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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Joburg Landfill Gas to Energy Project
PDD Version Number 6
26/07/2011

A.2. Description of the project activity:

The Joburg Landfill Gas to Energy Project (hereafter referred to as the "Project") developed by Ener-G Systems Joburg (Pty) Ltd. (hereafter, the "Project Developer") is a landfill gas (hereafter, "LFG") collection and utilisation project at the Johannesburg landfill sites located in Johannesburg, South Africa (hereafter, the "Host Country"). The landfill site addresses and coordinates are detailed in Section A.4.1.4.

The objective of the project is to collect and destroy/utilise the LFG generated at the Johannesburg landfill sites. The project activity will consist of two distinct stages:

1. LFG will be captured and destroyed by using a LFG flare. The purpose of LFG flaring is to dispose of the flammable constituents, particularly methane, safely, and to control odour nuisance, health risks, and adverse environmental impacts. Hence, investment will be made in a highly efficient gas collection system and flaring equipment.
2. Once generation of LFG is proven to be steady, the captured LFG will be fed to the LFG flare and modular electricity generation plants. The generators will combust the LFG methane to produce electricity for internal use and/or export to a local power purchaser. Excess LFG and all gas collected during periods when electricity is not produced, will be flared.

Prior to implementation of the project activity, the LFG was being freely emitted into the atmosphere resulting in GHG emissions. The Project involves the destruction/utilisation of methane emissions as well as the displacement of electricity from the South African coal-based grid, resulting in a consequent reduction in CO_2 emissions. In the baseline scenario, the LFG would have been released into the atmosphere resulting in GHG (CH_4) emissions to the atmosphere. The electricity would have been produced in the fossil fuel based South African grid resulting in CO_2 emissions.

Emission reductions will be constituted by:

- the capture and destruction/utilisation of LFG; and
- the displacement of coal-based electricity from the grid by the generation of electricity from captured LFG.

Moreover, the Project is assisting the Host Country in fulfilling its goal of promoting sustainable development, and will have several positive social and environmental impacts, namely:

- The integration of infrastructure which will improve environmental conditions. The installed LFG collection and flaring system will prevent potentially explosive situations associated with subsurface gas migration, as it represents an effective control system minimising off-site gas migration.

- Several LFG constituents are hazardous and pose a potentially significant risk to human health. The objective of LFG flaring is to dispose of these perilous constituents, particularly methane, safely, and to control and reduce odour nuisance and health risks.
- Minimisation of environmental damage through reduced methane emissions.
- Provision of a model for LFG management, which is a key element in improving landfill management practices throughout the Host Country.
- Optimising the use of natural resources by acting as a clean technology demonstration project, encouraging less dependency on grid-supplied electricity. Development in this area has been discouraged by the extremely low cost of electricity in South Africa (by international comparison)[1]. By promoting the use of this technology, sustainable and diverse energy systems are promoted.
- Finally, the Project will attempt to increase employment opportunities in the areas where the Project is located, by providing short- and long-term employment opportunities for local people. Local contractors and labourers will be required for construction, and long-term staff will be contracted to operate and maintain the system.

A.3. Project participants:

Name of party involved (*) ((host) indicates a host party)	Private and/or public entity(ies) Project participants (*) (as applicable)	Kindly indicate if the party involved wishes to be considered as project participant (Yes/No)
Republic of South Africa (host)	ENER-G Systems Joburg (PTY) Ltd. (private entity)	No
United Kingdom of Great Britain and Northern Ireland	EcoSecurities International Ltd. (private entity)	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 (country) involved may or may not have provided its approval. At the time requesting registration, the approval by the Party (ies) involved is required.

Further contact information of project participants is provided in Annex 1.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Republic of South Africa (the "Host Country")

[1] Eskom Annual Report 2008, p. vi, extract from NUS Consulting Group International Electricity Supply and Cost Comparison, April 2008.

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

Gauteng Province (subsequently “GP”).

A.4.1.3. City/Town/Community etc:

Johannesburg, in the City of Johannesburg Metropolitan Municipality.

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

All sites are located in the Gauteng Province of South Africa, and have the following co-ordinates:

Linbro Park Landfill - Marlboro Drive, Sandton: 26° 05’ 41.85” S & 28° 07’ 13.43” E;

Marie Louise Landfill - Dobsonville Drive, Roodepoort: 26° 11’ 23.89” S & 27° 53’ 00.13” E;

Robinson Deep Landfill – Turffontein Road, Turffontein: 26° 13’ 59.03” S & 28° 02’ 14.77” E;

Goudkoppies – Houthammer Road, Devland, Lenasia: 26° 16’ 52.31” S & 27° 55’ 24.93” E; and

Ennerdale Landfill – Old Lawley Road, Lawley: 26° 22’ 07.78” S & 27° 50’ 02.80” E.

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

According to Annex A of the Kyoto Protocol, this Project fits in the following Category:

Sectoral Scope 13 - Waste Handling and Disposal.

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

Table A.2.1: Joburg Landfill sites[2]

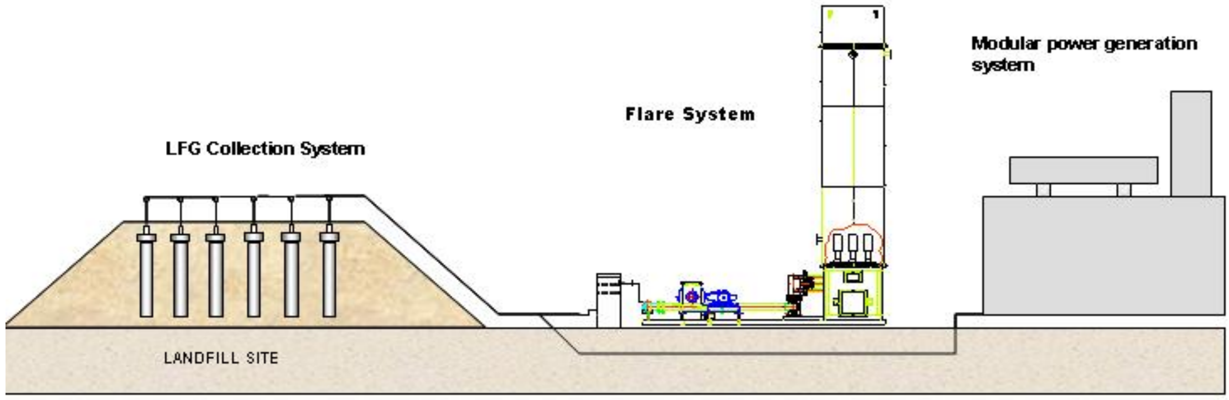
Site	Start year	Expected closure date	Status
Linbro Park	1969	09/2006	Closed
Marie Louise	1991	01/03/2016	Active
Robinson Deep	1936	01/08/2025	Active
Goudkoppies	1989	01/11/2045	Active
Ennerdale	1988	01/09/2022	Active

The baseline scenario at the 5 sites *prior* to the start of the implementation of the project activity was simple landfills *without* any gas collection, flaring, or electricity generation.

The project activity involves the installation of active LFG collection systems, enclosed flare systems, and subsequently modular electricity generation systems.

The following diagram illustrates the main components involved in the project activity (the general set-up will be the same for all sites):

2 Landfill Airspace Estimation Report and Waste Disposal Permit



This is a proven technology for LFG combustion, and has been widely proven as reliable and environmentally safe.

Technology transfer is involved in the project through the introduction and demonstration of a new and modern technology for capture, destruction/utilisation of LFG, and implementation of a detailed training program for maintenance and operation of the project equipment. The technology used in the project activity to collect, flare and utilise the LFG is designed in the UK.

Landfill Gas Collection System

The project activity involves the installation of active LFG collection systems using vertical and/or horizontal gas wells drilled into the landfill to extract the LFG. The gas collection pipe network consists of pipes that connect groups of gas wells to manifolds. These manifolds are connected to the main pipes and then to main header pipes, which deliver the LFG to the extraction plants and flares. The system operates at pressure slightly lower than atmospheric, as blowers will draw the gas from the wells through the collection system and deliver it to the flare or the LFG power generation system.

Flare System

The project activity involves the installation of modular enclosed gas flares at each landfill site consisting of pipe-work, valves, blower, stack with proprietary burners, instrumentation, and control panel. For safety purposes, flare units are fitted with flame arresters protecting the blower and the field pipe work- from burner flame flashback. At nominal flare temperatures (i.e. between 1,000 and 1,150°C), methane destruction efficiency is 99.9%[3] (i.e. full destruction of combustible constituents found in LFG), in accordance with the stringent UK Environment Agency guidelines[4].

Electricity Generation Technology

When the Project secures Power Purchase Agreements (hereafter, “PPA”s) enabling the sale of generated electricity, modular reciprocating engine facilities will be installed at the sites. Small modular reciprocating engine generator units make it possible to adapt the equipment to the site-specific gas volumes. These generators are designed by the Ener-G Group in Manchester, UK, and will be supplied to the Project Developer. The design capacity for this project activity is a maximum of 21 MW across the

[3] Please refer to "Biogas Technical Manual", p. 7-5, a soft copy of which was e-mailed (on 18/10/2010) to the validating DOE following the validation site visit.

[4] UK Environment Agency, 2002: Guidance on Landfill Gas Flaring. Biogas Technology Limited, Low Emission Ground Flare Systems Brochure.

five sites, comprising of gensets ranging in capacity from 0.3 to 1.2 MWe (all with manufacturer's expected efficiency of over 30%, with the ability to run at full load pending LFG availability). The LFG generators have an anticipated life of 10-15 years depending on operational conditions, fuel quality (in the form of LFG), and the maintenance regime adopted. The main mechanical-wearing components are limited to the generator (internal spark ignition engine), cooling fans, and blower.

The monitoring technology and protocol to be employed at the sites is standard, tested, and proven for LFG collection, flaring, and power generation systems worldwide. LFG flow will be continuously monitored via normalised flow-meters (which correct the quantity for fluctuations in temperature and pressure, thereby removing the need for separate temperature and pressure monitoring). Flaring conditions are closely monitored for safety and efficiency, and electricity measurement is accomplished via standard, regularly calibrated electricity meters.

Electricity generated by the project (at all the sites) will be transmitted to the Grid via electrical sub-stations (1 per site) that will each contain all suitable switching and metering equipment to facilitate such connection.

The major sources and gases included in the project boundary are as follows:

Emission Sources and Greenhouse gases involved in the project boundary		**Gas**
Baseline	Emissions from decomposition of waste at the landfill site.	CH_4
	Emissions from fossil fuel based grid electricity consumption.	CO_2
Project Activity	On-site electricity and/or fossil fuel consumption due to the project activity.	CO_2

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

Table A.4.4.1 - estimated emissions reductions resulting from the project

Years	**Estimation of annual emission reductions in tCO_2e**
2012	438,179
2013	481,853
2014	524,749
2015	549,106
2016	562,312
2017	572,017
2018	582,363
Total estimated reductions (tonnes of CO_2)	**3,710,580**
Total number of crediting years	21 years (3*7)
Annual average over the crediting period of estimated reductions (tonnes of CO_2)	**530,083**

A.4.5. Public funding of the project activity:

The project will not receive any public funding from Parties included in Annex I of the UNFCCC.

SECTION B. Application of a baseline and monitoring methodology

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

The large scale methodology ACM0001 Version 11, adopted at EB47, "Consolidated baseline and monitoring methodology for landfill gas project activities" has been employed in the project activity.

Furthermore, the project makes use of the following tools, which are referred to in ACM0001, Ver. 11:

- "Tool for the demonstration and assessment of additionality", Version 05.2, adopted at EB 39 (hereafter also referred to as "Additionality tool")
- "Tool to determine project emissions from flaring gases containing methane", Version 01, adopted at EB 28.
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", Version 01, adopted at EB 39.
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", Version 02, adopted at EB 41
- "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site", Version 05.1.0, adopted at EB 61.
- "Tool to calculate the emission factor for an electricity system", Version 02.2.0, adopted at EB 61.

All tools and the methodology referenced throughout the PDD refer to the corresponding version number stated in this section of the PDD for each tool and methodology.

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

The Project is anticipated to have two complementary activities, as follows:

(1) Methane collection and destruction:

The collection and destruction (through flaring) and/or utilisation of LFG (through combustion in electricity generation units), thus converting its methane content into CO_2, reducing its greenhouse gas effect; and

(2) Electricity displacement:

The generation and supply of electricity to the grid/or a local power purchaser, thus displacing a certain amount of fossil fuels that are used for electricity generation for the national grid.

The Project therefore fulfils the conditions of options a) and b) of ACM0001 applicability criteria (i.e. captured LFG is flared and used to produce energy), and is consequently considered the most appropriate methodology for the proposed project activity. Option c) (the captured gas is used to supply consumers through natural gas distribution network) is not applicable for this project.

When the Project progresses to stage 2, the baseline will be the generation of electricity by plants connected to the grid, and therefore the "Tool to calculate the emission factor for an electricity system" (Version 02.2.0, adopted at EB 61) will be applied to calculate the grid emission factor, as stated in ACM0001. As per the "Scope and applicability" of this tool (p. 2), the tool "may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity, i.e. where a project activity supplies activity to a grid or a project activity that results in savings of electricity that would have been provided by the grid" as is the case in the project activity.

All applicability conditions of the other tools are also met, specifically from the:

"*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" (Version 01, adopted at EB 39)

The project falls under *at least* one scenario of this tool, and as such, this Tool is applicable.

"Tool to determine project emission from flaring gases containing methane"
(Version 01, adopted at EB 28)

- The residual gas stream (LFG) to be flared contains no combustible gases other than methane, carbon monoxide, and hydrogen; and
- The residual gas steam to be flared is obtained from the decomposition of organic material from the landfills.

Therefore, this Tool is applicable.

"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"
(Version 05.1.0, adopted at EB 61)

- The Project activity where the solid waste disposal site waste *was/is* dumped can be clearly identified;
- The Project does not consider hazardous wastes; and
- The Project sites are *not* stockpiles.

Therefore, this Tool is applicable.

"*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*
(Version 02, adopted at EB 41)

- If and when the Project burns fossil fuel (in an on-site fossil fuel generator) the CO_2 emissions from this fossil fuel combustion will be based on the quantity of the fuel combusted and its properties.

For ease of reading, tool version numbers are *not* repeated throughout the PDD.

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

According to baseline methodology ACM0001, Version 11, the project boundary encloses the sites where the gas will be captured and destroyed/used.

