selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). Measurements will be cross-checked against receipts of fuel purchasing and/or internal orders of fuel transfering.
15. $NCV_{Diesel,y}$	Net calorific value of the fuel Diesel	GJ/liters	c	-	100%	electronic	During the crediting period and 2 years after	Value provided by the fuel supplier in invoices, regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval This parameter will be monitored only if alternative approaches 1 or 3 are selected for

								determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$).
16. $EF_{CO2,Diesel,y}$	CO_2 emission factor of fuel Diesel	tCO_2/GJ	c	-	100%	electronic	During the crediting period and 2 years after	Value provided by the fuel supplier in invoices, regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval This parameter will be monitored only if alternative approaches 1 or 3 are selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$).
17. $EG_{Diesel\text{-}generator,y}$	Quantity of electricity generated by captive off-grid electricity generator fuelled by Diesel	MWh	m	Continuous measurement. Accumulated values are to be recorded and reported at least once a month	100%	electronic	During the crediting period and 2 years after	Measured by electricity meter. Continuously, aggregated at least monthly. This parameter will be monitored only if altenative approach 1 is selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). If all electricity generated

								by the captive electricity generator is consumed by the project activity, $EG_{Diesel\text{-}generator,y} = EC_{captive,y}$
18. $PP_{CP,Diesel\text{-}generator}$	Rated capacity of the installed captive off-grid electricity generator fuelled by Diesel	MW	c	-	100%	electronic	During the crediting period and 2 years after	Determined as per manufacturer specifications or catalogue references. This parameter will be utilized only if alternative approach 4 is selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). While the currently installed captive off-grid electricity generator (fuelled by Diesel) can be eventually replaced (due to wear, damage or other reasons), $PP_{CP,Diesel\text{-}generator}$ is thus regarded as a monitoring parameter
19. $FC_{LPG,y}$	Quantity of fuel LPG combusted by the project activity	ton	m	Continuous measurement. Accumulated values are to be recorded and reported at least once a week	100%	electronic	During the crediting period and 2 years after	Measurements using mass meters (scale) or an alternative appropriate measurement instrument. Measurements will be cross-checked against receipts of fuel purchasing.
20. $EF_{CO2,LPG,y}$	CO_2 emission	tCO_2/GJ	c	-	100%	electronic	During the	Value provided by the fuel

	factor for fuel LPG						crediting period and 2 years after	supplier in invoices, Energy basis regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval may be used as a reference. Appropriate NCV value for LPG may be used for converting energy basis values into mass basis values.
21. $NCV_{LPG,y}$	Net calorific value of the fuel LPG	GJ/ton LPG	c	-	100%	electronic	During the crediting period and 2 years after	Value provided by the fuel supplier in invoices, regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval.

The occurred and planned permanent post-registration changes in the design for the “Loma Los Colorados Landfill Gas Project” that are related to the implementation and operation of the project’s electricity generation component do not compromise the compliance of the monitoring plan with the applied methodologies. The level of accuracy and completeness in overall monitoring of the project activity is not compromised either. The permanent changes from the monitoring plan do not compromise the compliance of the monitoring plan with the applied methodologies either.

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 4, July 2006.)

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.)

Emission reductions are to be achieved by offset of two greenhouse gases: combustion of methane (by LFG destruction/utilization component) as well as CO_2 emission reductions due to the generation of electricity using LFG as a renewable energy source.

Emission reductions are calculated as the difference between baseline emissions and project emissions.

Baseline emissions for the project's methane destruction component:
Baseline emissions associated with methane destruction to be achieved by the project activity during a given year "y" (ERM_y)[36] are determined as 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 $(MD_{reg,y})$[37], times the approved GWP Global Warming Potential value for methane (GWP_{CH_4}).

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

Where:

ERM_y	is measured in ton of CO_2 equivalent (tCO_{2e})
$MD_{project,y}$ and $MD_{reg,y}$	are measured in ton of methane (tCH_4)
GWP_{CH_4}	21 tCO_2e/tCH_4

As established by ACM0001 (version 4), in the case where $MD_{reg,y}$ is given/defined as a quantity that quantity will be used. 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.

Even though $MD_{reg,y}$, is not specified in regulatory or contractual requirements, since there are no legal requirements to capture and flare landfill gas in Chile, 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 (245 ton methane per year) and flared (assuming 100% flare efficiency) to be the amount of methane destroyed in the baseline scenario. If any such requirements are introduced during the first crediting period, an appropriate absolute value of $MD_{reg,y}$, shall be

[36] Although it is not explicitly indicated in ACM0001 (version 4), ERM_y corresponds to baseline emissions.

[37] Reg = regulatory and contractual requirements.

used and justified in the baseline for the second crediting period, taking into account the project context. Sometimes, $MD_{reg,y}$, is a fraction of the project methane destruction $MD_{project,y}$, and is given by the following equation:

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

where AF is an Adjustment Factor. Note that Eq. (2) and AF are not used in the present PDD.

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 combusted for electricity generation.

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

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

Where:

$MD_{flared,y}$	is the quantity of methane destroyed by flaring during the year measured in cubic meters (m^3)
$LFG_{flare,y}$	is the quantity of landfill gas flared or during the year measured in cubic meters (m^3)
$w_{CH_4,y}$	is the methane fraction of the landfill gas as measured 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 ton of methane per cubic meter of methane (tCH_4/m^3CH_4).

To be conservative in the estimation of $MD_{flared,y}$, , the flare efficiency (*FE*) was assumed to be 98%, based on the most conservative value given by the enclosed flare provider. Technical documentation sent by the equipment provider states:
"Destruction efficiency – 99% overall destruction of total hydrocarbons. 98% destruction efficiency for NMOCs. Guaranteed to meet EPA emission standards for landfill gas disposal in enclosed type flares. The designed operating temperature is 1600ºF."

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

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 methane fraction of the landfill gas as measured and expressed as a fraction (in m^3CH_4/m^3LFG)
D_{CH_4}	is the methane density expressed in ton of methane per cubic meter of methane (tCH_4/m^3CH_4).

Baseline emissions for the project's renewable energy generation component:

There are CO_2 emission reductions due electricity generation using LFG as fuel which promotes displacing of equivalent amount of electricity that would otherwise be generated by existing fossil fuel plants and new generation sources additions in the National Electricity Grid of Chile. The present PDD uses ACM0002 (version 6). As per the project design in mid 2006, the proposed project could be able to generate less than 15 MW up to 2015, and somewhat higher in subsequent years. In mid 2006, KDM S.A. was authorized to generate up to 3 MW, but given that they will be probably allowed to generate more power in the future, methodology ACM0002 was selected for the entire crediting period for the determination of baseline emissions associated to the generation of electricity by the project activity. The emission reductions for the project's electricity component are thus equivalent to baseline CO_2 emissions for this component of the project. Such baseline emissions are determined as associated emission for equivalent amount of electricity that would otherwise be generated in existing and/or new grid-connected power plants in the absence of the project activity (baseline scenario).

Carbon dioxide emissions reductions promoted by the project's renewable energy component during a given year y (*ERC y*) are determined (in tCO_2) as follows:

$$ERC_y = EL_y * CEF_y \quad (6)$$

(Where: $EL_y = EL_{EXPLFG,y}$)

Where:

$EL_{EXPLFG,y}$ Quantity of net electricity generated by the project activity using LFG as fuel which is exported during year *y* (in MWh)

The following notes are relavant for the determination of $EL_{EXPLFG,y}$:

Note 1:
Note that "net exported" here refers to net electricity being exported by the project activity through the SIC power grid (and not as the difference between exported by the project activity and grid electricity imported by the project activity).

Note 2:
Under normal circumstances electricity exported electricity could eventually be used to meet electricity demand from the landfill (e.g. leachate treatment, office use, etc., that are *not* associated with the landfill gas collection, flaring and use).

Note 3:
As part of operation of electricity generation facility(ies), a small fraction of the electricity generated by the engine-generator sets are to be consumed by ancillary equipments of the electricity generation facility(ies):

- LFG treatment and cooling system
- Radiator (heat exchangers) of the engine-generator sets cooling fluid
- blowers
- Etc.

Electricity consumption from these sources should not be deducted from measurement records of exports of "net electricity" as electricity meters that perform such measurements are positioned after the power transformer which feeds these ancillary equipment within the power lines.

Note 4:
As per the configuration of the project in June 2012, electricity demand from equipment that are part of the project's LFG destruction component (blowers, compressor for the leachate extraction pumps, etc.) has been entirely met by imports of grid electricity (sourced by a dedicated line). Such consumption of electricity is accounted as Project emissions due to consumption of grid electricity in year y ($PE_{EC,grid,y}$).
As per a revised configuration of the project's electrical diagram/scheme (yet to be implemented in September or October 2012), whenever the CLLC1 and/or CLLC-2 are under operation, no grid electricity is expected to be imported from the grid. Under this circumstance, the electricity demand for the whole project activity (including equipment which are part of the project's LFG destruction component) are to be met by a fraction of electricity generated by the project, which the excess being exported as "net export of electricity". In such circumstance, Project emissions due to consumption of grid electricity in year y ($PE_{EC,grid,y}$) will be accounted as zero.

Note 5:
Under both the current and planned new configuration of the project's electrical diagram/scheme, grid electricity (or electricity sourced by a captive off-grid fossil fuel electricity generator) may eventually and temporarily be used to also meet very small electricity demand from the project's electricity generation facility(ies) during temporary circumstances where such power plant(s) is/are not under operation[38]). In this context associated emissions are accounted as Project emissions due to consumption of grid electricity in year y ($PE_{EC,grid,y}$).