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

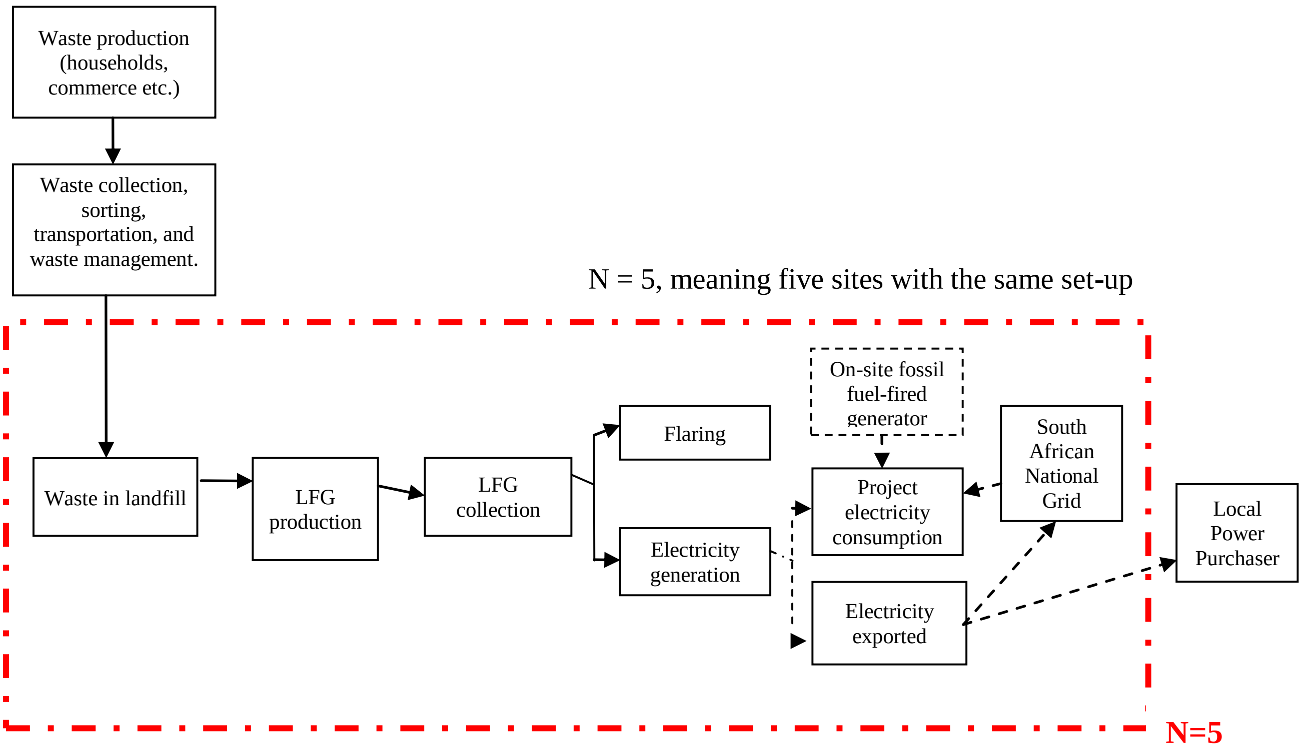
The following activities and emission sources are considered within the project boundaries:

Table B.3.1: Summary of gases and sources included in the project boundary and justification/explanation where gases and sources are not included.

	Source	Gas	Included?	Justification/Explanation
Baseline	Emission from decomposition of waste at the landfill sites	CH_4	Yes	The major source of emissions in the baseline.
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is *conservative*.
		CO_2	No	CO_2 emissions from decomposition of organic waste are not accounted for.
	Emissions from electricity consumption	CO_2	Yes	Electricity consumed from the South African National grid in the baseline scenario.
		CH_4	No	Excluded for simplification. This is *conservative*.
		N_2O	No	Excluded for simplification. This is *conservative*.
	Emission from thermal energy generation	CO_2	No	No thermal energy generation is planned in the project activity.
		CH_4	No	Excluded for simplification. This is *conservative*.
		N_2O	No	Excluded for simplification. This is *conservative*.
Project Activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	Yes	Only in case of back-up electricity generation.
		CH_4	No	Excluded for simplification. This emission source is negligible.
		N_2O	No	Excluded for simplification. This emission source is negligible.
	Emissions from on-site electricity use	CO_2	Yes	This is applicable for on-site electricity use, if and when the project activity does not generate electricity from the captured LFG.
		CH_4	No	Excluded for simplification. This emission source is negligible.
		N_2O	No	Excluded for simplification. This emission source is negligible.

A full flow diagram of the project set-up is presented in Figure B.3.1 (below). The flow diagram comprises all possible elements of the LFG collection systems and the equipment for electricity generation. The Project boundary is indicated by the broken red line. If and when the project activity includes electricity generation the project boundary will be extended to include a power purchaser - the South African national grid or a local power purchaser.

Figure B.3.1 - Flow diagram of Project set-up



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

The project activity is the installation of active LFG capturing systems on a set of five landfills in the Johannesburg area where there are no existing systems to capture and destroy the LFG gas. The most plausible baseline scenario is the release of LFG to the atmosphere and generation of electricity in the fossil fuel based grid. The regulatory requirements specified within the Landfill Permits for the sites *do not* require any LFG to be collected or flared at the sites.

The following alternatives are considered to determine the baseline scenario:

- **LFG 1**: The project activity (i.e. capture of LFG and its flaring and/or its use) undertaken without being registered as a CDM project activity;

- **LFG 2**: Atmospheric release of the LFG, which represents the business as usual scenario;

LFG1 *cannot* be the most plausible baseline scenario as it is not a feasible course of action in the absence of the project activity (as detailed in Section B.5).

As the Project may include electricity generation in the future, realistic and credible alternatives may include, *inter alia*:

- **P1.** Power generated from LFG undertaken without being registered as a CDM project activity;
- **P2.** Existing or construction of a new on-site or off-site fossil fuel fired cogeneration plant;
- **P3.** Existing or construction of a new on-site or off-site renewable based cogeneration plant;
- **P4.** Existing or construction of a new on-site or off-site fossil fuel fired captive power plant;
- **P5.** Existing or construction of a new on-site or off-site renewable based captive power plant; and
- **P6.** Existing and/or new grid-connected power plants.

Renewable sources other than LFG are not economically feasible for the project sites, as there are no other renewable energy options available at the project sites, and these would be less plausible than purchasing electricity from the National Grid. Therefore options P3 and P5 are discarded. Similarly, since heat is not considered as part of the proposed project activity, cogeneration plants are not a viable alternative, and alternatives P2 and P3 are discarded.

As a Grid connection already exists on all the landfill sites, construction of a new on-site fossil fuel fired captive power plant is not as plausible as purchasing power from the grid, so that P4 and P5 are also discarded.

Alternatives remaining for power generation are therefore P1 and P6.

Remaining options for plausible baseline alternatives for the project activity are then:

- **LFG 2:** Atmospheric release of the LFG, which represents the business as usual scenario;
- **P1:** Power generated from LFG undertaken without being registered as a CDM project activity, which represents the project activity. **P1** also corresponds to **LFG 1**; and
- **P6:** Power plants connected to the grid.

The baseline scenario is summarised in Table B.4.1:

Table B.4.1 - Baseline scenario summary for the Project.

Component	Baseline Option	Baseline Description
Landfill Gas	LFG2	The atmospheric release of the LFG. There are no active gas collection systems in place at the five Johannesburg landfill sites included in the Project.
Power	P6	Existing grid-connected power plants. The project sites are currently supplied by the grid.

In the particular case of the proposed project activity, the baseline scenario is defined as the result of the additionality assessment of the "Tool for the demonstration and assessment of additionality". Please refer to Section B.5 for detailed analysis of the baseline scenario identification and selection.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality): >>

Determination of the project scenario additionality is undertaken according to ACM0001, Version 11 (which refers to the CDM consolidated "Tool for the demonstration and assessment of additionality", hereafter referred to as "Additionality Tool"), which follows the subsequent steps:

Step 1. Identification of alternatives scenarios

Step 1 of the Additionality Tool is used, together with additional guidance from ACM0001.

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

- **LFG 1**: The project activity (i.e. capture of LFG and its flaring and/or its use) undertaken without being registered as a CDM project activity; and

- **LFG 2**: Atmospheric release of the LFG, which represents the business as usual scenario.

LFG1 cannot be the most plausible baseline scenario, as it is not a feasible course of action in the absence of the project activity (as explained in the investment analysis below).

As the Project may include electricity generation in the future, realistic and credible alternatives may include, *inter alia*:

- **P1.** Power generated from LFG undertaken without being registered as a CDM project activity;
- **P2.** Existing or construction of a new on-site or off-site fossil fuel fired cogeneration plant;
- **P3.** Existing or construction of a new on-site or off-site renewable based cogeneration plant;
- **P4.** Existing or construction of a new on-site or off-site fossil fuel fired captive power plant;
- **P5.** Existing or construction of a new on-site or off-site renewable based captive power plant; and
- **P6.** Existing and/or new grid-connected power plants.

Renewable sources other than LFG are not economically feasible for the project sites since there are no other renewable energy options available at the sites, and these would be less plausible than purchasing electricity from the National Grid. Therefore options P3 and P5 are discarded. Similarly, since heat is not considered as part of the proposed project activity, cogeneration plants are not a viable alternative, and alternatives P2 and P3 are discarded.

As a Grid connection already exists at the landfill sites, construction of a new on-site fossil fuel fired captive power plant is not as plausible as purchasing power from the grid, so that P4 and P5 are also discarded.

The remaining alternatives for power generation are therefore P1 and P6.

The remaining options for plausible baseline alternatives for the Project activity are:

- **LFG 2:** Atmospheric release of the LFG, which represents the business as usual scenario;
- **P1:** Power generated from LFG undertaken without being registered as CDM project activity, which *represents* the project activity. **P1** also corresponds to **LFG 1**; and
- **P6:** Power plants connected to the grid.

Heat generation is not considered in the absence of the project activity; given the lack of local off-takers. The costs associated with developing a pipeline to supply off-takers from the project sites would be *too high* to justify an investment in thermal energy production. Therefore, alternatives for heat generation are not considered.

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

LFG 2: Atmospheric release of the LFG represents the business as usual scenario, and complies with South Africa's local and national laws. While there exists a draft 'Minimum Requirements for Waste Disposal by Landfill' (published in 2005 and constituting the *most recent* legislation on landfill site management available in South Africa) it does not categorically specify that it is a mandatory requirement to actively capture, flare, or destroy LFG at *every* landfill in South Africa. The draft requirements provide guidelines to ensure safety on site (i.e. reducing the risk of explosions) by limiting LFG accumulation via passive ventilation. The prevailing practice in South Africa is either venting the LFG to ensure that the concentration of methane in any particular area of the landfill stays below hazardous levels, or to not install any kind of capturing system[5].

P1: Power generation without registration as a CDM project activity,complies with all the applicable laws and regulations.

P6: Power plants connected to the grid complies with all the applicable laws and regulations as they have to be licensed by the National Energy Regulator of South Africa in order to generate, transmit, or distribute electricity[6].

In summary, all possible scenarios described above comply with national and local regulations. There are no laws/regulations which specify that it is mandatory to destroy LFG at all landfills in the Host Country.

Step 2. Investment Analysis

Sub-step 2a: Determine appropriate analysis method

According to the "Tool for the demonstration and assessment of additionality", if the alternatives to the CDM project activity do not include investments of comparable scale to the project, then Option III must be used. In this case, the most likely alternative to the project is not to install flaring and generation equipment at the sites. Therefore, since no investments of a similar scale to the Project are involved, benchmark analysis is applied.

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[5] Department of Water Affairs and Forestry, 2005: Minimum requirements for waste disposal by landfill, draft 3rd edition, Chapter 8.4.6 Gas management systems, p. 99, available at: http://www.dwaf.gov.za/Documents/Other/WQM/RequirementsWasteDisposalLandfillSep05Part4.pdf

[6] Electricity Regulation Act, 2006: Government Gazette, Republic of South Africa, Vol. 493 No. 28992, Clause 8 (I) (a), available at: http://www.info.gov.za/view/DownloadFileAction?id=67855

Sub-step 2b: Option III - Apply benchmark analysis

The likelihood of development of the Project without being registered as a CDM (P1 or LFG 1), as opposed to the continuation of current activities (atmospheric release of LFG) will be determined by comparing the pre-tax Project IRR with a suitable benchmark rate of return available to investors in the Host Country.

According to the "Tool for the demonstration and assessment of additionality", a relevant benchmark for a project's equity IRR can be derived from government bond rates increased by a suitable risk premium (to reflect private investment and/or project type). The benchmark derived is a pre-tax WACC (Weighted Average Cost of Capital) and is comparable with pre-tax Project IRR. The benchmark has been derived from the following parameters:

- **Risk Free Rate**: According to Bloomberg, an acknowledged specialist in providing financial data and investment information, the risk free rate for South Africa (equivalent to long term government bond yields) is taken as the average yield from 1999 to 05/2009 (start date of the project activity) at 9.07%.
- **Risk Premium (Market Return - Risk Free Rate):** In order to estimate the standard market return in the Host Country, the average equity market return has been analyzed. The FTSE/JSE index consists of all stocks traded on the South African Stock Exchange. During the most recent ten years prior to the investment decision (i.e. 1999 - 2008), the FTSE/JSE index has achieved a compounded annual return of 14.28%. The Risk premium/country premium can be determined as the difference between the average market return and the average risk free rate, or 14.28% - 9.07% = 5.21%.
- A Beta (hereafter, "β") coefficient of 1.00 (market average) has been applied which is *conservative* for LFG to energy projects in the developing world (since they have a high probability of underperforming)[7].
- Income Tax Rates (28%)[8]: the tax rate applicable in South Africa is used to derive the pre-tax Equity IRR from the post-tax Equity IRR.

With the effective tax rate of 28% the pre-tax WACC Benchmark is calculated as follows:

- equity return (post-tax) = risk free rate + (β * equity country premium)
  = 9.07% + (1 * 5.21%)
  = 14.28%
  equity return (pre-tax) = equity return (post tax) / (1 – income tax rate)
  = 14.28 / (1-28%)
  = 19.83%

- WACC (pre-tax) = (debt part * Cost of Debt) + (equity part * Cost of Equity (pre-tax))
  = (69% * 11.15%[9]) + (31% * 19.83%)
  = 13.82%

7 A study performed for the world bank in 2007, "Landfill Gas Capture Design vs. Actual Performance and the Future for CDM Projects", http://siteresources.worldbank.org/INTLACREGTOPURBDEV/Resources/840343-1178120035287/EditedLFGWorkshopReportAugust14.pdf

8 http://kpmghu.lcc.ch/dbfetch/52616e646f6d495638d5fe192b00c8fdb1e872a3c31c6c4c34e2b269ef7e38a8/kpmg_indirecttaxratesurvey_accessible1.pdfhttp://www.google.co.in/#hl=en&source=hp&q=tax+adjusted+cost+of+equity&aq=f&aqi=&aql=&oq=&gs_rfai=&fp=f0bb1200aec65a16

9 As per indicative term sheets related to the bank loan.

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

Table 5.1 below illustrates the result of the financial analysis for the project activity, considering a twenty-one year period. As shown, the project IRR (without CDM revenue) is *lower* than the chosen benchmark.

Table B.5.1: Financial results of the project (LFG 1 or P1) with and without carbon finance

	Without CDM	**With CDM**
IRR	-0.34 %	19.86 %
Pre-tax WACC (the chosen benchmark)	13.82%	

Table B.5.2: Assumption for financial analysis

<table>
<tr><th>Input / Assumption</th><th>Unit</th><th>Value</th><th>Comments</th></tr>
<tr><td>Electricity price</td><td>ZAR/MWh</td><td>1050 in the first year (i.e. 2012).</td><td>Tariff used is as per the Maximum Programme Price of Eskom’s 2010-2018 MTPPP (Medium Term Power Purchase Programme). After 2018, an inflation corrected electricity price. See attached Financial Calculation.</td></tr>
<tr><td>Kyoto CER</td><td rowspan="2">ZAR/tonne CO_2e</td><td>170</td><td>http://www.globeinternational.org/docs/content/may_09_cms.pdf,</td></tr>
<tr><td>Post-Kyoto CER</td><td>34</td><td>Post-Kyoto CER price assumed to be 20% of Kyoto CER price.</td></tr>
<tr><td rowspan="2">CAPEX</td><td>ZAR</td><td>211,296,906</td><td>Total for actual power installed 17 MW
See attached Financial Calculation.</td></tr>
<tr><td>ZAR/MW</td><td>12,590,687</td><td>Per actual MW installed
See attached Financial Calculation.</td></tr>
<tr><td>OPEX</td><td>ZAR/MWh</td><td>425 in the first year (i.e. 2012).</td><td>2012 1st year full operation (inflation corrected for later years). See attached Financial Calculation.</td></tr>
</table>

The underlying calculation and detailed information on the financial analysis carried out can be found in the spreadsheet made available to the DOE.

Sub-step 2d: Sensitivity analysis
A sensitivity analysis was undertaken using assumptions that move the IRR to the benchmark value. The sensitivity analysis shows that a *considerable* variation of major parameters would have to transpire in order to improve the Project IRR to the benchmark value.

Table B.5.3 – Sensitivity analysis

Sensitivity Analysis	Variations [%]	IRR [%]	Benchmark [%]
Increase in Revenue	30.20	13.85	13.82
Decrease in Capex	53.90	13.83	13.82
Decrease in Opex	40.60	13.82	13.82

<u>Increase in revenue:</u>
The increase in revenue is composed of the following parameters:

- <u>*Power generation from the gas*</u>*:* Power generation is based on the gas model and the *highest* Power Load Factor (hereafter "PLF") was assumed by the project developer, so an *increase* in gas consumption or electricity generation is *highly unlikely*.
- <u>*Electricity tariff:*</u> In 04/2007, when the Project Developer sent a proposal to the Johannesburg Council for LFG collection and electricity generation at the five sites, the expected tariff was 0.37 Rand/kWh, which was based on actual prices at that time. The tariffs available to the Project Developer in 2009 were taken from Eskom's Medium Term Power Purchase Programme (MTPPP)[10]. Therein, a pricing pyramid was developed with a lower threshold of the Eskom Ceiling Price below which Eskom would accept all bids (starting at 0.65 Rand/kWh in 2009, and ending the contractual period in 2018 at 0.35 Rand/kWh). Eskom also developed a Maximum Programme Price for which they would not review any bids higher than the Maximum Programme Price (starting at 1.05 Rand/kWh in 2009, and ending the contractual period in 2018 at 0.35 Rand/kWh). This schedule was designed to encourage power producers online as soon as possible by providing an incentive for early start-up (when the value of additional capacity is greatest). To be *conservative*, the calculated project IRR is based on the Maximum Programme Price of Eskom's MTPPP (i.e. the price at which Eskom would not review any bids that are higher than this price). To date there has not been any contract signed under the MTPPP. For the period after 2018, the rate of 2018 corrected for inflation was employed. Since the project *already* applies the Maximum Programme Price of the MTPPP tariff, a *further* increase by 30.2% is *highly unlikely* to occur in the future.

<u>Decrease in CAPEX:</u>
A reduction of 53.90% in the investment cost would be necessary for the IRR to reach the benchmark, and such a reduction in investment cost by such a *significant* percentage is *highly unlikely*. These costs are based on the cost of equipment required for the Project, the major part of which concerns the generators for which a purchase order (with a defined purchase amount) has *already* been made.

<u>Decrease in OPEX:</u>
A decrease of 40.6% in the OPEX is required for the IRR to reach the benchmark. The primary components of OPEX are material and manpower costs, both of which are exposed to inflation and will therefore *increase* in the future. A reduction in operation and maintenance costs by *any* amount is *highly*

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[10] Schedule of the Eskom Medium Term Power Purchase Program base tariff, Appendix H, May 2008, available at: http://www.eskom.co.za/content/MTPPP%20RFT%20rev%201%2013%20May%202008%5B1%5D.doc

unlikely. These costs are not likely to decrease as it is known what maintenance is required, and the Project Developer has a good idea (from extensive prior experience in South Africa) what salaries and material costs are expected to be.

In conclusion, the Project IRR is not sufficient to warrant investment in this project *even* with an increase in electricity revenue or production, or a *decrease* in investment or operation and maintenance costs. The installation of a LFG to energy project is therefore not viable *without carbon finance*.

Method:
EB41 Annex 45 requires the consideration of sufficient variation in the input parameters to ensure that the additionality of a project is robust. This guidance suggests that variation of at least 10% in either direction should be considered where appropriate. The Project's additionality was tested by increasing revenues (+) and decreasing (-) costs, both capital and operational, and as a stopping point we used the values that rendered the project IRR equal to the benchmark. Decreasing revenues and increasing costs would not be reasonable as this would further decrease the financial attractiveness of the project i.e. would make the project *even more additional*. An explanation was then given regarding the probability of obtaining such additional revenue or reduction in expenditure to such a degree. The range tested was in fact *far larger* than +/-10%, and as such the EB41 Annex 45 guidance was adhered to.

Step 3. Barrier Analysis

Barrier Analysis is not used for the demonstration of additionality for the project as the CDM project activity is unlikely to be financially/economically attractive (as per Step 2c Para 11b).

Step 4. Common Practice Analysis for South Africa

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

Although LFG has been recognised as a source of odour and as a potential explosion hazard, few LFG management systems have been constructed in Southern Africa, and those that have make use of CDM[11]. Further, LFG management in South Africa is currently limited to passive venting of gas[12]. Passive venting involves construction of impervious migration barriers adjacent to the landfill and passive venting from boreholes and perforated pipes within the landfill – the result is GHG emissions. Therefore, prevailing practice in South Africa is to *either* vent LFG to ensure that the concentration of methane in any particular area of the landfill remains below hazardous levels, or to *not* install any kind of management and capturing system.

To date there has been limited development of LFG projects in the Host Country, where only a few landfills have been designed to partially collect and flare/utilise the generated LFG, these having been developed under the CDM (See table B.5.4).

The Project Developer independently (and at substantial cost), commissioned an independent consultant to undertake a study regarding LFG common practice in the Host Country. As per the Executive

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[11] Department of Water Affairs and Forestry, 1998: Minimum requirements for waste disposal by landfill, chapter 8.4.6 Gas Management Systems, page 8-11 Available at: http://www.dwaf.gov.za/Dir_WQM/docs/Pol_Landfill.PDF

[12] Department of Water Affairs and Forestry, 2005: Minimum requirements for waste disposal by landfill, draft 3rd edition, Chapter 8.4.6 Gas management systems, page 99 Available at:
http://www.dwaf.gov.za/Documents/Other/WQM/RequirementsWasteDisposalLandfillSep05Part4.pdf

Summary of the document, "[o]f the seven sites that responded, four of the sites have already implemented LFG extraction and electricity generation technology and are registered as CDM projects under the Kyoto Protocol", and as per Section 5 of the document, at the remaining 3 sites, LFG is either unmanaged or passive LFG venting is employed[13].

[13] "Landfill Gas Common Management Practice in South Africa" report prepared for EcoSecurities by SRK Consulting Engineers and Scientists. Report #: 406518, March 2010.

Table B.5.4: Activities similar to Proposed Project Activity:

Name	Status[14]
New England Landfill Gas to Energy Project	Finalised Validation as a CDM Project
Durban Landfill Gas to Energy Project – Marianhill and La Mercy Landfills	Registered as a CDM project on 15/12/2006
Enviroserv Chloorkop Landfill Gas Recovery Project	Registered as a CDM project on 27/04/2007
Durban Landfill-Gas Bisasar Road	Registered as a CDM project on 26/03/2009
Alton Landfill Gas to Energy Project	Registered as a CDM project on 24/08/2009
Ekurhuleni Landfill Gas Recovery Project – South Africa	Under Validation as a CDM Project

All projects similar to the proposed project activity are developed under the CDM, and are therefore excluded from the discussion on prevailing practice.

Thus, with the exception of a few landfills developing a CDM project, the other landfills do not have LFG collection and flaring systems. The reason for the lack of widespread LFG collection and combustion systems is that there currently is no law mandating the capture and destruction (or use) of LFG, and there is no economic incentive for capturing and utilising the LFG[15]. In summary, the passive venting method *remains* the prevailing practice in landfills throughout the Host Country.

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

Since the only landfills which have active LFG capture and flaring are CDM projects (or in the process of applying for CDM), the project does not have any options which do not consider CDM.

Additional step: CDM consideration

Project timeline and consideration

CDM was considered early on in the process. In fact upon the decision of the Project Developer to prepare a proposal (dated 23/04/2007), in response to a tender from the Municipality of Johannesburg. The Project Developer was awarded the project, and an agreement was signed with the Municipality on 27/05/2009. On 29/05/2009, a purchase order was made for the generators with a value of ZAR 137,130,053. This is the "point of no return" and therefore the "project start date".

A notification of CDM consideration was sent to and received by the UNFCCC *before* 27/11/2009, which is within 6 months after the signing date of the Agreement with the Municipality.

[14] http://cdm.unfccc.int/Projects/projsearch.html

[15] In South Africa currently the revenue from LFG electricity generation is not adequate to pay for all the capital investment and running costs. Landfill Gas use in South Africa - http://www.resource-india.net/html/landfill_gas_utlisation_in_sou.php

Table B.5.6: Major Milestones achieved throughout CDM Project

Milestone	Date achieved	Comments
Tender Notice published by City of Johannesburg Metropolitan Municipality to develop five sites under the CDM.	23/04/2007	The tender notice clearly mentions that the Johannesburg municipality, owner of the sites, is interested in developing the project under CDM.
ERPA signed between the project developer and EcoSecurities	10/07/2008	The signing of ERPA before the start date of the project activity further substantiates the seriousness of CDM consideration by the Project Developer.
Final Lease & Gas Rights Agreement Signed by the Project Developer and the Municipality of Johannesburg to develop the proposed project under CDM	27/05/2009	The Agreement mentions that PD will enter into ERPA for the sale and purchase of CERs related to the project with EcoSecurities.
Purchase order for Generators	29/05/2009	**Start date CDM Project**
Submittal EIA and EMP reports	09/2009	The EIA also included a stakeholder consultation in line with CDM requirements.
Notification of CDM consideration sent to UNFCCC and DNA	20/11/2009	Within 6 months after signing Agreement with the Municipality.
Validation Work Order Signed	11/08/2010	
Signing Power Purchase Agreements (PPAs) with Eskom	Expected Q2 2011	
Start Date of Construction	10/2010	
Expected Operation Start Date	Expected Q3 2011	

As can be seen from the timeline, at the point of submitting the PDD for validation the Project Developer has not agreed on a final PPA and has therefore not agreed on a tariff for the electricity to be produced as a result of utilisation of LFG at the sites. Besides this, the tariff known at the point in time when the investment was made (purchase order for generators dated 29/05/2009, i.e. the start date of the project, has been set for the definition of baseline and for the financial additionality test.

Start date of the project

The primary milestones achieved for the CDM project are presented in Table B.5.6 (above). The start date is in line with EB clarification from EB 41, paragraph 67, and refers to the definition of start date as per the Glossary of CDM terms, Version 04. The start date shall be considered to be the date on which the project participant has committed to expenditures related to the implementation or related to the construction of the project activity. This, for example, can be the date on which contracts have been signed for equipment or construction/operation services required for the project activity. Minor pre-project expenses such as the contracting of services/payment of fees for feasibility studies or preliminary surveys, should not be considered in the determination of the start date as they do not necessarily indicate the commencement of implementation of the project.

The project construction commenced in 10/2010, and the purchase order for generators has already been made. Thus the start date for the project activity is the date on which the purchase order was made, since this represents the point where the project developer committed to major expenditures related to the implementation of the project and is the earlier of construction/implementation for the project activity.

B.6 Emission Reductions

B.6.1. Explanation of methodological choices:

Baseline emissions

$BE_y = (MD_{project,y} – MD_{BL,y}) * GWP_{CH4} + (EL_{LFG,y} \cdot CEF_{elec,BL,y}) + (ET_{LFG,y} * CEF_{ther,BL,y})$ (1)

As the proposed project activity does *not include* a thermal energy component, all following equations[16] exclude this component (for simplification). Since the project *may* include an electricity generation component, all equations include this component.

$BE_y = (MD_{project,y} – MD_{BL,y}) * (GWP_{CH4} + EL_{LFG,y} . CEF_{elec,BL,y})$ (1*)

where:

BE_y	Baseline emissions in year *y* [tCO_2e];
$MD_{project,y}$	Amount of methane that would have been destroyed/combusted during year *y*, in the project scenario [tCH_4];
$MD_{BL,y}$	Amount of methane that would have been destroyed/combusted during year *y* in the absence of the project due to regulatory and/or contractual requirements [tCH_4];
GWP_{CH4}	Global Warming Potential value for methane [tCO_2 e/tCH_4][17];
$EL_{LFG,y}$	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year *y* [MWh];
$CEF_{elecy,BL,y}$	CO_2 emissions intensity of the baseline source of electricity displaced [tCO_2e/MWh].

[16] All equations which are modified and/or simplified are marked with an (*). Unless specified, *all* equations are from ACM0001.

[17] This is 21tCO_2e/tCH_4 for the first commitment period.

There is no regulation/contract for destruction of methane from the landfill in the baseline, and hence $MD_{BL,y}$ (the amount of methane that would have been destroyed/combusted during year *y*, in the absence of the project due to regulatory and/or contractual requirement) is zero.

A. Methane destroyed by the project activity ($MD_{project,y}$) – procedure to be used during project activity:

Sum of the quantities fed to the flare(s) and the power plant(s):

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} \qquad (8^*)$$

where:

$MD_{project,y}$	Quantity of methane that would have been destroyed/combusted during year *y*, in the project scenario [tCH_4];
$MD_{flared,y}$	Quantity of methane destroyed by flaring during year *y* [tCH_4];
$MD_{electricity,y}$	Quantity of methane destroyed by generation of electricity during year *y* [tCH_4].

If several flares or several electricity generators are used in the project, $MD_{flared,y}$ and, respectively, $MD_{electricity,y}$ will be the sum of the quantities destroyed in all the flares (respectively, in all the electricity generators).