Note 6:
Under the planned new configuration of the project's electrical diagram/scheme, electricity sourced from the grid (or eventually electricity sourced from a captive off-grid fossil fuel electricity generator) will be used to meet all electricity demand from the project's LFG destruction component during temporary circumstances where such power plant(s) is/are not under operation. In this circumstance, associated emissions are accounted as Project emissions due to consumption of grid electricity in year y ($PE_{EC,grid,y}$).

[38] During temporary circumstances the electricity generation facility(ies) is/are not under operation, electricity demand for the electricity generation facility(ies) (e.g. lighting, cooling, heating of engine-generator sets' cooling, etc.) may be met by (a) imports of grid electricity or (b) use of a captive off-grid electricity generator fuelled by fossil fuel. Under case (a), associated GHG emission will be accounted as Project emissions due to consumption of grid electricity in year y ($PE_{EC,grid,y}$).. Under case (b), associated emissions will be determined as "Project emissions due to consumption of electricity sourced by the captive off-grid electricity generator (fuelled by Diesel) in year y" ($PE_{EC,captive,y}$). Determinations of $PE_{EC,grid,y}$ and $PE_{EC,captive,y}$ are presented below.

CEF_y Emissions factor for electricity generation (in tCO_2/MWh). CEF_y is determined as follows:

$$CEF_y = \frac{CEF_{OM,y} + CEF_{BM,y}}{2} \quad (7)$$

Where:

$CEF_{OM,y}$ Operating margin emission factor (in tCO_2/MWh)

$CEF_{BM,y}$ Build margin emission factor (in tCO_2/MWh).

CEF_y is determined by using the applicable approved consolidated methodology ACM0002 (version 6), requiring a determination of the Build Margin (BM), the Operating Margin (OM) and a Combined Margin (CM). CEF_y is ex-ante calculated as 0.408 tCO_2/MWh.

ACM0002 (version 6) indicates four different procedures for determining the operating margin. These are denominated:

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

ACM0002 (version 6) further states that the Simple OM, simple -adjusted OM, and average OM emission factors can be calculated using either of the two following data vintages for years(s) *y*:

- (*ex-ante*) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission, if or,
- the year in which project generation occurs, if *EFOM,y* is updated based on ex-post monitoring. The choice between ex-ante and ex-post vintage should be specified in the PDD, and cannot be changed during the crediting period.

The proposed project will use ex-ante selected vintage using data from the three 2003, 2004 and 2005. Of the three choices for calculating Operating Margin, we choose the most complete "Simple Adjusted Operating Margin", since the Chilean power sector has the data to support this calculation.

Details of equations and procedures for calculating the Operating Margin, Build Margin, and Combined Margin emissions factor for power generation are given in Annex 3.

The Combined Margin emissions factor will be used to determine CO_2 emissions offset by the electricity generation using LFG.

Project emissions:

Considering both emission reductions from the project's methane destruction and renewable energy components (ER_y) are calculated by also taking into account associated project emissions, ER_y is thus determined as follows:

$$ER_y = ERM_y + ERC_y - PE_{i,y} \quad (8)$$

Where

$PE_{i,y,}$ Total project emissions. $PE_{i,y,}$ is calculated as follows:

$$PE_{i,y} = PE_{EC,y} + PE_{LPG,y} \quad (9)$$

Where:

$PE_{EC,y}$ = Project emissions due to electricity consumption in year y (in tCO_2/year).
Note: Although the project activity generates electricity which is exported through the SIC power grid, electricity supplied through the grid might also imported and consumed by the project activity, which is calculated as follows:

$PE_{LPG,y}$ = Project emissions due to consumption of fossil fuel LPG by the project activity (for uses other than electricity generation) (in tCO_2/year). Liquified Petroleum Gas (LPG) is expected to be used for igniting the flares.

Project emissions due to the consumption of electricy by the project acticity (grid electricity and/or electricity generated by a captive off-grid electricity generator fuelled by fossil fuel (Diesel).

Project emissions due to electricity consumption ($PE_{EC,y}$) are determined (in tCO_2) as follows:

$$PE_{EC,y} = PE_{EC,grid,y} + PE_{EC,captive,y} \quad (10)$$

Where:

$PE_{EC,grid,y}$ Project emissions due to consumption of grid electricity in year y (tCO_2). $PE_{EC,grid,y}$ is calculated by following the applicable guidance of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 1) as follows:

$$PE_{EC,grid,y} = EC_{grid,y} * CEF_y * (1 + TDL_{grid,y}) \quad (11)$$

Where:

$EC_{grid,y}$ = Amount of grid electricity consumed by the project activity. $EC_{grid,y}$ will be measured and monitored in MWh as per applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

CEF_y = CO_2 emission factor for grid electricity. CEF_y is ex-ante calculated as 0.408 tCO_2/MWh,

$TDL_{grid,y}$ = Average technical transmission and distribution losses for grid electricity. In accordance with applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $TDL_{grid,y}$ is ex-ante determined as 20% (conservative default value fixed along the whole crediting period).

$PE_{EC,captive,y}$ Project emissions due to consumption of electricity sourced by the captive off-grid electricity generator (fuelled by Diesel) in year y (tCO_2). $PE_{EC,captive,y}$ is calculated by following one of the four approaches below which are based on the existent determination options of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (B1, B2, B3 or B4) as follows:

Alternative approach 1 and alternative approach 2:
As per Option B1 and B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $PE_{EC,captive,y}$ is calculated as follows:

$$PE_{EC,captive,y} = EC_{captive,y} * EF_{EL,captive,y} * (1 + TDL_{captive,y}) \quad (12)$$

Where:

$EC_{captive,y}$ = Amount of electricity sourced by the captive electricity generator (fuelled by Diesel) and consumed by the project activity. $EC_{captive,y}$ will be measured and monitored in MWh as per the provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

$TDL_{captive,y}$ = Average technical transmission and distribution losses for electricity sourced by the captive electricity generator. In accordance with the applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", as a simplification, $TDL_{captive,y}$ is ex-ante determined as zero (fixed value along the whole crediting period).

$EF_{EL,captive,y}$ = CO_2 emission factor for electricity sourced by the captive off-grid electricity generator (tCO_2/MWh).

- *Alternative approach 1:*
  By following Option B1 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is determined as follows:

  $$EF_{EL,captive,y} = (FC_{Diesel} * NCV_{Diesel,y} * EF_{CO2,Diesel,y}) / EG_{Diesel\text{-}generator,y} \quad (13)$$

  Where:

  FC_{Diesel} = Quantity of fuel Diesel combusted by the captive off-grid electricity generator (liters)

  $NCV_{Diesel,y}$ = Net calorific value of the fuel Diesel (GJ/liters)
  $EF_{CO2,Diesel,y}$ = CO_2 emission factor of fuel Diesel (tCO_2/GJ)
  $EG_{Diesel\text{-}generator,y}$ = Quantity of electricity generated by captive off-grid electricity generator fuelled by Diesel (MWh). It is important to note that If all electricity generated by the captive electricity enerator is consumed by the project activity, $EG_{Diesel\text{-}generator,y} = EC_{captive,y}$

- *Alternative approach 2:*
  By following Option B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is determined as 1.3 tCO_2/MWh.

Alternative approach 3:
By following Option B3 the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $PE_{EC,captive,y}$ is calculated by determining the CO_2 emissions from all Diesel fuel combustion in the captive electricity generator. These emissions are calculated by adopting applicable provisions of the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2). This option provides an accurate estimate as all electricity generated by the captive off-grid generator is expected to be consumed by the project activity.

As per the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2), $PE_{EC,captive,y}$ is determined as follows:

$$PE_{EC,captive,y} = FC_{Diesel} * COEF_{Diesel} \quad (14)$$

Where:

FC_{Diesel} = Quantity of fuel Diesel combusted by the captive off-grid electricity generator (liters)

$COEF_{Diesel}$ = The CO_2 emission coefficient for the fuel Diesel (tCO_2/liters) which is calculated by following Option B of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" as follows:

$$COEF_{Diesel} = NCV_{Diesel,y} * EF_{CO2,Diesel,y} \quad (15)$$

Where:
$NCV_{Diesel,y}$ = Net calorific value of the fuel Diesel (in GJ/liters)
$EF_{CO2,Diesel,y}$ = CO_2 emission factor of fuel Diesel (tCO_2/GJ)

Alternative approach 4:
By taking into account Option B4 the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $PE_{EC,captive,y}$ is calculated based on the rated capacity of the installed captive off-grid electricity generator and by assuming a CO_2

emission factor of 1.3 tCO_2/MWh for electricity generated by the captive off-grid electricity generator (which is assumed as being operation of 8,760 hours per year) as follows:

$$PE_{EC,captive,y} = 11{,}400\ tCO_2/MWh * PP_{CP,Diesel\text{-}generator} \quad (16)$$

Where:

$PP_{CP,Diesel\text{-}generator}$ = Rated capacity of the installed captive off-grid electricity generator (fuelled by Diesel) (in MW)

Project emissions due to consumption of LPG (for igniting the flares):

In order to determine project emissions from LPG combustion ($PE_{LPG,y}$) for igniting the flares, applicable guidance of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2) is utilized as follows:

$$PE_{LPG,y} = \sum FC_{LPG,y} * COEF_{LPG,y} \quad (17)$$

Where:

$FC_{LPG,y}$ = Quantity of consumed fossil fuel (LPG) (in ton LPG);
$COEF_{LPG,y}$ = CO_2 emission coefficient for LPG (tCO_2/ton LPG). $COEF_{LPG,y}$ is determined as follows:

$$COEF_{LPG,y} = NCV_{LPG,y} * EF_{CO2,LPG,y} \quad (18)$$

Where:
$NCV_{LPG,y}$ = Net calorific value of the fuel LPG (in GJ/ton LPG)
$EF_{CO2,LPG,y}$ = CO_2 emission factor of fuel LPG (in tCO_2/GJ LPG)

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.
1-3. $LFG_{total,y}$, $LFG_{flare,y}$ *and* $LFG_{electricity,y}$	Low	LFG flow meters will be regularly calibrated as per recommendation of equipment supplier.
4. FE	Medium	Regular maintenance will ensure optimal operation of flares. Flare efficiency will be checked yearly on the basis of measurements and tests performed by a third party independent inspection service company. The enclosed flares shall be operated and maintained as per the specifications prescribed by the manufacturer. Flare efficiency is determined by measurement of methane content in LFG sent to the flares as well as residual methane in the exhaust gas of the flare. All related measurements will be performed by instruments/equipment with regular maintenance and calibration events.
5. $w_{CH4,y}$	Low	KDM S.A. will measure methane content using a continuous CH_4 content gas analyzer unit. A portable CH_4 content gas analyzer unit will be used to perform measurements of methane fraction in collected LFG under temporary circumstances when the continuous CH_4 content gas analyzer unit is not available. Equipment will be regularly calibrated/verified in accordance with recommendations from the equipment manufacturer.
6. T	Low	KDM S.A. will make continuous LFG temperature measurements through use of LFG temperature sensor or use of thermal mass flow meter (to correct for density). LFG temperature sensors will be regularly calibrated as per recommendation of equipment supplier.
7. P	Low	KDM will undertake continuous LFG pressure measurements using a pressure gauge as well as within the thermal mass flow meter (to correct for density). LFG temperature sensors will be regularly calibrated as per recommendation of equipment/instrument manufacturer.
8.(Regulatory Requirements)	None	Legal document.
9. $EL_{EXP\ LFG,y}$	Low	Electric meters with required accuracy level. Moreover, the meter will be calibrated periodically as per recommendation of equipment/instrument manufacturer.

10. (Operating Hours)	Low	The kWh meter will be subject to regular maintenance and testing regime to ensure accuracy.
11. $EC_{grid,y}$	Low	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically as per recommendation of equipment/instrument manufacturer.
12. $EC_{captive,y}$	Low	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically as per recommendation of equipment/instrument manufacturer.
13. $EF_{EL,captive,y}$	Low	This parameter will be monitored only if alternative approach 2 is selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). As per Option B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is directly determined as 1.3 tCO_2/MWh. This conservative default value may be used as an alternative.
14. FC_{Diesel}	Low	Measurements using flow meters or volume meters. As an alternative measuremens will be based on records of an integrated electronic system of the generator, which shows the percentage of stored fuel Monitoring will be made weekly, recording the operating hours and the percentage of fuel load of equipment, considering the consumption specified by the manufacturer. KDM S.A. has an operative instructive (Instructivo Sistema de Captacion y Abatimiento de Biogas IRSL-013) which describes and require procedures to record fuel consumption from each source.
15. $NCV_{Diesel,y}$	Low	Value provided by the fuel supplier in invoices, regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval This parameter will be monitored only if alternative approaches 1 or 3 are selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$).
16. $EF_{CO2,Diesel,y}$	Low	Value provided by the fuel supplier in invoices, regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval This parameter will be monitored only if alternative approaches 1 or 3 are selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$).

17. $EG_{Diesel\text{-}generator,y}$	Low	Electric meters are quite accurate. Moreover, the meter will be calibrated periodically as per recommendation of equipment/instrument manufacturer. This parameter will be monitored only if altenative approach 1 is selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). If all electricity generated by the captive electricity generator is consumed by the project activity, $EG_{Diesel\text{-}generator,y} = EC_{captive,y}$
18. $PP_{CP,Diesel\text{-}generator}$	Low	Determined as per manufacturer specifications or catalogue references. This parameter will be utilized only if alternative approach 4 is selected for determining project emissions consumption of electricity sourced by the captive off-grid electricity generator ($PE_{EC,captive,y}$). While the currently installed captive off-grid electricity generator (fuelled by Diesel) can be eventually replaced (due to wear, damage or other reasons), $PP_{CP,Diesel\text{-}generator}$ is thus regarded as a monitoring parameter.
19. $FC_{LPG,y}$	Low	In the case of using LPG as fuel, consumption will be measured by weighting the tanks weekly, recording the weight and the difference from the previous measurement. The weighting scale is calibrated according to manufacturer's specification. KDM S.A. has an operative instructive (Instructivo Sistema de Captacion y Abatimiento de Biogas IRSL-013) which describes and require procedures to record fuel consumption from each source.
20. $EF_{CO2,LPG,y}$	Low	Determined based on value provided by the fuel supplier in invoices. Energy basis regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval may be used as a reference.
21. $NCV_{LPG,y}$	Low	

The landfill operator KDM S.A. 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 Operators supervised by the Landfill Gas Project Engineer, all of them belonging to the Engineering 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 Engineering Department.

KDM S.A. is a company with its QA/QC and environmental management system certified under ISO 9001 and ISO 14001. This means that KDM S.A. is obliged to qualify its personnel under rigorous procedures at the beginning of the project and on a monthly basis afterwards. In the first phase of the project, KDM S.A. will count on supervision from the flare supplier for training, commissioning and start-up. In a second phase, i.e. when power generation starts, KDM S.A. will also acquire either from equipment supplier and/or specialist consultant all the services needed for training related to the operation of the LFG generation system. KDM S.A. staff to be trained are those with extensive experience at the landfill.

One measurement involves the residual methane content in the exhaust gas of the flares, which is needed to determine what fraction of methane captured and sent to the flare did indeed burn. Project proponent expects to acquire equipment to do these measurements in-house. However, if this is not feasible, then an outside third party independent inspector service laboratory/company would be contracted to undertake these or other needed measurements on a yearly basis.

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.

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

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

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

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
1	Reading of landfill gas capture and gas flared/used	Engineering Department of KDM S.A.	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring and checking .	Yes	The Data will be monitoring and filed by the KDM Engineering Department.
2	Calibration of the flow meters	External calibration laboratory	As per recommendation of equipment manufacturer.	Yes	Calibration certificate will be issued by the Calibration Laboratory/Certification company. This certificate will be filed by the KDM Engineering Department.
3	Measurement or calculation of flare/combustion efficiency (FE)	Engineering Department of KDM S.A.	Yearly	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 Engineering Department. This value would be used for estimating accumulated value for the parameter ERM until next measurement of flare efficiency is performed.
4	Measurement of residual methane content in the exhaust gas of flare	Engineering Department of KDM S.A. (if feasible) or by external third party independent	Yearly, in order to determine flare efficiency (FE) .	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 Engineering Department. This value would be used until next measurement of methane content of exhaust gas is performed.

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
		inspection service company.			
5	Measurement of methane fraction in the landfill gas sent to the flares and/or electricity generation facility(ies)	Engineering Department of KDM S.A. or external laboratory	Continuous measurements. Values are to be recorded and reported with frequency of at least every minute. During the temporarily utilization of portable CH_4 content gas analyzer, measurements and recording + reporting of measurements are to be done under a frequency of at least every 5 minutes. .	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 Engineering Department.
6	Measurement of Pressure and Temperature	Engineering Department of KDM S.A.	Weekly. Data will be entered into a spreadsheet on a weekly basis, permitting continuous monitoring.	Yes	Daily data on pressure and temperature would be recorded in a spreadsheet file. The data records will be filed by the person responsible for data filing and the Head of the Engineering Department.
7	Sustainability indicators file	Engineering Department KDM S.A.	Annual	Yes	This data file will be completed and filed by the person responsible for data filing and the Head of the Engineering Department..
8	Monitoring of regulatory requirements relating to landfill gas projects	Engineering Department KDM S.A.	Annual	No	The Head of the Engineering Department will prepare the report on the current situation with respect to legal requirements.

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
9	Electricity exported and imported from the grid + electricity generated by captive off-grid electricity generator fuelled by Diesel.	Engineering Department KDM S.A.	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 Engineering Department.
10	Electric meter calibration	External calibration laboratory	Twice a year or as per recommendations of equipment/meter manufacturers	Yes	Calibration certificate will be issued by the Calibration Laboratory. This certificate will be filed by the KDM Engineering Department.
11	Internal Audit	KDM S.A. Central Office in Santiago.	Twice a year	Yes	The internal auditor will prepare a report to the Manager of the landfill site and the Head of the Engineering 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 Engineering Department.
12	Fossil Fuel consumption metering (consumption of Diesel by captive off-grid electricity generator and consumption of LPG for igniting the flares).	KDM. S.A. Biogas plant management	Every time fuel is required for the different consumption sources	Yes	KDM has an operative instructive (Instructivo Sistema de Captacion y Abatimiento de Biogas IRSL-013) which describes and require procedures to record fuel consumption from each source.

#	Task name	Responsible	Frequency	Internal procedures of Quality Control	Documentation
13	Determination of emission factor for (a) electricity supplied by captive off-grid electricity generator; (b) utilized fossil fuel (Diesel and LPG)	KDM. S.A. Biogas plant management	Every time emission reduction are calculated and reported.	Yes	Values will be determined by taking into consideration: - Applicable default values as per CDM guidance - Value provided by the fuel supplier in invoices, - - Regional or national default values or IPCC values at upper limit of uncertainty at 95% confidence interval
14	Monitoring of regulatoring requirements for collection and destruction/utilization of LFG.	KDM. S.A. Biogas plant management		Yes	The eventual implementation of new regulatory requirements will be monitored.

Other environmental indicators.