The quantity of methane destroyed by flaring is calculated using the following equation:

$$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) – (PE_{flare,y} / GWP_{CH4}) \qquad (9)$$

where:

$MD_{flared,y}$	Quantity of methane destroyed by flaring during year *y* [tCH_4];
$LFG_{flare,y}$	Quantity of landfill gas fed to the flare(s) during the year *y* [Nm^3LFG];
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured[18] during a year *y* [Nm^3CH_4/Nm^3LFG];
D_{CH4}	Methane density[19] [tCH_4/Nm^3CH_4];
$PE_{flare,y}$	Project emissions from flaring of the residual gas stream in year *y* determined following the procedure described in the *"Tool to determine project emissions from flaring gases containing methane"* [tCO_2e];
GWP_{CH4}	Global Warming Potential of methane [tCO_2e/tCH_4].

Once the Project includes electricity generation from the captured LFG, the quantity of methane destroyed through combustion in the electricity generation engines will be calculated using the following equation:

[18] Methane fraction of LFG to be measured on wet basis.

[19] At standard temperature and pressure (0° C and 1,013 bar) the density of methane is 0.0007168 $tCH_4/m^3 CH_4$.

$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4}$ (10)

where:

$MD_{electricity,y}$	Quantity of methane destroyed by generation of electricity during year *y* [tCH_4];
$LFG_{electricity,y}$	Quantity of landfill gas fed into the electricity generator during year *y* [Nm^3LFG];
$w_{CH4,y}$	Average methane fraction of the landfill gas as measured during year *y* [Nm^3CH_4/Nm^3LFG];
D_{CH4}	Methane density [tCH_4/Nm^3LFG].

B. Methane destroyed by the project activity ($MD_{project,y}$) – procedure to be used for *ex-ante* estimate:

The amount of methane that will be destroyed/combusted during year *y* (i.e. $MD_{project,y}$) is estimated *ex-ante* using the following equation:

$MD_{project,y} = BE_{CH4,SWDS,y}/GWP_{CH4} * \varepsilon_{degassing\ system}$[20] (13)

$BE_{CH4,SWDS,y}$ is the methane generation from the landfill in the absence of the project activity in year *y* [tCO_2e], calculated as per the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*.

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

where:

Parameter	Unit	Default	Description
$BE_{CH4,SWDS,y}$	tCO_2e		Methane emissions avoided during year *y* from preventing waste disposal at the solid waste disposal site (hereafter "SWDS") during the period from the start of the project activity to the end of year *y*.
Φ	-	0.9	Model correction factor to account for model uncertainties.
f	-	0[21]	Fraction of methane captured at the SWDS and flared, combusted, or used in another manner; to meet the relevant regulations or contractual requirements.

[20] This factor has been added to the equation in order to reflect the guidance provided in ACM0001: "The efficiency of the degassing system which will be installed in the project activity should be taken into account while estimating the ex-ante estimation".

[21] Refer to ACM0001, Version 11.

GWP_{CH4}	$tCO_2e/t\ CH_4$	21 for 1st period	Global Warming Potential of methane, valid for the relevant commitment period;
OX	-	0.1	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste);
F	Volume fraction	0.5	Fraction of methane in the SWDS gas;
DOC_f	-	0.5	Fraction of degradable organic carbon that can decompose;
MCF	-	1.0	Methane correction factor;
$W_{j,x}$	Tons		Amount of organic waste type *j* prevented from disposal in the SWDS in year *x*;
DOC_j	weight fraction	See B.6.2	Fraction of degradable organic carbon (by weight) in waste type *j*;
k_j	-	See B.6.2	Decay rate for waste type *j*;
J	-	-	Waste type category (index);
X	-	-	Year during the crediting period : *x* runs from the year when the landfill started receiving wastes (*x*=1) to the year for which emissions are calculated (*x*=*y*);
Y	-	-	Year for which methane generation potential is calculated.

The default values above were taken from the ***"****Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*. Where the tool provides different values to choose from, the following choices were made:

- f: 0 according to guidance in equation 13 of ACM0001;
- OX: 0.1 because the landfill is covered with a mix of soil and sand;
- MCF: 1.0 because the landfills are considered as anaerobic managed solid waste disposal sites with controlled placement of waste, cover material, and levelling of the waste.
- DOC_j: Values are chosen assuming that the waste is wet (no drying process before being landfilled). Please find values for different waste types listed in Section B.6.2.
- k_j: Values are chosen considering that the climate is boreal and temperate (Mean Annual Temperature < 20ºC) and dry (Mean Annual Precipitation < 1,000mm), which is the case in Johannesburg[22].

Once $BE_{CH4,SWDS,y}$ is calculated according to the Tool, a collection efficiency is applied to this value in order to reflect the fact that not all methane generated is actually captured by the collection system.
The collection efficiency value should consider the physical conditions of the landfill (properly managed with lining) as well as the capping material (mix of clay and sand) used to cover the waste, however these parameters are *already* addressed by the formula used to calculate $BE_{CH4,SWDS,y}$. Therefore 50% collection efficiency is reasonable, as it reflects *only* the efficiency of the system itself (pipes, blower etc.). However, this is only for the purpose of *ex-ante* calculation of baseline emissions. The actual baseline emissions would be based on monitored quantity of LFG avoided from release into atmosphere.

[22] See Climate Data for Johannesburg from the South African Weather Service.

C. Amount of methane that would have been destroyed/combusted in the absence of the Project due to regulatory and/or contractual requirements ($MD_{BL,y}$)

The amount of methane that would have been destroyed/combusted in the absence of the project activity due to regulatory and/or contractual requirements is zero. This value is based on the fact that the regulatory requirements as specified in the Landfill Permit for the sites do not indicate any specific amount of gas collection and destruction or utilisation. The landfill operator is also not collecting the gas generated in the landfill in the baseline scenario, so $MD_{BL,y}$ is zero.

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

As the baseline is electricity generated by plants connected to the grid, the emission factor $CEF_{elec,BL,y,}$ for the relevant grid is calculated according to the requirements of the *"Tool to calculate the emission factor for an electricity system"*. The calculation method, steps, and results are below:

- STEP 1: ***Identify the relevant electricity system.***

The landfill sites where the project activity takes place are connected to the National Grid of South Africa, therefore, the National Grid of South Africa is the relevant electricity system for the Project activity.

- STEP 2: ***Choose whether to include off-grid power plants in the project electricity system (optional).***

  This step is optional, and has not been undertaken for the Project.

- STEP 3: ***Select an operating margin method (OM).***

Calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch data analysis OM, or
(d) Average OM.

As per the aforementioned tool, the grid data for South Africa indicates that low cost must run resources constitute *less* than 50% of total grid generation. Thus the **Simple OM** method will be used *ex-ante* to calculate the $EF_{grid,OM,y}$.

- STEP 4: ***Calculate the operating margin emission factor according to the selected method***

In accordance with the tool, there is data on fuel consumption and net electricity generation for each power plant, and thus Option A (and the following equation) may be used:

$$EF_{grid,OMsimple,y} = \frac{\sum_{m} EG_{m,y} \cdot EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \qquad (1)$$

where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year *y* [tCO_2/MWh]
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power plant / unit *m* in year *y* [MWh]
$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year *y* [tCO_2/MWh]
m	All power units serving the grid in year *y* except low cost/must run power units
y	The relevant year as per the data vintage chosen in Step 3.

The emission factor of each power unit m is determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}} \qquad (2)$$

where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year *y* [tCO_2/MWh]
$FC_{i,m,y}$	Amount of fossil fuel type *i* consumed by power plant/unit *m* in year *y* [mass or volume unit]
$NCV_{i,y}$	Net calorific value (energy content) of fossil fuel type *i* in year *y* [GJ/mass or volume unit]
$EF_{CO2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year *y* [tCO_2/GJ]
$EG_{m,y}$	Net electricity generated and delivered to the grid by power plant/unit *m* in year *y* [MWh]
m	All power plants / units serving the grid in year *y* except low cost/must run power plants/units
i	All fossil fuel types combusted in power plant/unit *m* in year *y*
y	The relevant year as per the data vintage chosen in Step 3.

- STEP 5: ***Identify the cohort of power units to be included in the build margin***

In terms of data vintage, the build margin will be calculated *ex-ante* i.e. using Option 1 of step 5.

The sample group of power units, *m*, used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently (SET5-units) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) (SET ≥ 20%) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$ in MWh);

(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

$SET_{5\text{-units}}$ comprises the larger annual generation compared to $SET_{\geq 20\%}$, as the last 5 power plants built (see Annex 3) constitute 31% of the system generation.

The build margin emission factor is the generation-weighted average emission factor (in tCO_2/MWh) of all power units (m) during the most recent year y for which power generation data is available, and is calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \quad (13)$$

where:

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

- STEP 6: ***calculate the combined margin emission factor***

The combined margin emission factor is calculated as follows:

$EF_{grid,CM,y} = (EF_{grid,OM,y} * W_{OM}) + (EF_{grid,BM,y} * W_{BM})$ (14)

where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year *y* [tCO_2/MWh]
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year *y* [tCO_2/MWh]
W_{OM}	Weighting of operating margin emission factor [%]
W_{BM}	Weighting of build margin emission factor [%]

In accordance with the tool W_{OM} = 0.5 and W_{BM} = 0.5 respectively.

Project emissions:

Project emissions are calculated as follows:

$PE_y = PE_{EC,y} + PE_{FC,j,y}$ (16)

where:

PE_y	Project emissions in year *y* [tCO_2/yr];
$PE_{EC,y}$	Emissions from consumption of electricity in the project case. Project emissions from electricity consumption $PE_{EC,y}$ will be calculated following the latest version of *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* [tCO_2/yr];
$PE_{FCj,y}$	The CO_2 emissions from fossil fuel combustion in the event of grid failure during year *y*. Project emissions from fossil fuel consumption $PE_{FC,y}$ will be calculated following the latest version of *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"* defined in Section B.2 [tCO_2/yr].

In addition to these two sources of project emissions, there are emissions due to flaring, which are accounted for separately in equation 9 of ACM0001. The procedures to calculate those 3 sources of project emissions are described below.

<u>Project emissions from flaring</u>

Project emissions from flaring will be calculated and monitored according to the procedures described in the "*Tool to determine project emissions from flaring gases containing methane*". As the Project uses enclosed flares, two options are available to determine flare efficiency. Option a) will be chosen, i.e. to use a 90% default value.

Project emissions from flaring gases are calculated as follows:

$$PE_{flare,y} = \sum_{i=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH4}}{1000} \quad (15)$$

where:

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

As the project uses the default efficiency value for enclosed flares, the flare efficiency in hour *h* ($\eta_{flare,h}$) is:

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

The mass flow rate of methane in the residual gas is calculated as follows:

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n} \qquad (13)$$

where:

$TM_{RG,h}$	Mass flow rate of methane in the residual gas in hour *h* [kg/h];
$FV_{RG,h}$	Volumetric flow rate of the residual gas at normal conditions in hour *h* [Nm^3/h];
$fv_{CH4,RG,h}$	Volumetric fraction of methane in the residual gas in hour *h*;
$\rho_{CH4,n}$	Density of methane at normal conditions (i.e. 0.7168 kg/Nm^3).

Project emissions from electricity consumption:

Project emissions from electricity consumption will be calculated and monitored according to the procedures described in the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.

Scenario A: Electricity consumption from the grid is applicable to the project activity, using the following formula:

$$PE_{EC,y} = \sum EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y}) \qquad (1)$$

where:

$PE_{EC,y}$	Project emissions from electricity consumption by the project activity in year *y* [tCO_2/yr];
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electricity consumption source j in year *y* [MWh];
$EF_{EL,j,y}$	Emission factor for electricity generation for source *j* in year *y* [tCO_2/MWh];
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source j in year y.

According to the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*, Option A1 is selected to calculate the combined margin emission factor for the South African electricity system. According to the *"Tool to calculate the emission factor for an electricity system"* ($EF_{EL,j,y} = EF_{grid,CM,y}$) and will be fixed *ex-ante* (see paragraph D of baseline emission section above). $TDL_{j,y}$ will be taken from the South African national electricity utility, Eskom, at 8%[23].

In stage I, the auxiliary equipment will be supplied with electricity from the national grid. Project emissions due to grid electricity consumption will be measured by monitoring the electricity imported from the grid. In stage II, auxiliary consumption will be met by the renewable electricity generated by the Project activity. Surplus electricity, if any, will be exported to the grid. The baseline emissions, due to generation of renewable electricity in stage II, will be based on net electricity exported to the grid. In

[23] Eskom 2008 Annual Report, available from: http://financialresults.co.za/eskom_ar2008/ar_2008/con_directors_report_02.htm

stage II, if any electricity is imported from the grid to meet auxiliary requirements, it would be monitored to calculate Project emissions due to grid electricity consumption.

Project emissions from fossil fuel consumption:

The Project may use a fossil fuel generator on-site to generate electricity in case there is a failure of grid electricity (though this is *highly* unlikely). If this occurs, emissions from fossil fuel combustion ($PE_{FC,j,y}$) will be calculated as per Option B3 of the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.

As per option B3 of the aforementioned tool, the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"* shall be followed to determine the Project or leakage emissions, as per the following equation:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \qquad (1)$$

where:

$PE_{FC,j,y}$	CO_2 emissions from fossil fuel combustion in process *j* during year *y* [tCO_2/yr];
$FC_{i,j,y}$	Quantity of fuel type *i* combusted in process *j* during year *y* [Mass or volume unit/yr];
$COEF_{i,y}$	CO_2 emission coefficient of fuel type *i* in year *y* [tCO_2/mass or volume unit];

The CO_2 emission factor of the fuel type used is calculated using Option B according to the '*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion' as per the following equation:*

$$\mathbf{COEF_{i,y} = NCV_{i,y} * EFCO_{2,i,y}} \qquad (4)$$

where:

$COEF_{i,y}$	CO_2 emission coefficient of fuel type *i* in year *y* [tCO_2/mass or volume unit];
$NCV_{j,y}$	Weighted average net calorific value of the fuel type *i* year *y* [GJ/mass or volume unit];
$EF_{,j,y}$	Weighted average CO_2 emission factor of fuel type *i* in year *y* [tCO_2/GJ];
I	Fuel types combusted in process *j* during year *y*

Leakage emissions:

No leakage effects need to be accounted for under this methodology.

Emission reductions:

The relevant equation of ACM0001 is below and exploded to differentiate between the various sources of Project emissions. Project emissions from flaring are *already* included in the calculation of $MD_{flare,y}$ (equation (9)), and therefore also in $MD_{project}$ and BE_y. Hence, they do not have to be deducted once more in the overall emission reduction calculation in equation (17*).

$$ER_y = BE_y - PE_y = BE_y - PE_{EC,y} - PE_{FC,jy} \qquad (17^*)$$

where:

ER_y	Emission reductions in year *y* [tCO_2e/yr];
BE_y	Baseline emissions in year *y* [tCO_2e/yr];
PE_y	Project emissions in year *y* [tCO_2e/yr];
$PE_{EC,y}$	Project emissions from electricity consumption in year *y* [tCO_2e/yr]; and
$PE_{FC,jy}$	CO_2 emissions from fossil fuel combustion in process *j* during year *y* [tCO_2/yr]

All *ex-ante* calculations to obtain the emission reduction from the Project activity are listed in Section B.6.3.

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

The table for parameter $CEF_{elec,BL,y}$ has been included in the list of "Data and parameters that are available at validation" while ACM0001 lists it in "Data and parameters monitored". This reason for this is that the option of *ex-ante* determination in accordance with the "Tool to calculate the emission factor for an electricity system" has been chosen.

The following parameters included in ACM0001 as "Data and parameters not monitored" are not applicable:

- MD_{Hist} since $MD_{bl,y} = 0$
- MG_{Hist} since $MD_{bl,y} = 0$

Tables for the following parameters have been included in "Data and parameters that are available at validation", while the 'Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" lists them as "Data and parameters monitored":

- "f (fraction of methane captured at SWDS and flared, combusted or used in another manner)" as ACM0001 assigns it a value of 0;
- GWP_{CH4} as ACM0001 defines it as a parameter that is not monitored; and
- W_x because it is determined only once *ex-ante* for the purpose of estimating emission reductions.

<u>Parameters available at validation stage as per ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities".</u>

Data / Parameter:	**Regulatory requirements relating to landfill gas projects**
Data unit:	-
Description:	Regulatory requirements relating to landfill gas projects
Source of data used:	Draft 'Minimum Requirements for Waste Disposal by Landfill', Department of Water Affairs & Forestry, 2005, and Landfill Permits for all Landfill Sites.
Value applied:	0 for the first crediting period
Justification of the choice of data or description of measurement methods and procedures actually applied:	Reflected in $MD_{Bl,y}$. The draft 'Minimum Requirements for Waste Disposal by Landfill', published in 2005 constitutes the most *recent legislation* on landfill site management in South Africa. It does not specify that it is a mandatory requirement to actively capture, flare, or destroy LFG at *every* landfill in South Africa. It provides guidelines to ensure safety by limiting LFG accumulation via passive ventilation. The Landfill Permits for the sites, which specify specific regulatory requirements for the sites, do not mandate that any LFG must be captured or flared. The information will be monitored annually, however it will only be used for changes to $MD_{BL,y}$ at the renewal of the crediting period. At the time of renewal of the crediting period, emission reductions shall be calculated accordingly in the event new regulations are formulated requiring mandatory capture, flaring, or destruction of LFG.
Any comment:	Further information in Section B.6.3.

Data / Parameter:	**GWP_{CH4}**
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of methane
Source of data used:	IPCC
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied:	21 for the first commitment period. Shall be updated according to any future COP/MOP decisions.
Any comment:	This parameter is also referred to in the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"

Data / Parameter:	**D_{CH4}**
Data unit:	tCH_4/m^3CH_4
Description:	Methane Density
Source of data used:	ACM0001, Version 11
Value applied:	0.0007168
Justification of the choice of data or description of measurement methods and procedures actually applied:	At standard temperature and pressure (0° C and 1,013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.
Any comment:	

Data / Parameter:	$BE_{CH4,SWDS,y}$
Data unit:	tCO_2e
Description:	Methane generation from the landfill in the absence of the project activity at year *y*
Source of data used :	Calculated as per the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*.
Value applied:	*ex-ante* estimate: 530,083 tCO_2e (annual average over 1st crediting period)
Justification of the choice of data or description of measurement methods and procedures actually applied:	As per the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site*". Please see below for tables describing the parameters used in this tool.
Any comment:	Used for *ex-ante* estimation of the amount of methane that would have been destroyed/combusted during the year.

Data / Parameter:	$CEF_{elec,BL,y}$
Data unit:	tCO_2/MWh
Description:	Carbon dioxide emission factor of grid electricity
Source of data used:	*"Tool to calculate emission factor for an electricity system"*
Value applied:	0.93
Justification of the choice of data or description of measurement methods and procedures actually applied:	This factor is calculated as per the "*Tool to calculate the emission factor for an electricity system*". The parameter will not be monitored annually as the *ex-ante* option is employed to calculate the simple OM as permitted by the *"Tool to calculate project emissions for an electricity system".* Please refer to Annex 3 for detailed calculations of this factor, including all assumptions used.
Any comment:	Note that $\mathbf{CEF_{elec,BL,y}} = EF_{EL,j,y}$ from *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" and* $EF_{grid,CM,y}$ from the *"Tool to calculate the emission factor for an electricity system"*

The following parameters are taken from the *"Tool to calculate the emission factor for an electricity system"*, and are used to calculate $CEF_{elec,BL,y}$:

Data / Parameter:	$FC_{i,m,y}$
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type *i* consumed by the group of power units *m* in year *y* (mass or volume unit)
Source of data used:	Eskom (South African electricity supply company) NERSA (National Electricity Regulator South Africa), latest Electricity Supply Statistics
Value applied:	See Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Once for each crediting period (*ex-ante* option). Most up-to-date and publicly available data on fossil fuel consumption by power plants in South Africa.

Any comment:	

Data / Parameter:	***$NCV_{i,y}$***
Data unit:	GJ/mass or volume unit
Description:	Net calorific value (energy content) of fossil fuel type *i* in year *y*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	See Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default values. Once for each crediting period (*ex-ante* option)
Any comment:	

Data / Parameter:	***$EF_{CO2,i,y}$***
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor of fossil fuel type *i* in year *y*
Source of data used:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value applied:	See Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default values. Once for each crediting period (*ex-ante* option)
Any comment:	

Data / Parameter:	***$EG_{m,y}$***
Data unit:	MWh
Description:	Net electricity generated and delivered to the grid by power plant / unit *m* in year *y*
Source of data used:	Eskom (South African electricity supply company) NERSA (National Electricity Regulator South Africa), latest Electricity Supply Statistics
Value applied:	See Annex 3
Justification of the choice of data or description of measurement methods and procedures actually applied :	Most recent publicly available data on electricity supply statistics sourced from South African electricity utility (Eskom) and National Energy Regulator (NERSA). Once for each crediting period (*ex-ante* option)
Any comment:	

The following parameters are taken from the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*, and are used to calculate $MG_{PR,y}$ (also designated by the symbol $BE_{CH4,SWDS,y}$).

Data / Parameter:	**Φ**
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	As defined in the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05.1.0, adopted at EB 61.
Any comment:	

Data / Parameter:	**OX**
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)
Source of data used:	"*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05.1.0, adopted at EB 61.
Value applied:	0.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	As defined in the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05.1.0, adopted at EB 61.
Any comment:	

Data / Parameter:	**F**
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value from the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05.1.0, adopted at EB 61.
Any comment:	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC.

Data / Parameter:	**DOC_f**

Data unit:	-
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as defined in the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"* Version 05.1.0, adopted at EB 61.
Any comment:	

Data / Parameter:	**MCF**
Data unit:	-
Description:	Methane Correction Factor
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	1.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	1.0 for **anaerobic managed solid waste disposal sites**. Default value as defined in the "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*, Version 05.1.0, adopted at EB 61 (for a site with controlled placement of waste, cover material, and levelling of the waste) was used.
Any comment:	The methane correction factor (MCF) accounts for the fact that unmanaged SWDSs produce less methane from a given amount of waste than managed SWDSs, since a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDSs.

Data / Parameter:	**DOC*j***
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*.
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value applied:	The following values for the different waste types *j* are applied: (see table below)
Justification of the choice of data or description of measurement methods and procedures actually applied:	In accordance with the *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"*, Version 05.1.0, adopted at EB 61.
Any comments	The values applied are for wet waste.

Waste type *j*	**DOC_j (% wet waste)**
Wood and wood products	43
Pulp, paper and cardboard (other than sludge)	40
Food, food waste, beverages and tobacco (other than sludge)	15
Textiles	24
Garden, yard and park waste	20
Glass, plastic, metal, other inert waste	0

<table>
<tr><td>Data / Parameter:</td><td>k_j</td></tr>
<tr><td>Data unit:</td><td>-</td></tr>
<tr><td>Description:</td><td>Decay rate for the waste type j</td></tr>
<tr><td>Source of data used:</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3).</td></tr>
<tr><td>Value applied:</td><td>
<table>
<tr><th colspan="2" rowspan="2">Waste type j</th><th colspan="2">Boreal and Temperate (MAT≤20°C)</th><th colspan="2">Tropical (MAT>20°C)</th></tr>
<tr><th>Dry (MAP/PET <1)</th><th>Wet (MAP/PET >1)</th><th>Dry (MAP< 1000mm)</th><th>Wet (MAP> 1000mm)</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td><td>0.06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.10</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, sewage sludge, beverages and tobacco</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>As per the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”.</td></tr>
<tr><td>Any comment:</td><td>The values applied are for Boreal & temperate (MAT < 20°C) and dry (MAP < 1,000mm) conditions. Proof of the climate data for Johannesburg from the South African Weather Service will be provided to the DOE upon request.</td></tr>
</table>

Data / Parameter:	**f**
Data unit:	-
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Source of data used:	ACM0001
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied:	ACM0001 specifies that ‘f’ shall be assigned a value of 0

Any comment:	

Data / Parameter:	$\mathbf{W_x}$
Data unit:	Tons
Description:	Total amount of organic waste in year x (tons)
Source of data used:	Landfill Operator
Value applied:	Please refer to calculation spreadsheet
Justification of the choice of data or description of measurement methods and procedures actually applied:	Data is taken from historical records of landfill operation and aggregated annually.
Any comments	This is determined once *ex-ante* for the purpose of estimating emission reductions.

The following parameter is taken from the *"Tool to determine project emissions from flaring gases containing methane":*

Data / Parameter:	$\boldsymbol{\eta_{flare,h}}$
Data unit:	-
Description:	Flare efficiency in the hour *h*
Source of data used:	*"Tool to determine project emissions from flaring gases containing methane".*
Value applied:	90% / 50% / 0%
Justification of the choice of data or description of measurement methods and procedures actually applied:	Default value for enclosed flares as per *"Tool to determine project emissions from flaring gases containing methane".*
Any comment:	This is used for the purposes of estimating *ex-ante* emission reductions

The following parameters are taken from the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion":*

Data / Parameter:	$\mathbf{COEF_{i,j}}$
Data unit:	tCO_2/mass or volume unit
Description:	CO_2 emission coefficient of fuel type *i* in year *y*
Source of data to be Used:	Calculated using Option B in the *"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".*
Value applied:	3.24
Justification of the choice of data or description of measurement methods and procedures actually	This is calculated using the following equation: $COEF_{i,j} = NCV_{i,y} \times EFCO_{2i,y}$[24]

[24] See tables below for $NCV_{i,y}$ and $EFCO_{2,i,y}$

applied:	
Any comment:	This parameter will *only* be used if and when there is fossil fuel consumption. Fossil fuel consumption will be monitored as stated in Section 7.1.

Data / Parameter:	**$NCV_{i,y}$**
Data unit:	GJ per mass or volume unit
Description:	Weighted average net calorific value of fuel type *i* in the year *y*
Source of data to be used:	IPCC default values as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.
Value applied:	0.0433 TJ/t
Justification of the choice of data or description of measurement methods and procedures actually applied:	Values are taken from IPCC (2006) for diesel[25]. Any future revision of IPCC guidelines will be taken into account at the renewal of the crediting period.
Any comment:	This parameter will only be used if and when there is fossil fuel consumption. Fossil fuel consumption will be monitored as stated in Section 7.1.

Data / Parameter:	**$EFCO_{2,i,y}$**
Data unit:	tCO_2/GJ
Description:	Weighted average CO_2 emission factor of fuel type *i* in the year *y*
Source of data to be used:	IPCC default values as provided in Table 1.4 of Chapter 1 of Vol.2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.
Value applied:	74.8 tCO_2/TJ
Justification of the choice of data or description of measurement methods and procedures actually applied:	Values are taken from IPCC (2006) for diesel[26]. Any future revision of IPCC guidelines will be taken into account at the renewal of the crediting period.
Any comment:	This parameter will *only* be used if and when there is fossil fuel consumption. Fossil fuel consumption will be monitored as stated in Section 7.1.

Data / Parameter:	**$TDL_{j,y}$**
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.
Source of data to be used:	South African national electricity utility, Eskom Annual Report
Value of data applied for the purpose of	8.0%

[25] This is used for illustrative purposes for *ex-ante* estimations, as the fossil fuel used in the project activity may be subject to change. Thus the actual NCV of the fuel consumed shall be used for *ex-post* ER calculations.

[26] This is used for illustrative reasons for *ex-ante* estimations, as the fossil fuel used in the project activity may be subject to change. Thus the actual **$EFCO_{2,i,y}$** from the fuel consumed shall be used for *ex-post* ER calculations.

calculating expected emission reductions in section B.5:	
Description of measurement methods and procedures to be applied:	Eskom is South Africa's National Electricity utility which publishes in the Annual Report a percentage for line losses. The most recent figure will be sourced annually and used for TDL_y. However, if data is not available, or if this figure is older than 5 years, then the default value of 20% will be used, in accordance with the requirements of the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.
QA/QC Procedures to be applied:	Annual revision of publicly available information / check availability of updates on transmission losses in the relevant grid.
Any comment:	For *ex-ante* estimation purposes, Eskom Annual Report 2008, Directors' Report, p. 105 has been employed.

B.6.3 Ex-ante calculation of emission reductions:

Baseline emissions

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + (EL_{LFG,y} * CEF_{elec,BL,y}) \quad (1^*)$$

1. $MD_{project,y}$

a) Estimated amount of methane destroyed by the project activity - Sum of quantities fed to the flare(s) and power plant(s):

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} \quad (8^*)$$

Table 1[27]:

Year	MD flare [tCH_4]	MD electricity [tCH_4]	MD project [tCH_4]
2012	8,825	10,410	19,235
2013	3,951	16,747	20,697
2014	652	21,358	22,010
2015	369	22,644	23,014
2016	580	23,041	23,620
2017	1,328	22,810	24,138
2018	2,193	22,499	24,693
Total	**17,898**	**139,509**	**157,407**

Where the quantity of methane destroyed by flaring was calculated using the following equation:

$$MD_{flared,y} = (LFG_{flare,y} * w_{CH4,y} * D_{CH4}) – (PE_{flare,y} / GWP_{CH4}) \qquad (9)$$

Table 2:

Year	$LFG_{flare,y}$ [m^3]	$PE_{flare,y}$ [tCO_2e]	MD flare [tCH_4]
2012	27,360,091	20,592	8,825
2013	12,247,946	9,218	3,951
2014	2,019,970	1,520	652
2015	1,145,339	862	369
2016	1,797,558	1,353	580
2017	4,116,337	3,098	1,328
2018	6,799,910	5,118	2,193
Total	**55,487,152**	**41,762**	**17,898**
Default values: $w_{CH4,y}$ = 50%; D_{CH4} = 0.0007168; GWP_{CH4} = 21			

The quantity of methane destroyed through combustion in the electricity generation engines is estimated using the following equation:

$$MD_{electricity,y} = LFG_{electricity,y} * w_{CH4,y} * D_{CH4} \qquad (10)$$

27 The values for $MD_{flare,y}$ and $MD_{electricity}$ in Table 1 are derived from a retransformation from the FOD model (tCO_2e retransformed into LFG flow in Nm^3/hr) as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site".