The environmental approval given by the Chilean Environmental Commission (CONAMA) requires the monitoring of data other than those required by the adopted CDM baseline and monitoring methodology ACM0001 (version 4). These include the measurements of other components of LFG collected: carbon dioxide and oxygen content, to be measured continuously; hydrogen sulphide on a daily basis; nitrogen on a quarterly basis; lower heating value (from methane content) on a daily basis. These requirements also include measurements following LFG flaring, to include: temperature and flow rate of exhaust gases, on a continuous basis; moisture content, particulate matter, carbon dioxide, oxygen, carbon monoxide, sulphur dioxide, nitrogen oxides, non methane hydrocarbons (NMHC), and halogenated compounds, all on a quarterly basis; and dioxin and furans annually. A variety of test procedures has been established by the Chilean government for these measurements. USEPA protocols are used for halogenated compounds, dioxin and furanes.

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

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

Contact information:

MGM International
Encomenderos 161, Of 2A
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The monitoring plan was updated, by:

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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 ton 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.
Any electricity used for landfill gas extraction, which would be imported from the power grid, is included in the emissions reductions calculation. See Equations in Section D.2.4.

E.2. Estimated leakage:

Not applicable for this type of project activity (ACM0001 version 4).

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

Project emissions are determined by direct measurements of electricity and/or fossil fuels consumption + determination of related CO_2 emission factors. See section E.1.

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 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:

- Measured 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 analyzer) 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 March 2007. Baseline capture methane emissions is assumed to be 245 ton of methane throughout. Destruction efficiency was assumed to be 100% in the baseline scenario and 98% in the project activity. An emissions factor for electricity purchased and for electricity supplied to the grid has been calculated to be 0.408 tCO_2/MWh (Combined Margin), as determined in Annex 3, has been used in this *ex-ante* estimate.

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

Year	Year	Estimation of project activity emissions reductions (tCO_2e)	Estimation of baseline emission (tCO_2e)	Estimation of leakage (tCO_2e)	Estimation of total emission reductions (tCO_2e)
1	2007 (from March)	385,451	4,288	0	381,163
2	2008	499,599	5,145	0	494,454
3	2009	535,880	5,145	0	530,735
4	2010	579,105	5,145	0	573,960
5	2011	649,244	5,145	0	644,099
6	2012	703,839	5,145	0	698,694
7	2013	747,739	5,145	0	742,594
8	2014 (up to February)	131,040	858	0	130,182
	Total	**4,231,896**	**36,015**	**0**	**4,195,881**

SECTION F. Environmental impacts

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

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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 generates small amounts of nitrogen oxides (NO_x), particulate matter and carbon monoxide (CO), as would be the case in the kitchen stove or any other combustion 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. Regarding project emissions, the recently approved environmental license, "Resolución de Calificación Ambiental - RCA Nº 391", established that KDM S.A. will have a compensation plan for all the emissions involved. 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.

Note that the Environmental License (RCA 391/2006) issued on 29 June 2006 to the landfill operator (project sponsor) allows for power generation but with a maximum power output of 3 MW. In mid 2006, it was assumed that when at the time of increase of installed electricity generation capacity, the corresponding permits are to be requested to the Ministry of the Environment (former CONAMA)[39].

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:

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The Environmental License (RCA 391) establishes that the project has environmental impact through the following components: air (atmospheric emissions, odors, and noise), water, soil and adjacent roadways.

It is KDM's responsibility to monitor and/or take into account relevant environmental impacts, by implementing a series of measures to meet complying of environmental standards applicable to the project. In broad terms, these measures cover:

- Minimize atmospheric emissions associated with project construction and operation, through the use of wet processes, irrigation, covered transport, washing vehicles, and in general, following the indications of the national legislation applicable to processes of this nature.
- Monitor emissions of particulate matter, nitrogen oxides (NO_x) and carbon monoxide, as indicated in the RCA 391, with respect to frequency of measurement and measurement procedures. To this end, the company must design a plan for the compensation of environmental emissions, i.e. generate an effective reduction in emissions that are quantifiable and additional, valid for the project and registered with the environmental authorities once the plan has been approved by the authorities. This plan for compensations should include a comprehensive monitoring program that has been submitted to the authorities. ***Note that this emissions compensation program is analogous to the CDM, but applicable to local air pollutants. Chile is the only developing country in the world with such a program in operation.***
- LFG capture efficiency should be subject to the safety of landfill operation and landfill stability. Periodic analysis of the latter must be undertaken. Note that the Environmental Authority has stated in the RCA that "*currently landfill gas is extracted mainly to control the internal pressure within the landfill and reduce risks of local accumulations that could lead to undesirable surface fires. These objectives have been satisfactorily met with the quantity of LFG historically and currently captured and flared.*"

[39] In June 2012, the project activity had the following status related to compliance with environmental permits and regulations:

- The project was granted with the Environmental license registered under Resolution N°344/2010, enabling power generation up to 28MW. This environmental permit was issued by CONAMA in May 2010.

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 was 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 (Climate change affairs, coordinator Executive Directory)	CONAMA – Comisión Nacional de Medio Ambiente	

Javier García	Ingeniero Civil Industrial, Depto. Control de la Contaminación (Industrial civil engineer, department of contamination control)	CONAMA	Yes
Genaro Rodríguez	Area Residuos (Area of waste)	CONAMA	
Joost Meijer	Area Residuos (Area of waste)	CONAMA	
Pablo Badenier	Director CONAMA RM	CONAMA RM – Comisión Nacional de Medio Ambiente para Región Metropolitana (CONAMA RM – National environmental comission for the metropolitan región)	
Ivo Kovacic	Jefe de Area Evaluación de Impacto Ambiental (Chief of area of environmental impact evaluations)	CONAMA RM	
Cristián Araneda	Area Evaluación de Impacto Ambiental (Area of environmental impact evaluations)	CONAMA RM	
Gonzalo Velásquez	Jefe de Area Residuos Sólidos (Chief of area of solid waste)	CONAMA RM	
Marcelo Fernández	Jefe de Area Calidad del Aire (Chief of area for air quality)	CONAMA RM	Yes
		CONAMA RM	Yes
Juan Antonio Muñoz	Jefe de SEREMI Obras Públicas (Chief of SEREMI public infrastructure development)	MOP – Ministerio de Obras Públicas (MOP – Ministry of public infrastructure development)	Yes
Mirza Lemus	-	MOP	Yes
Benjamín Araneda	-	SAG - Servicio Agrícola Ganadero (SAG – Service for agriculture and cattle ranching)	-
Cristián Calderón	Jefe Unidad de Residuos Sólidos (Chief of solid waste unit)	SEREMI Salud (SEREMI Healthcare)	-
Marta Zamudio	Jefe (Subrogante) Depto. Acción Sanitaria (Chief, department of sanitary	SEREMI Salud (SEREMI Healthcare)	-

	action)		
Yorka Retamal	Jefe Depto. Gestión Ambiental Chief, department of environmental management)	SEREMI Salud (SEREMI Healthcare)	-
Omar Cáceres	Jefe (Subrogante) Subdepto. Entorno Saludable (Chief, sub-department of healthy suroundings)	SEREMI Salud (SEREMI Healthcare)	-
José Miguel Arriaza	Depto. Gestión Ambiental (Department of Environmental management)	SEREMI Salud (SEREMI Healthcare)	Yes
Rodrigo Rivera	-	SEREMI Salud (SEREMI Healthcare)	Yes
Alejandra Hernández	-	SEREMI Salud (SEREMI Healthcare)	
Magdalena Arancibia	-	SEREMI Salud (SEREMI Healthcare)	
Soledad Ubilla	Jefe División Políticas Públicas (Chief Division of Public Policies)	MINSAL – Ministerio de Salud (MINSAL – Ministry of Healthcare)	
Jaime Bravo	Jefe del Area Medio Ambiente y Eficiencia Energética (Chief of area of environmental affairs and energy efficiency)	CNE - Comisión Nacional de Energía (CNE – Energy National Commision)	
Luis Cifuentes	Jefe Centro Medio Ambiente, Escuela Ingeniería (Chief of the environmental studies center, Engineering School)	PUC - Pontificia Universidad Católica de Chile	
César Saez	Profesor Centro de Medio Ambiente, Escuela Ingeniería (Lecturer of the environmental studies center, Engineering School)	PUC	
Enzo Sauma	Profesor Centro de Medio Ambiente, Escuela Ingeniería (Lecturer of the environmental studies center, Engineering School)	PUC	
Juan de Dios Rivera	Profesor del Departamento de Ingeniería Mecánica y Metalúrgica (Lecturer within the department of Mechanical and metalurgic engineering)	PUC	

Orelvis González	Jefe Sector Energía Sustentable (Chief, Sector for sustainable energy)	PUC	
Raúl O'Ryan	-	Universidad de Chile	
Leandro Herrera	-	Universidad de Chile	
José Hernández	-	Universidad de Chile	
Marcel Szantó	Ingeniería en Contrucción (Construction engineer)	UCV - Pontificia Universidad Católica de Valparaíso	
Juan Palma	Ingeniería en Contrucción (Construction engineer)	UCV	
Paola Conca	Gerente de Medio Ambiente (Environmental manager)	ProChile	Yes
Ana María Ruz	Director Programa Energía Sustentable (Director for the programme in sustainable energy)	Fundación Chile	Yes
Javier Obach	-	Fundación Chile	Yes
Marcela Angulo	Director General (General director)	Fundación Chile	Yes
Jaime Dinamarca	Gerente de Medio Ambiente (Environmental manager)	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 (Manager for area of key clients)	Metrogas S.A.	Yes
Oscar Uribe	Subgerente de Estudios (Sub-manager for studies and evaluations)	Metrogas S.A.	
Gerardo Muñoz	Subgerente Area GNC y Climatización (Sub-manager for area of CNG and climatization)	Metrogas S.A.	Yes
Francisco Richards	Area Grandes Clientes (Key client area)	Metrogas S.A.	Yes
Sebastián Bernstein	Ingeniero de Estudios	Metrogas S.A.	