Table 3:

Year	**$LFG_{elec,y}$ [m^3]**	**$MD_{electricity}$ [tCH_4]**
2012	29,045,016	10,410
2013	46,726,300	16,747
2014	59,592,848	21,358
2015	63,181,902	22,644
2016	64,287,479	23,041
2017	63,644,453	22,810
2018	62,776,689	22,499
Total	**389,254,687**	**139,509**
Default values: $w_{CH4,y}$ = 50%; D_{CH4} = 0.0007168		

b) *Ex-ante estimation of the amount of methane that would have been destroyed/combusted during the year* ($MD_{project,y}$)

$MD_{project,y} = BE_{CH4,SWDS,y}/GWP_{CH4}$ (13)

Table 4:

Year	**$BE_{CH4,SWDS,y}$ (tCH_4)**	**$MD_{project,y}$ (tCH_4)**
2012	424,527	20,216
2013	443,864	21,136
2014	463,723	22,082
2015	484,153	23,055
2016	497,382	23,685
2017	509,995	24,285
2018	523,661	24,936
Total	**3,347,305**	**159,395**
Default values: $w_{CH4,y}$ = 50%; D_{CH4} = 0.0007168; E_{DS}: Degassing efficiency :50% (The degassing efficiency is already applied to the $BE_{CH4,SWDS,y}$ values in this table)		

The comparison of $MD_{project,y}$ from Table 1 and Table 4 shows that $MD_{project,y}$ from Table 1 gives *lower* values, as it includes the project emissions from flaring. $MD_{project,y}$ values from Table 1 will be adopted for the *ex-ante* estimations.

The methane actually destroyed by the project activity is determined *ex-post* by monitoring the quantity of methane flared and/or used to generate electricity.

2. $MD_{BL,y}$

As explained in Section B.6.1, $MD_{BL,y}$ equals zero for the first commitment period.

Project emissions:

1. Project emissions from flaring

$$PE_{flare,y} = \sum_{i=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH4}}{1000}$$

with: $TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$

Table 5:

Year	$FV_{RG,h}$ [Nm^3/h]	$TM_{RG,h}$ [Kg/h]	$PE_{flare,y}$ [tCO_2e]
2012	3,420	1,226	20,592
2013	1,531	549	9,218
2014	252	90	1,520
2015	143	51	862
2016	225	81	1,353
2017	515	184	3,098
2018	850	305	5,118
Total	**6,936**	**2,486**	**41,762**
Default values: $fv_{CH4,RG,h}$ = 50%; $\rho_{CH4,n}$ = 0.7168; $\eta_{flare,h}$ = 90%; GWP_{CH4} = 21			

These Project emissions are *already* included in the calculation of $MD_{project.y}$ (equation (8*)), and therefore also in BE_y. Hence, they must be deducted again in the overall emission reduction calculation in equation (17*).

2. Project emissions from electricity consumption

$PE_y = PE_{EC,y}$ (16*)

$$PE_{EC,y} = \sum EC_{PJ,j,y} * EF_{EL,j,y} * (1 + TDL_{j,y}) \quad (1)$$

$PE_{EC,y} = EC_{PJ,y} * 0.93 * (1 + 0.08) = PE_y$[28]

Since the backup diesel generators will *only* be used in the event of a failure in the grid electricity (which is *highly* unlikely), project emissions associated with fossil fuel consumption will be set as zero *ex-ante*, and monitored during the crediting period.

[28] With default values as defined in the *"Tool to calculate the emission factor for an electricity system"*.

Table 6:

Year	**Electricity consumption $EC_{PJ,y}$ [MWh]**	**$PE_{EC,y}$ [tCO_2e]**
2012	4,820	4,841
2013	4,820	4,841
2014	4,820	4,841
2015	4,820	4,841
2016	4,820	4,841
2017	4,820	4,841
2018	4,820	4,841
Total	**33,740**	**33,888**

Emission reduction

The greenhouse gas emission reductions achieved by the Project activity during a given year *y* (ER_y) are calculated using a modified equation (based on the formula above).

$ER_y = BE_y – PE_{EC,y}$ (17*)

Table 7:

Year	**BE_y [tCO_2e]**	**$PE_{EC,y}$ [tCO_2e]**	**ER_y [tCO_2e]**
2012	443,020	4,841	438,179
2013	486,695	4,841	481,853
2014	529,591	4,841	524,749
2015	553,947	4,841	549,106
2016	567,154	4,841	562,312
2017	576,859	4,841	572,017
2018	587,204	4,841	582,363
Total	**3,744,469**	**33,888**	**3,710,580**

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

Table B.6.4.1: Total Emission Reductions over the first crediting period

Year	**Estimation of project activity emissions [tCO_2e]**	**Estimation of baseline emissions [tCO_2e]**	**Estimation of leakage [tCO_2e]**	**Estimation of overall emission reductions [tCO_2e]**
2012	4,841	443,020	0	438,179
2013	4,841	486,695	0	481,853

2014	4,841	529,591	0	524,749
2015	4,841	553,947	0	549,106
2016	4,841	567,154	0	562,312
2017	4,841	576,859	0	572,017
2018	4,841	587,204	0	582,363
Total [tCO2e]	**33,888**	**3,744,469**	**3,710,580**	**3,710,580**

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

B.7.1 Data and parameters monitored:

The tables for the following parameters listed in ACM0001 as “Data and Parameters monitored” are not applicable:

- $LFG_{thermal, y}$: No methane will be combusted in a boiler/air heater/heat generating equipment;
- $LFG_{PL, y}$: No LFG will be sent through gas pipelines,
- T: Flow meters will express LFG volumes in normalised cubic meters, therefore no separate monitoring of temperature is necessary;
- P: Flow meters will express LFG volumes in normalised cubic meters, therefore no separate monitoring of pressure is necessary;
- ET_{LFG}: No thermal energy will be generated using LFG;
- $EF_{fuel,BL}$: No fossil fuel was used in baseline captive power plant or thermal generation;
- $NCV_{fuel, BL}$: No fossil fuel was used in baseline for thermal energy generation and/or electricity generation;
- $\varepsilon_{gen, BL}$: No baseline captive power plant was used;
- $\varepsilon_{boiler/airheater}$: No baseline boiler/air heater was used for producing thermal energy;
- Operation of the boiler/air heater/heat generating equipment: No boiler/air heater/heat generating equipment will be used;
- $MG_{PR,y}$: has been included in the monitoring methodology in ACM0001 as it discounts the baseline emissions by the Adjustment Factor (AF) in "cases where a specific system for collection and destruction of methane is mandated by regulatory or contractual requirements or is undertaken for other reasons". However, in the Project, the above is not mandated by contracts/regulations or undertaken, and therefore MD_{BL} is not based on calculation of AF. Instead, MD_{BL} is equal to zero as the contract between the Municipality and the Project developer clearly mentions ensuring ventilation of the gas generated in the waste disposal area in order to prevent dangerous concentrations. Thus parameters relating to determination of AF (including $MG_{PR, y}$) do not form a part of the monitoring plan in the PDD.

The tables for the following parameters included in the ‘Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site’ as “Data and parameters monitored” are not applicable:

- z: ACM0001 p. 7 specifies that sampling to determine the different waste types is unnecessary; and
- $p_{n,j,x}$: ACM0001 p. 7 specifies that sampling to determine the different waste types is unnecessary.

Parameters from ACM0001 *"Consolidated baseline and monitoring methodology for landfill gas project activities"*

Data / Parameter:	**$LFG_{total,y}$**
Data unit:	Nm^3
Description:	Total amount of LFG captured at Normal Temperature and Pressure
Source of data to be used:	Project Developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	63,534,548 (annual average over the first crediting period)
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a thermal mass flow meter by the Project developer. The flow meter will be maintained and calibrated regularly in line with manufacturer's recommendations to ensure that the accuracy of the measurement instrument is maintained, and this can be assumed to be < 3%. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meter will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	The flow meter will express gas flow in normalised cubic meters, therefore no separate monitoring of pressure (P) and temperature (T) of LFG is necessary. Whenever, the Project does not generate electricity, $LFG_{total,y}$ will be identical to $LFG_{flare,y}$ since all captured LFG will be fed to the flare.

Data / Parameter:	**$LFG_{flare,y}$**
Data unit:	Nm^3
Description:	Amount of LFG flared at Normal Temperature and Pressure
Source of data to be used:	Project Developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	7,926,736 (annual average over the first crediting period)
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a thermal mass flow meter by the Project developer. The flow meter will be maintained and calibrated regularly in line with manufacturer's recommendations to ensure that the accuracy of the measurement instrument is maintained, and this can be assumed to be < 3%. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	The flow meter will express gas flow in normalised cubic meters, therefore no separate monitoring of pressure (P) and temperature (T) of LFG is necessary.

Data / Parameter:	**$LFG_{electricity,y}$**
Data unit:	Nm^3
Description:	Amount of LFG combusted in power plants at Normal Temperature and

	Pressure
Source of data to be used:	Project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	55,607,812 (annual average over the first crediting period)
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a thermal mass flow meter by the project developer. The flow meter will be maintained and calibrated regularly in line with manufacturer's recommendations to ensure that the accuracy of the measurement instrument is maintained, and which can be assumed to be < 3%. Data to be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters will be subject to a regular maintenance and testing regime to ensure accuracy.
Any comment:	The flow meter will express gas flow in normalised cubic meters, therefore no separate monitoring of pressure (P) and temperature (T) of LFG is necessary. This parameter shall *only* be measured if and when the project generates electricity.

Data / Parameter:	$PE_{flare,y}$
Data unit:	tCO_2e
Description:	Project emissions from flaring of the residual gas stream in year *y*
Source of data to be used:	Calculated as per the '*Tool to determine project emissions from flaring gases containing Methane*"
Value of data applied for the purpose of calculating expected emission reductions in section B.5	5,966 (annual average over the first crediting period)
Description of measurement methods and procedures to be applied:	Calculated as per the *"Tool to determine project emissions from flaring gases containing Methane."*
QA/QC procedures to be applied:	As per the *"Tool to determine project emissions from flaring gases containing Methane"*.
Any comment:	

Data / Parameter:	w_{CH4}
Data unit:	Nm^3CH_4 / Nm^3LFG
Description:	Methane fraction in the landfill gas
Source of data to be used:	Project developer

Value of data applied for the purpose of calculating expected emission reductions in section B.5	50%[29]
Description of measurement methods and procedures to be applied:	Methane content will be measured directly with a continuous gas analyser (i.e. at least hourly), by the Project Developer. Values to be averaged hourly or at a short time interval (with permissible accuracy of 2% at full scale).
QA/QC procedures to be applied:	The gas analysing unit(s) will be maintained and calibrated regularly in line with manufacturer's requirements in order to ensure accuracy.
Any comment:	

Data / Parameter:	**EL_{LFG}**
Data unit:	MWh
Description:	Net amount of electricity generated using LFG
Source of data to be used:	Project developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	54,740 (annual average over first crediting period)
Description of measurement methods and procedures to be applied:	Electricity will be monitored continuously using electricity meter(s) of Class 0.5.
QA/QC procedures to be applied:	Electricity meter(s) will be subject to regular maintenance and testing in accordance with stipulation of the meter supplier, to ensure accuracy.
Any comment:	Required to calculate the emission reductions from electricity generation from LFG. Will *only* be used if and when the project produces electricity.

[29] This value is illustrative and only used to calculate *ex-ante* estimations. The value applied to the Emission Reduction calculations will be monitored *ex-post*.

Data / Parameter:	**Operation of the energy plant**
Data unit:	Hours
Description:	Operation of the energy plant in a year *y*
Source of data to be used:	Project Developer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	7,800 (*ex-ante* estimate)
Description of measurement methods and procedures to be applied:	Data will be recorded annually by the Project developer to ensure methane destruction is claimed for methane used in electricity plant when it is operational.
QA/QC procedures to be applied:	
Any comment:	Data shall *only* be collected if and when the Project generates electricity.

Data / Parameter:	$\mathbf{PE_{EC,y}}$
Data unit:	tCO_2
Description:	Project emissions from electricity consumption by the project activity during the year *y*
Source of data to be used:	Calculated as per the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	40,343 (annual average over the first crediting period)
Description of measurement methods and procedures to be applied:	As per the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.
QA/QC procedures to be applied:	As per the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*.
Any comment:	

Data / Parameter:	$\mathbf{PE_{FC,j,y}}$
Data unit:	tCO_{2e}
Description:	Project emissions from fossil fuel combustion in fossil fuel based generators during the year *y*
Source of data to be used:	Calculated as per the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"*

Value of data applied for the purpose of calculating expected emission reductions in section B.5	0[30]
Description of measurement methods and procedures to be applied:	Calculated as per the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".*
QA/QC procedures to be applied:	
Any comment:	This parameter will *only* be used if and when there is fossil fuel consumption.

The following parameters are taken from the "*Tool to determine project emissions from flaring gases containing methane*".

Data / Parameter:	**T_{flare}**
Data unit:	˚C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Project developer
Value of data Applied for the purpose of calculating expected emission reductions in section B.5:	>500°C[31]
Description of measurement methods and procedures to be applied:	Continuous monitoring of the temperature in the exhaust gas with a type N thermocouple as described in the "*Tool to determine project emissions from flaring gases containing methane*". Accuracy of applied thermocouples: +/-0.75% (for 333°C to 1,200°C).
QA/QC procedures to be applied:	The thermocouple will be subject to exchange or calibration on an annual basis to ensure accuracy.
Any comment:	

Data / Parameter:	**Other flare operational parameters**
Data unit:	-
Description:	Includes all data and parameters that are required to monitor whether the flare operates within the range of operating conditions according to manufacturer's specifications. This may include but is *not* limited to Minimum Combustion Temperature, Maximum Combustion Temperature, and Minimum Methane content.

[30] For *ex-ante* estimation purposes only. Shall be calculated *ex-post* based on direct monitoring and default factors.

[31] This is an illustrative value used for the purposes of estimating emission reductions. Actual values used for the calculation of emission reductions will be monitored *ex-post*.

Source of data to be used:	Project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5:	-
Description of measurement methods and procedures to be applied:	Continuously monitored
QA/QC procedures to be applied:	
Any comment:	*Only* applicable in case of use of a default value.

The following parameters are taken from the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption" Version 01, adopted at EB 39,* and used to calculate $PE_{EC,y}$.

Data / Parameter:	$\mathbf{EC_{PJ,j,y}}$
Data unit:	MWh
Description:	Onsite consumption of electricity attributable to the project activity during the year *y*
Source of data to be used:	Project participant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4,820 (annual average, *ex-ante* estimate from Project Developer)
Description of measurement methods and procedures to be applied:	Electricity will be measured using electricity meters and data will be aggregated at least annually.
QA/QC procedures to be applied:	Electricity meters will be subject to regular maintenance and testing in accordance with stipulation of the meter supplier to ensure accuracy.
Any comment:	

The following parameters are taken from the "*Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"* and used to calculate $PE_{FC,j,y}$

Data / Parameter:	$\mathbf{FC_{i,j,y}}$
Data unit:	Tonnes
Description:	Amount of diesel combusted to meet power requirements of project
Source of data to be used:	Project developer

Value of data applied for the purpose of calculating expected emission reductions in section B.5:	0 (*ex-ante* estimate)
Description of measurement methods and procedures to be applied:	Diesel will be supplied from tanks and ruler gauges will be used to determine volume of diesel consumed. The ruler gauges will be part of the tank and calibrated at least once a year. The measurements will be recorded in a book (on a daily basis or per shift). The volume is obtained by multiplying the tank level by the tank cross-sectional area. The mass is calculated by multiplying the resulting volume by the density value of 0.84 Kg/l from Oak Ridge National Laboratory, (http://bioenergy.ornl.gov/papers/misc/energy_conv.html).
QA/QC procedures to be applied:	The metered fuel consumption quantities may be cross-checked against purchase invoices (if available).
Any comment:	

B.7.2 Description of the monitoring plan:

The Monitoring Plan for this project has been developed to ensure that from the start, the project is well organised in terms of the collection and archiving of complete and reliable data.

<u>Data collection and record keeping arrangements</u>
Monitoring data will be collected and recorded as detailed in Section B.7.1. All data required for verification and issuance will be backed-up and retained for at least two years following the end of the crediting period or the last issuance of CERs of the Project, whichever occurs later.

Data collected on-site will be compiled in an electronic format which will be sent to EcoSecurities on a regular basis.

<u>Data Quality Control and Quality Assurance</u>
All data collected on-site will be checked internally before being stored to assure it is complete and of an appropriate quality.

EcoSecurities will perform regular checks of the final data, and analyse project performance *prior* to any verification. Moreover, regular internal audits will be conducted to assure that the Project is in compliance with CDM requirements.

Procedures will be developed to deal with possible monitoring data adjustments and uncertainties as well as emergencies.

<u>Maintenance and Calibration of monitoring equipment</u>
The Project Developer is responsible for general maintenance of all equipment, which will be maintained and calibrated in line with manufacturers’ recommendations. This will assure that equipment operates at the accuracies stated by monitoring equipment provider(s).

All relevant monitoring equipment will be traceable with specific serial and/or tag numbers.

Staff training

Training is conducted on-site at regular intervals to ensure that staff are capable of performing their designated tasks at high standards. The parties will agree upon procedures and responsibilities for CDM-specific training to warrant that they understand the importance of complete and accurate data and records for CDM monitoring.

CDM monitoring organisation and management

Prior to the start of the crediting period, the organisation of the monitoring team will be finalised. Clear roles and responsibilities will be assigned to all staff involved in the CDM project. The Project developer will have a designated CDM Monitoring Manager who will be responsible for monitoring operations of the project activity. All staff involved in the collection of data and records will be coordinated by the Monitoring Manager.

Please refer to Annex 4 for details.

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

Date of completion of the baseline and monitoring methodology: 17/08/2010
Person/entity:

Amin Bekai & Mark Ghorayeb
EcoSecurities Group Ltd.
Office 1503, Saba Tower 1
Jumeirah Lakes Towers
Dubai
United Arab Emirates

Phone: +971 4 446 9754/58

e-mail: amin.bekai@ecosecurities.com & mark.ghorayeb@ecosecurities.com

Detailed baseline and monitoring information are attached in Annex 3 and 4.

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:

29/05/2009 (Purchase Order of LFG to Energy Generator)

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

Up to 20 years and 0 months[32].

[32] The agreement between Project Developer and the Johannesburg Municipality (signed 27/05/2009) ends after 20 years, i.e. on 27/05/2029.

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

C.2.1. Renewable crediting period

3*7 years (i.e. 3 consecutive crediting periods of 7 years and 0 months, for a total of 21 years and 0 months).

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

The crediting period will start on 01/03/2011, or on the date of registration of the CDM project activity, whichever is later.

C.2.1.2. Length of the first crediting period:

7 years and 0 months.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Not applicable.

C.2.2.2. Length:

Not applicable.

SECTION D. Environmental impacts

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

The Project will actively collect and combust LFG, thereby improving overall LFG management and reducing adverse global and local environmental effects of uncontrolled releases of LFG. Whilst the main global environmental concern over gaseous emissions of methane is the fact that it is a potent greenhouse gas, thus contributing importantly to global warming, emissions of LFG can also have significant health and safety implications at the local level. For example:

- Risk of explosions and/or fires either within the landfill or outside its boundaries, although the majority of LFG emissions are quickly diluted in the atmosphere;

- Asphyxiation and/or toxic effects to humans from concentrated emissions of LFG; and

- Local and global environmental effects such as odour nuisances, stratospheric ozone layer depletion, and ground-level ozone creation due to over 150 trace component contained in LFG.

Through both the installation of a well-designed LFG collection and a destruction/utilisation system and its proper operation, LFG will be captured and combusted in a controlled manner, thereby removing safety risks from the surrounding community, reducing the risks of toxic effects on the local community and the local environment as well as reducing the emissions of a potent greenhouse gas.

It is worth noting that the Project developer will install flares and electricity generation units which minimise the environmental impact of LFG emissions, which is *significantly less harmful* than the continued uncontrolled release of LFG into the atmosphere. The Project will significantly reduce odour and greenhouse gas emissions.

Thus, the project activity can be referred as environmentally ameliorative, and the installation of the LFG collection and combustion system is part of a broader effort by the Project developer to continue to improve waste management practices.

In South Africa it is nevertheless a legal requirement that a professional body conducts the Environmental Impact Assessment (EIA) which needs to be submitted to the Gauteng Department of Agriculture, Conservation and Environment (DEAT). The EIA Scoping Report was submitted to DEAT in September 2009, and in parallel the CDM process is under way to receive the Record of Decision from DEAT, necessary to be in compliance with South African Environmental legislation. The EIA Scoping Report is available for the DOE (on request), and the Record of Decision will be provided as soon as it is received, before the start of the crediting period.

The potential impacts of the Project have been divided into those that can be mitigated during the design phase, and those impacts that require management during the construction and operational phase of the Project:

- **Preconstruction (Design phase):**
  Surface and groundwater impacts

- **Construction phase:**

Employment opportunities
Dust
Noise
Waste disposal
Safety

- **Operational Phase**

Solid Waste Management
Vegetation
Noise
Safety

Identified issues are addressed in Section D.2.

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

Identified environmental impacts	**Measures undertaken**
Pre-Construction (Design Phase)	
Surface & Groundwater impacts	The potential negative impacts of the Project on surface and groundwater quality downstream will be insignificant provided that the storm-water and wash-water are managed.
Vegetation & Biodiversity	Vegetation at the site had been highly disturbed and invaded, and as such there are no significant environmental impacts.
Construction Phase	
Visual aspects	The following mitigation measures will be implemented: • All construction activities are to be undertaken from a designated contractor lay-down area, which must be clearly demarcated within the landfill site. • Ensure that contractors and staff are well managed and adhere to the mitigation and management measures stipulated in this report. • All infrastructures will be situated in such a way as to reduce the negative aesthetics associated with the LFG Utilisation Plant.
Dust	The following measures will be taken to control the dust nuisance generated during the construction phase: • Speed limits on dust roads will be implemented to prevent dust entrainment into the atmosphere. • All stockpiles must be restricted to

	designated areas and may not exceed a height of two metres.
Noise	The following measures must be implemented on-site to minimise potential noise impacts: • Ensure the flare is enclosed to retard noise generation. • All vehicle and equipment exhaust systems should be maintained to prevent excessive noise.
Soil erosion & compaction	The following mitigation measures will reduce the risk of any negative impacts on in situ soil: • Contractors will be limited to clearly defined access routes and areas to be constructed in order to ensure that undisturbed areas will not be disturbed. • Sustainable erosion control measures (for wind and water erosion) will be implemented and maintained where necessary in areas disturbed by construction operations, or existing erosion control measures will be maintained.
Vegetation Damage	Most natural vegetation in the construction footprint is already degraded and the only plants to be maintained are situated along the fence line. Potential damage to vegetation and biodiversity impacts will be insignificant.
Waste Disposal	Waste such as builders' rubble, fill material, oils, general waste, and sewage will be generated during the construction phase. All waste must be disposed of in a legally acceptable manner, with no burning of refuse to take place on-site. Provided that these management recommendations are implemented, the impacts of waste generated by the development will be insignificant.
Safety	All employees must be made aware of the dangers associated with LFG. No smoking is to be allowed on-site due to the risks associated with LFG.
Operational Phase	
Solid Waste Management	All solid waste must be disposed of at a permitted landfill site. The impacts of solid waste from this site will be insignificant.
Noise	The following measures must be implemented on site to minimise potential noise impacts: • Routine maintenance of the plant must be undertaken to ensure noise nuisance does not occur.

Storm water management	All storm water drains must be maintained on a regular basis and cleared of refuse and debris.

SECTION E. Stakeholders' comments

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

WSP Environmental South Africa (Pty) Ltd. was appointed by Ener-G Systems Joburg (Pty) Ltd. to carry out the environmental scoping, Environmental Impact Assessment (EIA), and draft Environmental Management Plan (EMP), for the development of the Joburg Landfill Gas to Energy Project into a CDM Project. The scoping report and the stakeholder consultation *clearly* specify that the project is designed under the CDM. Scoping and EIA reports have been prepared and submitted to the Department of Environmental Affairs and Tourism (DEAT) as per the requirements of the National Environmental Management Act (No. 107 of 1998) (NEMA) that were promulgated on 03/07/2006.

The following authorities have been advised of the proposed development:

- Department of Environmental Affairs and Tourism (DEAT)
- City of Johannesburg Region E
- Ward Councillor 105
- Urban Management
- Environmental Health Department City of Johannesburg

Interested & Affected Parties (I&APs) were identified by placing official notices of the EIA process for the proposed development in the national newspaper, "The Citizen" on 19/02/2009. In addition advertisements were placed in "The Citizen" and "The Sowetan" newspapers on the 07/08/2009. The reports went on public review for a period of four weeks from 07/08/2009 to 04/09/2009 at appropriate public venues in the areas of the landfills.

The EIA and EMP reports were updated with public comments and submitted to DEAT. Furthermore a "knock and drop" of Project Background Information Documents was conducted to residents surrounding the sites. Copies of the adverts and Background Information Documents (as well as proof of distribution) are attached to the Environmental Impact Report as Appendix C[33].

[33] A copy of the EIA report for *every* site is available to the DOE on request.

Table E.1.1: Summary of Public and Authority Involvement to date

Date	Event/Activity	Comments
19/02/2009	Advertisement national news paper: “The Citizen”	
23/02/2009	Public meeting Linbro Park: 17:00-18:00 – Rembrandt Park Primary School	EIA Appendix F contains attendance register
25/02/2009	Public meeting Marie Louise – St. Angela’s Catholic Church	EIA Appendix F contains attendance register
26/02/2009	Public meeting Goudkoppies: 17:00-18:00 – Silver Oaks High School	EIA appendix F contains attendance register
26/02/2009	Public meeting Robinson Deep: 17:00-18:00	EIA Appendix F contains attendance register
27/02/2009	Authorities meeting: 09h30-11:30 – WSP Main Boardroom	EIA appendix F contains attendance register
27/02/2009	Public meeting Ennerdale: 17:00-18:00 – Ennerdale Civic Centre	EIA appendix F contains attendance register
12/03/2009	Additional public meeting Linbro Park: 18:30-19:30 – Nation Farm in Linbro Park	EIA appendix F contains attendance register
30/03/2009	Submission EIA Application Authorisation - Ennerdale - Goudkoppies - Linbro Park - Marie Louise - Robinson Deep	- DEAT Reference Nr.: 12/12/20/1472 - DEAT Reference Nr.: 12/12/20/1476 - DEAT Reference Nr.: 12/12/20/1475 - DEAT Reference Nr.: 12/12/20/1473 - DEAT Reference Nr.: 12/12/20/1474
05/06/2009	Scoping Report sent to DEAT	
08/07/2009	Authorities’ site visit 08/07/2009 & 09/07/2009	On request of Mr. Ngidi, DEAT
07/08/2009	Advertisement: “The Citizen” and “The Sowetan”	
07/082009	Start Public Review Ennerdale -Main security office Ennerdale landfill site - Ennerdale Civic Centre Goudkoppies - Goudkoppies landfill site main entrance	Review Period 07/08/2009 – 04/09/2009

	- Eldorado Park Thusong library centre Linbro Park - Linbro Park Public Library - Nelton Farm Marie Louise - Marie Louise Landfill Site - Dobsonville Thusong Service Centre Robinson Deep - Robinson Deep main entrance office - Rosettenville library	
09/2009	Submission EIA and EMP Reports	

E.2. Summary of the comments received:

In general the following types of issues were raised by the Authorities and I&APs:

- Air quality – a few stakeholders asked questions pertaining to the Project's impact on local air quality, and these were answered to their satisfaction, with the Project Developer explaining how the project will in fact *improve* air quality in the area of the landfills;
- Possibilities for office blocks and housing – questions were raised regarding the potential use of the rehabilitated landfills, and the Project Developer explained that there is indeed a potential to utilise the areas for recreational purposes, but not for housing (considering the underlying ecology); and
- Employment – a few stakeholders asked questions regarding employment and training for locals at the landfills, and the Project Developer stated that they would utilise local employment capacity and provide necessary training is.

The EIA reports include a comprehensive list of *all* issues raised by I&APs and Stakeholders during public and authorities meetings.

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

The main issues as mentioned in Section E.2 are addressed as follows:

Air quality
The proposed project will extract natural LFGes thereby improving the general air quality in the area. Although this project will have benefits to the physical and socio-economic environment, it will not impact on water resources in the area.

Possibilities for office blocks and housing

The landfill area cannot, in its current state, be used for an area of residential or commercial development. Due to the fact that the underlying geology of the site is not stable, due to dumping of domestic waste, no considerable buildings would be permitted to be constructed on-site. The site may be used as a recreational area *after* sufficient rehabilitation.

Employment
The project will generate minor employment during the Construction and Operational Phases.

The EIA reports include a response to all issues raised by I&APs and Stakeholders during public and authorities meetings, and in response to the public review. Moreover, it includes an assessment of the impact on the Biophysical and Socio-economic Environments, and subsequent management and mitigation measures which have been identified.