	(Engineer for studies and evaluations)		
Matías del Río	Jefe Comunidades y Centrales Térmicas (Chief, Communities and termal power plants)	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 (Manager, Environmental Services sector)	SGS Chile	
Edgardo Devoto	-	DNV	
Manuel Antonio Pérez	Representante en Chile (Representative in Chile)	LFG Specialties	Yes
Fernando Azofeifa	-	Banco Santander Santiago	
José Vargas	Ingeniero Proyectos (Project engineer)	Pyros	Yes
Mario Solís	Area Negocios y Ventas (Area for business and sales)	Pyros	Yes
Patricio Ossandón	Ingeniero de Proyectos (Project engineer)	Pyros	Yes
Carlos Gebert	-	Sumitomo	
Alvaro Acevedo	Gerente General (General manager)	Queulat	Yes
César Contreras	-	Gasco	
Alfredo Becerra	Gerente General (General manager)	Geoandina	Yes
Jean Francois Bradfer	Gerente General (General manager)	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 favorable 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.

Favorable Comments

Favorable 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. Note that off-site use of LFG is not allowed by the CDM methodology ACM0001, so that the most appropriate option is power generation, as analyzed in this PDD.

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 of 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 ten to twelve 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
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Represented by:	
Title:	General Manager
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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 reductions 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.

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

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 2028 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 ton. 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%.

Justification of L_0 and k:
(Source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories)

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

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

L_o is dimensionless, e.g. ton of methane per ton of solid waste. Each of the parameters in Eq. (1) is discussed below.

MCF: Methane correction factor. The IPCC MCF default values of vary between 0.4 and 1.0, depending on the level of control applied to the waste placement and the anaerobic/aerobic conditions. We use a value of 1, since the project landfill is an anaerobic managed solid waste disposal site, with controlled placement of the waste.

DOC: Degradable organic carbon in waste. IPCC provides the following formula:
DOC = (0.4 * A) + (0.17 * B) + (0.15 * C) + (0.3 * D)

Where:
A = Fraction of MSW that is paper and textiles
B = Fraction of MSW that is garden waste, park waste or other non-food organic putrescribles
C = Fraction of MSW that is food waste
D = Fraction of MSW that is wood or straw

From an analysis of waste data corresponding to the project landfill we have
A: paper, board and textile = 21.5%
B+C: food and green waste = 44.8%
D: wood = 5.2%

Since, these data do not distinguish between categories B and C, and the coefficients are very close in any case, we modify Eq. (1) as follows:
DOC = (0.4 * A) + (0.16 * (B + C)) + (0.3 * D) = 0.17

DOC_f: fraction of degradable organic carbon dissimilated. IPCC provides two default values, equals to 0.5 if the waste includes lignin C, and 0.77 if it does not. Since we do not know the lignin content of the waste, we choose the conservative (lower) value DOC_f = 0.5, leading to a lower Lo value.

F: Fraction by volume of methane in landfill gas. We consider a conservative value of 50% CH_4 in LFG, as is common.

Applying these values in Eq. 1, we obtain:
Lo = 0.058 ton CH_4/ ton waste
Or, alternatively,

Lo = 80.64 Nm^3 CH_4/ ton waste, considering methane density of 0.7168 kg/Nm^3, at 1 atmosphere and 0 C.

The **methane generation rate constant, k,** that appears in the landfill gas production model is related to the time taken for the DOC in waste to decay to half its initial mass (the 'half life' or $t_{½}$). The rate constant k has dimensions of "per year".

Based on measurements in the USA, the United Kingdom and the Netherlands, IPCC supports values of k in the range of 0.03 per year (dry conditions) to 0.20 per year (high temperature and humidity condition). Note that there IPCC provides no data for developing countries, and in its uncertainty assessment (Table 5.2) indicates a default value of 0.05 per year with large uncertainties of –40% to +300%.

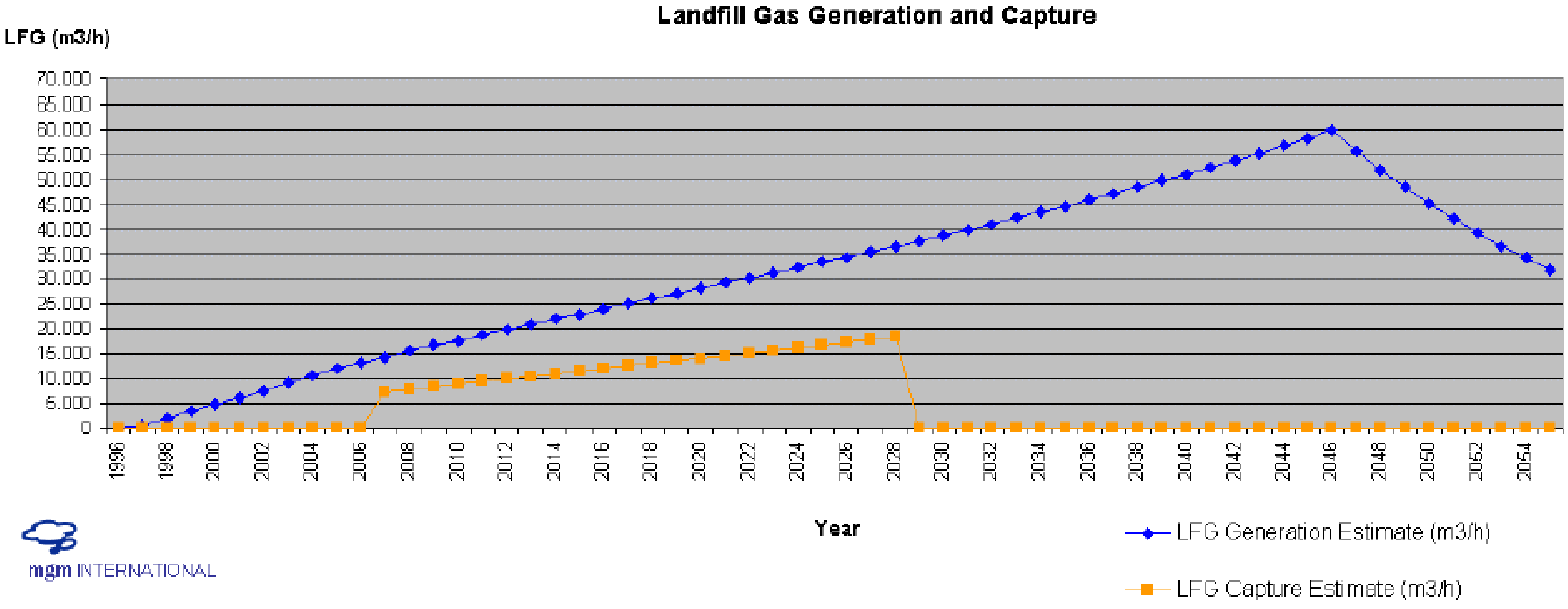
The precipitation at Loma Los Colorados Landfill is about 340 mm/yr and the average temperature is 18ºC. These are relatively dry and temperate conditions. Moreover, the waste is covered daily with a layer of clay of low permeability (less than 10^{-7} cm/s), reducing gas outflow. We have chosen a k value of 0.07 per year. Note, however, that k does not affect the total amount of methane emitted by the landfill; hence does not affect total emissions reductions that may be obtained from methane capture and destruction.

Loma Los Colorados Estimated Landfill Gas Generation, Capture & Emissions Reduction									
Year	Total Disposal Rate (ton/yr)	Total Refuse In-Place (ton)	LFG Generation (m^3/h)	LFG Capture Efficiency (%)	Project LFG Capture (m^3/h)	Baseline CH_4 capture (ton methane per year)	Max. electricity generation potential (MW)[40]	Possible scenario for power generation (MW)	**Total emissions reduction (tCO_2e/year)**
1996	544,867	544,867	0	0%	0	0	0	0	0
1997	1,118,610	1,663,477	655	0%	0	0	0	0	0
1998	1,284,802	2,948,279	1,955	0%	0	0	0	0	0
1999	1,346,151	4,294,430	3,366	0%	0	0	0	0	0
2000	1,409,470	5,703,900	4,757	0%	0	0	0	0	0
2001	1,534,759	7,238,659	6,129	0%	0	0	0	0	0
2002	1,771,241	9,009,900	7,559	0%	0	0	0	0	0
2003	1,689,504	10,699,404	9,176	0%	0	0	0	0	0
2004	1,730,062	12,429,466	10,586	0%	0	0	0	0	0
2005	1,675,812	14,105,278	11,949	0%	0	0	0	0	0
2006	1,718,210	15,823,488	13,155	0%	0	0	0	0	0
2007	1,761,681	17,585,169	14,331	50%	7,165	245	13.0	0.0	457,396
2008	1,806,251	19,391,420	15,479	50%	7,739	245	14.1	0.0	494,454
2009	1,851,949	21,243,369	16,603	50%	8,301	245	15.1	0.0	530,735
2010	1,898,804	23,142,173	17,706	50%	8,853	245	16.1	2.0	573,960
2011	1,946,843	25,089,016	18,791	50%	9,395	245	17.1	11.9	644,099
2012	1,996,099	27,085,115	19,860	50%	9,930	245	18.1	17.5	698,694
2013	2,046,600	29,131,715	20,916	50%	10,458	245	19.0	20.4	742,594
2014	2,098,379	31,230,094	21,961	50%	10,980	245	20.0	21.8	781,094
2015	2,151,468	33,381,562	22,998	50%	11,499	245	20.9	23.2	819,315
2016	2,205,900	35,587,462	24,028	50%	12,014	245	21.8	23.2	853,289
2017	2,261,709	37,849,171	25,055	50%	12,527	245	22.8	24.6	891,162
2018	2,318,931	40,168,102	26,079	50%	13,039	245	23.7	26.0	928,958
2019	2,377,599	42,545,701	27,102	50%	13,551	245	24.6	27.4	966,740

[40] It is worth clarifying that "Max. electricity generation potential (MW)" corresponds to the maximum technical power generation according to the available steady flow of collected LFG (for example in year 2028 the total LFG flow available divided by the assumed LFG flow consumption rate to generate 1 MW of power, results in 18,281 (m^3/h) /550 (m^3/MW) = 33.2MW. However, to achieve this total nameplate installed capacity, (i.e. use all the available LFG) it is assumed as necessary to install a higher number of engine-generator sets in order to enable alternate maintenance of the engine-generator sets without reducing LFG utilization as fuel for electricity generation. This is why column "*Possible power for electricity generation (MW)*" presents larger values than the column "*Maximum electricity generation potential (MW)*".

2020	2,437,753	44,983,454	28,127	50%	14,063	245	25.6	27.4	1,000,524
2021	2,499,428	47,482,882	29,155	50%	14,577	245	26.5	28.8	1,038,447
2022	2,562,663	50,045,545	30,187	50%	15,093	245	27.4	30.3	1,076,523
2023	2,627,499	52,673,044	31,226	50%	15,613	245	28.4	31.7	1,114,802
2024	2,693,975	55,367,019	32,272	50%	16,136	245	29.3	31.7	1,149,295
2025	2,762,132	58,129,151	33,328	50%	16,664	245	30.3	33.1	1,188,130
2026	2,832,014	60,961,165	34,394	50%	17,197	245	31.3	33.1	1,223,272
2027	2,903,664	63,864,829	35,472	50%	17,736	245	32.2	33.1	1,258,216
2028	2,977,127	66,841,956	36,563	50%	18,281	245	33.2	33.1	1,293,467
2029	3,052,448	69,894,404	37,669	0%	0	0	0	0	0
2030	3,129,675	73,024,079	38,790	0%	0	0	0	0	0
2031	3,208,856	76,232,935	39,928	0%	0	0	0	0	0
2032	3,290,040	79,522,975	41,085	0%	0	0	0	0	0
2033	3,373,278	82,896,253	42,261	0%	0	0	0	0	0
2034	3,458,622	86,354,875	43,458	0%	0	0	0	0	0
2035	3,546,125	89,901,000	44,676	0%	0	0	0	0	0
2036	3,635,842	93,536,842	45,917	0%	0	0	0	0	0
2037	3,727,829	97,264,671	47,181	0%	0	0	0	0	0
2038	3,822,143	101,086,814	48,471	0%	0	0	0	0	0
2039	3,918,843	105,005,657	49,787	0%	0	0	0	0	0
2040	4,017,990	109,023,647	51,131	0%	0	0	0	0	0
2041	4,119,645	113,143,292	52,502	0%	0	0	0	0	0
2042	4,223,872	117,367,164	53,903	0%	0	0	0	0	0
2043	4,330,736	121,697,900	55,335	0%	0	0	0	0	0
2044	4,440,303	126,138,203	56,798	0%	0	0	0	0	0
2045	4,552,643	130,690,846	58,294	0%	0	0	0	0	0
2046	0	130,690,846	59,824	0%	0	0	0	0	0
2047	0	130,690,846	55,779	0%	0	0	0	0	0
2048	0	130,690,846	52,008	0%	0	0	0	0	0
2049	0	130,690,846	48,492	0%	0	0	0	0	0
2050	0	130,690,846	45,214	0%	0	0	0	0	0
2051	0	130,690,846	42,157	0%	0	0	0	0	0
2052	0	130,690,846	39,307	0%	0	0	0	0	0
2053	0	130,690,846	36,650	0%	0	0	0	0	0
2054	0	130,690,846	34,172	0%	0	0	0	0	0
2055	0	130,690,846	31,862	0%	0	0	0	0	0

* Projects emissions, due to the electricity consumption of the blower


Landfill Gas Generation and Capture
LFG (m3/h)
70.000
65.000
60.000
55.000
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
2052
2054
Year
LFG Generation Estimate (m3/h)
LFG Capture Estimate (m3/h)
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 S.A.	-	127,380	5,125	18,742	6,405	0	102,656	119,377
February	m^3		Reported by KDM S.A.	-	107,500	555	22,856	8,435	0	109,644	107,359
March	m^3		Reported by KDM S.A.		147,688	552	2,688	8,450	9,740	107,026	44,758
April	m^3		Reported by KDM S.A.		118,276	6,002	39,227	9,700	15,084	108,118	47,725
May	m^3		Reported by KDM S.A.	4,638	106,856	17,227	42,325	9,370	13,842	120,166	87,444
June	m^3		Reported by KDM S.A.	13,385	68,230	39,417	7,974	9,471	13,597	98,609	102,130
July	m^3		Reported by KDM S.A.	31,131	84,713	7,149	6,520	8,160	102,606	99,530	105,236
August	m^3		Reported by KDM S.A.	37,787	88,573	108,261	7,491	8,200	102,292	108,725	
September	m^3		Reported by KDM S.A.	38,499		45,732	5,921	9,290	129,379	104,545	
October	m^3		Reported by KDM S.A.	36,911	47,277	35,712	5,804	9,460	102,500	108,878	
November	m^3		Reported by KDM S.A.	107,105	21,746	5,493	7,605	9,490	103,126	108,729	
December	m^3		Reported by KDM S.A.	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 * 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 * Tadj * Padj	0.592	0.592	0.592	0.592	0.592	0.592	0.592	0.592
Mass of Flared Methane	kg	MMkg		142,401	334,742	98,562	61,879	35,167	239,411	459,643	218,134
Mass of Flared Methane	**ton**	**MM**		**142**	**335**	**99**	**62**	**35**	**239**	**459.64**	**218**
								Use last three years as baseline			
								Average: 245 ton 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	D_{stp}	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 (version 6), requiring a determination of the Build Margin, the Operating Margin and a Combined Margin.

Electricity will be purchased from the power grid to meet the demand of the project activity, principally for the blowers for LFG collection. The emission factor for electricity purchases from the grid has been taken to be the Combined Margin.

Note that the emissions factor is determined ex-ante and kept fixed for the first crediting period, as allowed by ACM0002.

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), where the project activity is located and also includes the capital city of Santiago. The SIC provides electricity to 92.7% of the Chilean population.

ACM0002 indicates that the emissions factor is a so-called "combined margin", which is determined in three steps:
1. **Calculate the Operating Margin emission factor**
2. **Calculate the Build Margin emission factor**
3. **Calculate the baseline emission factor Combined Margin** as the weighted average of the Operating Margin emission factor and the Build Margin emission factor

Step 1. Operating Margin Calculation

Four different procedures are indicated for determining the operating margin. These are denominated:

(e) Simple Operating Margin

(f) Simple Adjusted Operating Margin

(g) Dispatch Data Analysis Operating Margin
(h) Average Operating Margin.

Of the methodological choices provided, ACM0002 states the following:

"The Simple OM, simple-adjusted OM, and average OM emission factors can be calculated using either of the two following data vintages for years(s) *y*:

- (*ex-ante*) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission, if or,
- the year in which project generation occurs, if $EF_{OM,y}$ is updated based on ex-post monitoring. The choice between ex-ante and ex-post vintage should be specified in the PDD, and cannot be changed during the crediting period."

As stated in Section D of the PDD, this project chooses an *ex-ante* vintage for the first crediting period. Of the three applicable ex-ante procedures, the most accurate one is the Simple Adjusted Operating Margin. Data available for the Chilean SIC power grid supports this approach, which is followed here. The results are presented below:

Simple Adjusted Operating Margin

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

$$EF_{OMSimpleAdjusted,y} = (1-\lambda_y)*\frac{\sum_{i,y} F_{i,j,y} * COEF_{i,y}}{\sum_j GEN_{j,y}} + \lambda_y * \frac{\sum_{i,k} F_{i,k,y} * COEF_{i,k}}{\sum_k GEN_{k,y}} \quad (1)$$

Where

$EF_{OM,y}$	simple adjusted OM emission factor in year '*y*' (tCO_2/MWh)
$F_{i,j,y} / F_{i,k,y}$	amount of fuel *i* (in mass or volume unit) consumed by relevant power sources *j* / *k* in the year *y*
$GEN_{j,y} / GEN_{k,y}$	electricity delivered to the grid by source *j* / *k* in year *y*
$COEF_{j,y} / COEF_{k,y}$	CO_2 emission coefficient for fuel *i* (tCO_2/mass or volume unit of the fuel) taking into account the carbon content of the fuels used by relevant power sources *j* / *k*, and the percent oxidation of the fuel.

The CO_2 emission coefficient $COEF_i$ is obtained as:

$$COEF_i = NCV_i * EF_{CO_2,i} * OXID_i \quad (2)$$

Where

NCV_i	Net calorific value of (energy content) per mass or volume unit of a fuel *i*
$EF_{CO_2,i}$	CO_2 emission factor per unit of energy of the fuel *i*
$OXID_i$	Oxidation factor of the fuel

The Simple OM, simple-adjusted OM, and average OM emission factors can be calculated using either of the two following data vintages for years(s) *y*:

- (*ex-ante*) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission, if or,
- the year in which project generation occurs, if $EF_{OM,y}$ is updated based on ex-post monitoring. The choice between ex-ante and ex-post vintage should be specified in the PDD, and cannot be changed during the crediting period.

We select using the data vintages for years (y) in which project generation occurs, then $EF_{OM\ Simple\ Adjusted,y}$ will be kept fixed based on ex-ante monitoring.

The simple adjusted operating margin was calculated for the most recent three years for which data were available: 2003, 2004, and 2005. The calculations are shown in the workbook: Chile_SIC Emission Factor_Los Colorados.xls.

The results are summarized below:

	2003	2004	2005
?Fij COEFi,j (tCO2/year) of NO LC/MR	6,563,215	8,913,029	7,830,347
?Fij COEFi,j (tCO2/year) of LC/MR	0	0	0
NO LC/MR Generation (GWh)	11,420	14,807	12,020
LC/MR Generation (GWh)	22,288	21,537	25,945
Imports (GWh)	0	0	0
lambda	0.0014	0.0008	0.0024
OM EF (tCO_2/MWh)	0.574	0.601	0.650
Average EF OM (tCO_2/MWh)	**0.608**		

Step 2. Build Margin Calculation

According to ACM0002, the build margin is determined by the average emissions factor of a sample of recently built power plants. The sample may be the most recent five power plants built if they add up to more than 20% of the total generation in the grid. If not, the sample must include enough of the most recently built power plants in order that together they represent at least 20% of the total generation.

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} * COEF_{i,m}}{\sum_{m} GEN_{m,y}} \qquad (3)$$

In this case, more than five power plants are needed to make up 20% of the total generation: Total generation in 2005 was 37,994,900 MWh, and 20% of that is 7,592,980 MWh. The most recently built power plants are listed in the table below, together with their 2005 generation. All except the last one listed are needed to add up to at least 7,592,980. The total power generation of these power plants is 8,113,946 MWh, and the total emissions corresponding to these power plants (1,682,601 $tCO_{2)}$ is the basis for the estimation of the Build Margin emissions factor.

Power Plant	Generation (GWh)	Cumulative Generation MWh	Start Year	Type	Fuel consumption (TJ)			CO_2 Emissions (tCO_2)	Cumulative CO_2Emisiones (tCO_2/year)
					Coal	Diesel	Natural Gas		
Coronel	69.1	69,100.0	2005	gas-diesel	0	40.1474	730.660288	43,729	43,729
Candelaria	26.9	96,000.0	2005	gas-diesel	0	0	185.095976	10,332	54,061
Nueva Aldea I	73.0	169,000.0	2005	steam forest residue.	-	-	-		54,061
Nueva Aldea II	0.0	169,000.0	2005	natural gas open cycle	-	-	-		54,061
Antilhue TG	49.6	218,600.0	2005	diesel	0	246.8638	0	18,102	72,162
Ralco	3,495.7	3,714,300.0	2004	Hydro	0	0	0	0	72,162
Valdivia	157.6	3,871,900.0	2004	steam forest residue	-	-	-		72,162
Licantén	21.7	3,893,600.0	2004	steam forest residue	-	-	-		72,162
Horcones	2.1	3,895,700.0	2004	gas-diesel	0	0	24.656312	1,376	73,539
Cholguán	79.2	3,974,900.0	2003	steam forest residue	-	-	-		73,539
Nehuenco II	2,383.8	6,358,700.0	2003	gas natural combined cycle	0	0	16391.2384	914,951	988,489
Chacabuquito	172.0	6,530,700.0	2002	Hydro	0	0	0	0	988,489
Nehuenco 9B	103.1	6,633,800.0	2002	gas-diesel	0	313.4914	480.624448	49,815	1,038,305
San Francisco de Mostazal	18.9	6,652,700.0	2002	gas-diesel	0	272.0627	0	19,949	1,058,254
Mampil	192.7	6,845,400.0	2000	Hydro	0	0	0	0	1,058,254
Peuchén	294.8	7,140,200.0	2000	Hydro	0	0	0	0	1,058,254
Taltal I	573.4	7,713,622.0	2000	natural gas open cycle	0	0	6587.74984	367,725	1,425,979
Taltal II	400.3	8,113,946.0	2000	natural gas open cycle	0	1.7084	4595.103104	256,622	1,682,601

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

The results are summarized below. The build margin emissions factor for baseline power generation is **0.207 tCO_2/MWh**.

Total Generation 2005 (MWh)	37,964,900
20% of Total Generation 2005 (MWh)	7,592,980
Generation for BM calculation (MWh)	8,113,946
Total CO_2 Emissions (tCO_2)	1,682,601
EF_{BM} (tCO_2/MWh)	**0.207**

Step 3. Calculate the baseline emissions factor

ACM0002 indicates that the emissions factor is a weighted average of the operating margin and the build margin, suggesting a 50/50 weighting.

$$EF_{CM} = \frac{EF_{OM} + EF_{BM}}{2} \quad (4)$$

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

Operating Margin Emission Factor (Average 2003, 2004 and 2005)	**0.608**	($t-CO_2/MWh$)
Build Margin Emission Factor (2005)	**0.207**	($t-CO_2/MWh$)
Combined Margin Emission Factor	**0.408**	($t-CO_2/MWh$)

Thus, the combined margin is **0.408 tCO_2/MWh**.

Data sources:

- Estadísticas de Operación 1996 - 2005 -- CDEC-SIC
- "Fijación de Precios Nudo 2003/2006 - Sistema Interconectado Central (SIC)" (Comision Nacional de Energía - Gobierno de Chile - www.cne.cl)

Annex 4

MONITORING PLAN

The monitoring methodology used for this project is as developed as per the applicable requirements of ACM0001 (version 4), with minor adjustments for application to the conditions of this project.

Applicable requirements of the latest versions of the following tools are also taken into account in the context of the design of the monitoring plan:

- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

The project involves landfill gas capture and flaring. Some gas will be used for power generation at the landfill site. ACM0001 (version 4) provides guidance and equations for these applications. ACM0001 (version 4) also provides guidance 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 ACM0001.

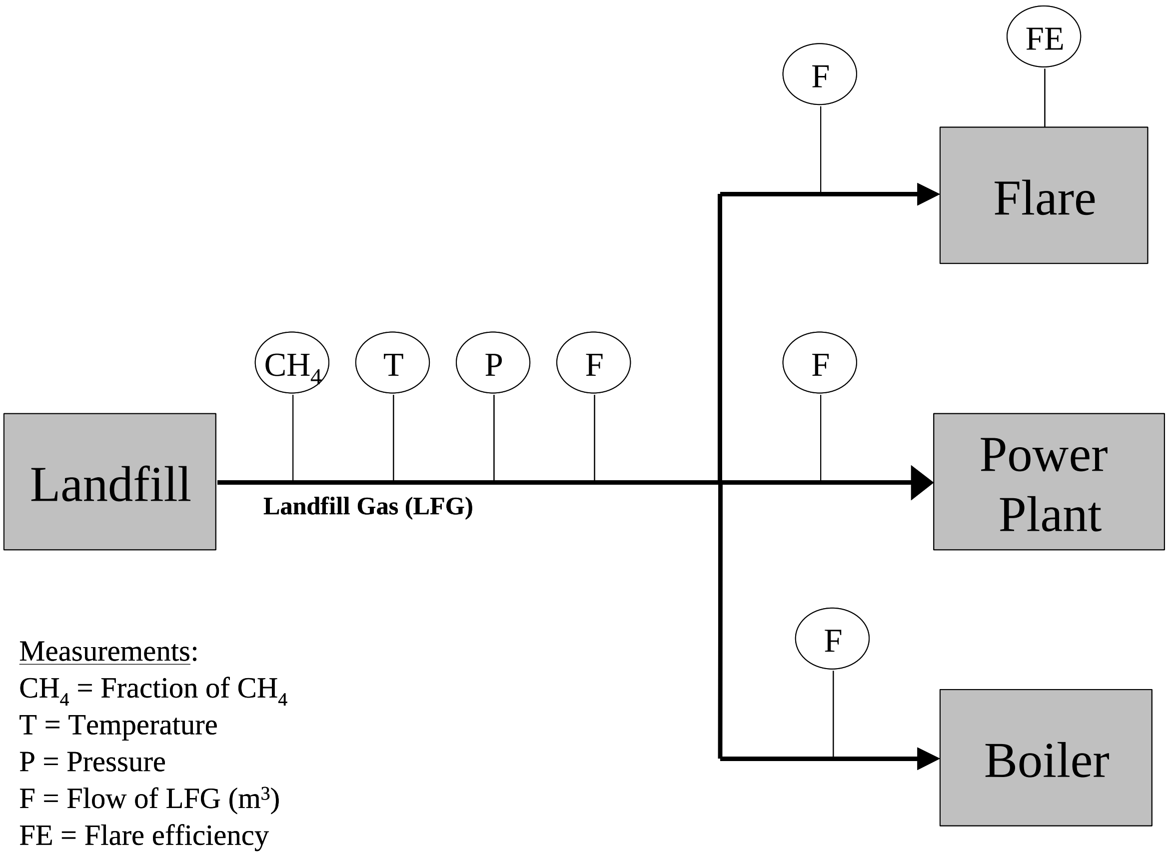


Figure A.4.1: Key Data Points for Monitoring (from ACM0001- version 4)
(Note: In this project, "Boiler" indicates users of LFG as fuel off-site)

The specific project is not expected to involve LFG use to generated thermal energy use on site.

The monitoring procedure, including relevant equations, are summarized 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 (Project's methane destruction component)

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:

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

Where:

$MD_{flared,y}$	is the quantity of methane destroyed by flaring during the year measured (in ton of CH_4)
$LFG_{flared,y}$	is the quantity of landfill gas flared or during the year measured in cubic meters (m^3)
$w_{CH_4,y}$	is the methane fraction of the landfill gas 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 ton of methane per cubic meter of methane (tCH_4/m^3CH_4).

There are similar equations (5 and 7) in Section D.2.4 for methane used for electricity generation and for total methane destroyed:

$$MD_{electriciy,y} = LFG_{electricity,y} * w_{CH_4,y} * D_{CH_4} * FE$$

$$MD_{total,y} = LFG_{total,y} * w_{CH_4,y} * D_{CH_4}$$

In this last formula $MD_{total,y}$ is the total calculated accumulated quantity of methane destroyed by the flares and by the electricity generation facilities based on measurements of $LFG_{total,y}$ by the LFG flow

meter that measures all collected LFG which is sent to both the flares and the electricity generation facilities.

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.

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

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 ($MD_{electricity,y}$) each year is determined similarly, by summing hourly values over the year.

In the above equation, a single value of flare efficiency (FE) is shown. Since ACM0001 (version 4) requires FE to be measured yearly, the mass flow of methane flared also would need to be determined on a yearly 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 year.

Once the components of methane destroyed in any of the two ways have been determined, the total mass of methane destroyed in each year can be determined using the following equation:

$$MD_{project,y} = \min\ (MD_{total,y}\ ; (MD_{flared,y} + MD_{electricity,y})) \qquad \text{(A.4.2)}$$

Then, the emissions reductions associated with methane destruction are then determined by Eq (1) of Section D.2.4:

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

Where:

ERM_y is measured in ton of CO_2 equivalent (tCO_2e)

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

For reasons explained in Section D.2.4, $MD_{reg,y}$ is a fixed number, equivalent to 245 ton/year, 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 (Project's renewable energy generation component)

In this project, carbon dioxide emissions reductions may also 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.

Carbon dioxide emissions reductions during a given year y (ERC_y) are given by Eq (7) of Section D.2.4 of the PDD:

$$ERC_y = EL_y * CEF_y \qquad \text{(A.4.4)}$$

Where:

ERC_y Quantity of net exported electricity during the year *y* (in MWh), given by:

$$EL_y = EL_{EXP\ LFG,y} - EL_{IMP,y}$$

Where:

$EL_{EXP,LFG,y}$ Quantity of net electricity generated by the project activity using LFG as fuel which is exported during year *y* (in MWh)

Note that "exported" here refers to net electricity being exported by the project activity through the SIC power grid: Note that exported net electricity could eventually be used to meet electricity demand from the landfill (e.g. leachate treatment, office use, etc., that are *not* associated with the landfill gas collection, flaring and use).

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

Parameters to be monitored in order to determine carbon dioxide emissions reduction from electricity generation are listed below:

- Net electricity output of the LFG generation system, which would be measured using an electricity meters. This amount of electricity may be sent to the rest of the landfill (not a part of the project activity) or sold to the grid. Electricity sold to the grid will be measured in any case, since it is the basis for transactions in the wholesale power market. While it is not necessary to measure the electricity sent to other uses on site, this is also recommended.
- When electricity is not generated, any electricity purchased from the grid to meet project requirements should be monitored using an electric meter. Even in this case, Eq. A.4.5 remains valid, though the value for emissions reductions is negative. The value should be recorded as "project emissions."

In each case, electric meters shall be calibrated periodically according to manufacturer recommendations, e.g. every two years.

Project emissions due to the consumption of electricy by the project acticity (grid electricity and/or electricity generated by a captive off-grid electricity generator fuelled by fossil fuel (Diesel).

Project emissions due to electricity consumption ($PE_{EC,y}$) are determined (in tCO_2) as follows:

$$PE_{EC,y} = PE_{EC,grid,y} + PE_{EC,captive,y}$$

Where:

$PE_{EC,grid,y}$ Project emissions sue to consumption of grid electricity in year y (tCO_2). $PE_{EC,grid,y}$ is calculated by following the applicable guidance of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (version 1) as follows:

$$PE_{EC,grid,y} = EC_{grid,y} * CEF_y * (1 + TDL_{grid,y})$$

Where:

$EC_{grid,y}$ = Amount of grid electricity consumed by the project activity. $EC_{grid,y}$ will be measured and monitored in MWh as per applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

CEF_y = CO_2 emission factor for grid electricity. CEF_y is ex-ante calculated as 0.408 tCO_2/MWh,

$TDL_{grid,y}$ = Average technical transmission and distribution losses for grid electricity. In accordance with applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $TDL_{grid,y}$ is ex-ante determined as 20% (conservative default value fixed along the whole crediting period).

$PE_{EC,captive,y}$ Project emissions due to consumption of electricity sourced by the captive off-grid electricity generator (fuelled by Diesel) in year y (tCO_2). $PE_{EC,captive,y}$ is calculated by following one of the four approaches below which are based on the existent determination options of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (B1, B2, B3 or B4) as follows:

Alternative approach 1 and alternative approach 2:
As per Option B1 and B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $PE_{EC,captive,y}$ is calculated as follows:

$$PE_{EC,captive,y} = EC_{captive,y} * EF_{EL,captive,y} * (1 + TDL_{captive,y})$$

Where:

$EC_{captive,y}$ = Amount of electricity sourced by the captive electricity generator (fuelled by Diesel) and consumed by the project activity. $EC_{captive,y}$ will be measured and monitored in MWh as per the provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

$TDL_{captive,y}$ = Average technical transmission and distribution losses for electricity sourced by the captive electricity generator. In accordance with the applicable provisions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", as a simplification, $TDL_{captive,y}$ is ex-ante determined as zero (fixed value along the whole crediting period).

$EF_{EL,captive,y}$ = CO_2 emission factor for electricity sourced by the captive off-grid electricity generator (tCO_2/MWh).

- *Alternative approach 1:*
  By following Option B1 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is determined as follows:

$$EF_{EL,captive,y} = (FC_{Diesel} * NCV_{Diesel,y} * EF_{CO2,Diesel,y}) / EG_{Diesel\text{-}generator,y}$$

Where:

FC_{Diesel} = Quantity of fuel Diesel combusted by the captive off-grid electricity generator (liters)

$NCV_{Diesel,y}$ = Net calorific value of the fuel Diesel (GJ/liters)

$EF_{CO2,Diesel,y}$ = CO_2 emission factor of fuel Diesel (tCO_2/GJ)

$EG_{Diesel\text{-}generator,y}$ = Quantity of electricity generated by captive off-grid electricity generator fuelled by Diesel (MWh). It is important to note that If all electricity generated by the captive electricity generator is consumed by the project activity, $EG_{Diesel\text{-}generator,y} = EC_{captive,y}$

- *Alternative approach 2:*
  By following Option B2 of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $EF_{EL,captive,y}$ is determined as 1.3 tCO_2/MWh.

Alternative approach 3:
By following Option B3 the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", $PE_{EC,captive,y}$ is calculated by determining the CO_2 emissions from all Diesel fuel combustion in the captive electricity generator. These emissions are calculated by adopting applicable provisions of the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 2). This option provides an accurate estimate as all electricity generated by the captive off-grid generator is expected to be consumed by the project activity.

As per the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (version 2), $PE_{EC,captive,y}$ is determined as follows:

$PE_{EC,captive,y} = FC_{Diesel} * COEF_{Diesel}$

Where:

FC_{Diesel} = Quantity of fuel Diesel combusted by the captive off-grid electricity generator (liters)

$COEF_{Diesel}$ = The CO_2 emission coefficient for the fuel Diesel (tCO_2/liters) which is calculated by following Option B of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” as follows:

$COEF_{Diesel} = NCV_{Diesel,y} * EF_{CO2,Diesel,y}$

Where:

$NCV_{Diesel,y}$ = Net calorific value of the fuel Diesel (in GJ/liters)

$EF_{CO2,Diesel,y}$ = CO_2 emission factor of fuel Diesel (tCO_2/GJ)

Alternative approach 4:

By taking into account Option B4 the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”, $PE_{EC,captive,y}$ is calculated based on the rated capacity of the installed captive off-grid electricity generator and by assuming a CO_2 emission factor of 1.3 tCO_2/MWh for electricity generated by the captive off-grid electricity generator (which is assumed as being operation of 8,760 hours per year) as follows:

$PE_{EC,captive,y} = 11{,}400\ tCO_2/MWh * PP_{CP,Diesel\text{-}generator}$

Where:

$PP_{CP,Diesel\text{-}generator}$ = Rated capacity of the installed captive off-grid electricity generator (fuelled by Diesel) (in MW)

Project emissions due to consumption of LPG (for igniting the flares):

In order to determine project emissions from LPG combustion ($PE_{LPG,y}$) for igniting the flares, applicable guidance of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (version 2) is utilized as follows:

$$PE_{LPG,y} = \sum FC_{LPG,y} * COEF_{LPG,y}$$

Where:

$FC_{LPG,y:}$ = Quantity of consumed fossil fuel (LPG) (in ton LPG);
$COEF_{LPG,y}$ = CO_2 emission coefficient for LPG (tCO_2/ton LPG). $COEF_{LPG,y}$ is determined as follows:

$$COEF_{LPG,y} = NCV_{LPG,y} * EF_{CO2,LPG,y}$$

Where:
$NCV_{LPG,y}$ = Net calorific value of the fuel LPG (in GJ/ton LPG)
$EF_{CO2,LPG,y}$ = CO_2 emission factor of fuel LPG (tCO_2/GJ LPG)