It has been concluded by WSP Environmental South Africa (Pty) Ltd. that *there are no environmental fatal flaws and no significant negative impacts associated with the proposed project should mitigation and management measures be implemented*. It should be noted that positive impacts if the proposed project include *carbon credits*, the production of electricity as well as the reduction in LFG emissions from surrounding residential areas. Socio-economic impacts are perceived to be positive by providing employment opportunities and improving the ambient air quality.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Project developer:

Organization:	Ener-G Systems Joburg (PTY) Ltd.
Street/P. O. Box:	205 Northway
Building:	GES House
City:	Durban
State/Region:	KZN
Postfix/ZIP:	4051
Country:	South Africa
Telephone:	+27 31-5640222
FAX:	+27 31-5643802
E-Mail:	dcornish@gessa.co.za
URL:	
Represented by:	
Title:	
Salutation:	Mr.
Last Name:	Cornish
Middle Name:	-
First Name:	David
Department:	-
Mobile:	+27 83 385 0661
Direct FAX:	-
Direct tel:	As above
Personal E-Mail:	dcornish@gessa.co.za

Project Annex 1 participant:

Organization:	EcoSecurities Group Plc.
Street/P.O.Box:	40 Dawson Street
Building:	-
City:	Dublin
State/Region:	Dublin
Postfix/ZIP:	02
Country:	Ireland
Telephone:	+353 1613 9814
FAX:	+353 1672 4716
E-Mail:	info@ecosecurities.com
URL:	www.ecosecurities.com
Represented by:	
Title:	Company Secretary
Salutation:	Mr.
Last Name:	Browne
Middle Name:	-
First Name:	Patrick
Department:	-
Mobile:	-
Direct FAX:	-
Direct tel:	-
Personal E-Mail:	cdm@ecosecurities.com

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The project will not receive any public funding from an Annex 1 country.

Annex 3

BASELINE INFORMATION

1. **Baseline & Emission reduction calculations**
   a) **Baseline Emissions (First Crediting Period):**

Linbro Park

		2012	2013	2014	2015	2016	2017	2018
BE *CH4, SWDS,y*	t CO_2e	156,207	149,971	144,001	138,283	132,807	127,563	122,539
With collection efficiency 50%	%							
BE *CH4, SWDS,y*	t CO_2e	78,104	74,986	72,000	69,141	66,404	63,781	61,269
MD project	**t CH_4**	3,719	3,571	3,429	3,292	3,162	3,037	2,918
Total LFG collected per year	m^3 LFG	10,377,285	9,963,028	9,566,369	9,186,525	8,822,753	8,474,341	8,140,610
Total CH4 collected per year	m^3CH_4	5,188,643	5,188,643	5,188,643	5,188,643	5,188,643	5,188,643	5,188,643
Total LFG combusted in power generation	m^3 LFG	9,343,152	9,963,028	9,566,369	9,186,525	8,822,753	8,474,341	8,140,610
Total CH4 combusted in power generation	m^3CH_4	4,671,576	4,981,514	4,783,184	4,593,263	4,411,376	4,237,170	4,070,305
Total LFG to be flared	m^3 LFG	1,034,133	0	0	0	0	0	0
Total CH4 to be flared	m^3CH_4	517,067	0	0	0	0	0	0
MD electricity	t CH_4	3,349	3,571	3,429	3,292	3,162	3,037	2,918
$FV_{RG,h}$	m3 LFG/h	129	0	0	0	0	0	0
$TM_{RG,h}$	kg CH_4/hr	46	0	0	0	0	0	0
$PE_{flare,y}$	t CO_2e	778	0	0	0	0	0	0
MD flared	t CH_4	334	0	0	0	0	0	0
MD project	**t CH_4**	**3,682**	**3,571**	**3,429**	**3,292**	**3,162**	**3,037**	**2,918**
MD,Baseline	t CH_4	0	0	0	0	0	0	0
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
collected m^3 LFG/hour	m3/hr	1,297	1,245	1,196	1,148	1,103	1,059	1,018
Total LFG to be flared	m3/hr	129	0	0	0	0	0	0
Total LFG combusted in power generation	m3/hr	1,168	1,245	1,196	1,148	1,103	1,059	1,018
Total CH4combusted in power generation	m3/hr	584	623	598	574	551	530	509
Potential MW	MW	2.15	2.06	1.98	1.90	1.82	1.75	1.68
Expected Installed capacity	MW	2.30	3.45	3.45	2.30	2.30	2.30	2.30
performance @ 84% capcity	MW	1.93	2.90	2.90	1.93	1.93	1.93	1.93
Emission reductions from methane destruction								
(MD project,y - MD reg,y)* GWP CH4	tCO_2e	77,325	74,986	72,000	69,141	66,404	63,781	61,269
Emission reductions from grid displacement								
Electricity generation EL_{LFG}	MWh/year	15,070	16,069	15,430	14,817	14,230	13,668	13,130
Electricity consumption	MWh/year	964	964	964	964	964	964	964
Electricity generation	tCO2e	13,118	14,048	13,453	12,883	12,338	11,815	11,314
Baseline emissions								
Baseline emissions	tCO2e	90,443	89,034	85,453	82,025	78,741	75,596	72,584

Marie Louise

		2012	2013	2014	2015	2016	2017	2018
BE *CH4, SWDS,y*	t CO2	179,164	190,284	201,058	211,500	205,983	197,582	189,543
With collection efficiency 50%								
BE *CH4, SWDS,y*	t CO2	89,582	95,142	100,529	105,750	102,992	98,791	94,772
MD project	t CH_4	4,266	4,531	4,787	5,036	4,904	4,704	4,513
Total LFG collected per year	m^3 LFG	11,902,384	12,641,135	13,356,845	14,050,542	13,684,051	13,125,928	12,591,894
Total CH4 collected per year	m^3CH_4	5,951,192	6,320,568	6,678,422	7,025,271	6,842,026	6,562,964	6,295,947
Total LFG combusted in power generation	m^3 LFG	9,343,152	9,343,152	13,356,845	14,014,728	13,684,051	13,125,928	12,591,894
Total CH4 combusted in power generation	m^3CH_4	4,671,576	4,671,576	6,678,422	7,007,364	6,842,026	6,562,964	6,295,947
Total LFG to be flared	m^3 LFG	2,559,232	3,297,983	0	35,814	0	0	0
Total CH4 to be flared	m^3CH_4	1,279,616	6,595,967	0	71,629	0	0	0
MD electricity	t CH4	3,349	3,349	4,787	5,023	4,904	4,704	4,513
$FV_{RG,h}$	m3/h	320	412	0	4	0	0	0
$TM_{RG,h}$	kg/hr	115	148	0	2	0	0	0
$PE_{flare,y}$	t CO2	1,926	2,482	0	27	0	0	0
MD flared	t CH4	826	1,064	0	12	0	0	0
MD project	t CH4	4,174	4,412	4,787	5,034	4,904	4,704	4,513
MD,Baseline		0	0	0	0	0	0	0
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
collected m^3 LFG/hour	m3/hr	1,488	1,580	1,670	1,756	1,711	1,641	1,574
Total LFG to be flared	m3/hr	320	412	0	4	0	0	0
Total LFG combusted in power generation	m3/hr	1,168	1,168	1,670	1,752	1,711	1,641	1,574
Total CH4combusted in power generation	m3/hr	584	584	835	876	855	820	787
Potential MW	MW	2.46	2.61	2.76	2.91	2.83	2.71	2.60
Expected Installed capacity	MW	2.30	2.30	3.45	3.45	5.75	5.75	5.75
performance @ 84% capcity	MW	1.93	1.93	2.90	2.90	4.83	4.83	4.83
Emission reductions from methane destruction								
(MD project,y - MD reg,y)* GWP CH4	tCO_2e	87,656	92,660	100,529	105,723	102,992	98,791	94,772
Emission reductions from grid displacement								
Electricity generation EL_{LFG}	MWh/year	15,070	15,070	21,543	22,604	22,071	21,171	20,310
Electricity consumption	MWh/year	964	964	964	964	964	964	964
Electricity generation	tCO2e	13,118	13,118	19,139	20,126	19,630	18,792	17,991
Baseline emissions								
Baseline emissions	tCO2e	100,774	105,778	119,668	125,849	122,621	117,583	112,763

Goudkoppies

		2012	2013	2014	2015	2016	2017	2018
BE *CH4, SWDS,y*	t CO2	185,257	192,878	200,379	207,768	215,052	222,238	229,332
With collection efficiency 50%								
BE *CH4, SWDS,y*	t CO2	92,628	96,439	100,190	103,884	107,526	111,119	114,666
MD project	**t CH_4**	4,411	4,592	4,771	4,947	5,120	5,291	5,460
Total LFG collected per year	m^3 LFG	12,307,145	12,813,429	13,311,755	13,802,622	14,286,511	14,763,884	15,235,183
Total CH4 collected per year	m^3CH_4	5,951,192	6,406,715	6,655,877	6,901,311	7,143,256	7,381,942	7,617,592
Total LFG combusted in power generation	m^3 LFG	9,343,152	9,343,152	13,311,755	13,802,622	14,014,728	14,014,728	14,014,728
Total CH4 combusted in power generation	m^3CH_4	4,671,576	4,671,576	6,655,877	6,901,311	7,007,364	7,007,364	7,007,364
Total LFG to be flared	m^3 LFG	2,963,993	3,470,277	0	0	271,783	749,156	1,220,455
Total CH4 to be flared	m^3CH_4	1,481,996	1,735,139	0	0	135,892	374,578	610,228
MD electricity	t CH4	3,349	3,349	4,771	4,947	5,023	5,023	5,023
$FV_{RG,h}$	m3/h	370	434	0	0	34	94	153
$TM_{RG,h}$	kg/hr	133	155	0	0	12	34	55
$PE_{flare,y}$	t CO2	2,231	2,612	0	0	205	564	919
MD flared	t CH4	956	1,119	0	0	88	242	394
MD project	**t CH4**	4,305	4,468	4,771	4,947	5,111	5,265	5,417
MD,Baseline		0	0	0	0	0	0	0
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
collected m^3 LFG/hour	m3/hr	1,538	1,602	1,664	1,725	1,786	1,845	1,904
Total LFG to be flared	m3/hr	370	434	0	0	34	94	153
Total LFG combusted in power generation	m3/hr	1,168	1,168	1,664	1,725	1,752	1,752	1,752
Total CH4combusted in power generation	m3/hr	584	584	832	863	876	876	876
Potential MW	MW	2.54	2.65	2.75	2.85	2.95	3.05	3.15
Expected Installed capacity	MW	2.30	2.30	3.45	3.45	3.45	3.45	3.45
performance @ 84% capcity	MW	1.93	1.93	2.90	2.90	2.90	2.90	2.90

Emission reductions from methane destruction								
(MD project,y - MD reg,y)* GWP CH4	tCO_2e	90,398	93,827	100,190	103,884	107,321	110,555	113,748
Emission reductions from grid displacement								
Electricity generation	MWh/year	15,070	15,070	21,471	22,262	22,604	22,604	22,604
EL LFG,y *CEF elec, BL,y	MWh/year	964	964	964	964	964	964	964
Electricity generation	tCO2e	13,118	13,118	19,071	19,807	20,126	20,126	20,126
Baseline emissions								
Baseline emissions	tCO2e	103,516	106,945	119,261	123,691	127,447	130,681	133,873

Ennerdale

		2012	2013	2014	2015	2016	2017	2018
BE *CH4, SWDS,y*	t CO2	69,732	75,260	81,018	87,022	93,287	99,832	106,673
With collection efficiency 50%								
BE *CH4, SWDS,y*	t CO2	34,866	37,630	40,509	43,511	46,644	49,916	53,337
MD project	**t CH_4**	1,660	1,792	1,929	2,072	2,221	2,377	2,540
Total LFG collected per year	m^3 LFG	4,632,518	4,999,737	5,382,255	5,781,101	6,197,351	6,632,131	7,086,619
Total CH4 collected per year	m^3CH_4	2,316,259	2,499,868	2,691,127	2,890,550	3,098,676	3,316,065	3,543,309
Total LFG combusted in power generation	m^3 LFG	1,015,560	2,031,120	4,671,576	4,671,576	4,671,576	4,671,576	4,671,576
Total CH4 combusted in power generation	m^3CH_4	507,780	1,015,560	2,335,788	2,335,788	2,335,788	2,335,788	2,335,788
Total LFG to be flared	m^3 LFG	3,616,958	2,968,617	710,679	1,109,525	1,525,775	1,960,555	2,415,043
Total CH4 to be flared	m^3CH_4	1,808,479	1,484,308	355,339	554,762	762,888	980,277	1,207,521
MD electricity	t CH4	364	728	1,674	1,674	1,674	1,674	1,674
$FV_{RG,h}$	m3/h	452	371	89	139	191	245	302
$TM_{RG,h}$	kg/hr	162	133	32	50	68	88	108
$PE_{flare,y}$	t CO2	2,722	2,234	535	835	1,148	1,476	1,818
MD flared	t CH4	1,167	958	229	358	492	632	779
MD project	**t CH4**	1,531	1,686	1,904	2,032	2,166	2,307	2,453
MD,Baseline		0	0	0	0	0	0	0
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
collected m^3 LFG/hour	m3/hr	579	625	673	723	775	829	886
Total LFG to be flared	m3/hr	452	371	89	139	191	245	302
Total LFG combusted in power generation	m3/hr	127	254	584	584	584	584	584
Total CH4combusted in power generation	m3/hr	63	127	292	292	292	292	292
Potential MW	MW	0.96	1.03	1.11	1.20	1.28	1.37	1.47
Expected Installed capacity	MW	0.50	0.50	1.15	1.15	1.15	1.15	1.15
performance @ 84% capcity	MW	0.42	0.42	0.97	0.97	0.97	0.97	0.97
Emission reductions from methane destruction								
(MD project,y - MD reg,y)* GWP CH4	tCO_2e	32,144	35,396	39,974	42,676	45,495	48,440	51,519
Emission reductions from grid displacement								
Electricity generation	MWh/year	1,638	1,638	3,767	3,767	3,767	3,767	3,767
EL LFG,y *CEF elec, BL,y	MWh/year	964	964	964	964	964	964	964
Electricity generation	tCO2e	627	627	2,607	2,607	2,607	2,607	2,607
Baseline emissions								
Baseline emissions	tCO2e	32,771	36,023	42,581	45,283	48,103	51,048	54,126

Robinson Deep

		2012	2013	2014	2015	2016	2017	2018
BE *CH4, SWDS,y*	t CO2	258,694	279,334	300,990	323,732	347,635	372,775	399,235
With collection efficiency 50%								
BE *CH4, SWDS,y*	t CO2	129,347	139,667	150,495	161,866	173,817	186,388	199,617
MD project	t CH_4	6,159	6,651	7,166	7,708	8,277	8,876	9,506
Total LFG collected per year	m^3 LFG	17,185,775	18,556,917	19,995,596	21,506,451	23,094,371	24,764,506	26,522,292
Total CH4 collected per year	m^3CH_4	8,592,888	9,278,458	9,997,798	10,753,226	11,547,185	12,382,253	13,261,146
Total LFG combusted in power generation	m^3 LFG	0	16,045,848	18,686,304	21,506,451	23,094,371	23,357,880	23,357,880
Total CH4 combusted in power generation	m^3CH_4	0	8,022,924	9,343,152	10,753,226	11,547,185	11,678,940	11,678,940
Total LFG to be flared	m^3 LFG	17,185,775	2,511,069	1,309,292	0	0	1,406,626	3,164,412
Total CH4 to be flared	m^3CH_4	8,592,888	1,255,534	654,646	0	0	703,313	1,582,206
MD electricity	t CH4	0	5,751	6,697	7,708	8,277	8,371	8,371
$FV_{RG,h}$	m3/h	2,148	314	164	0	0	176	396
$TM_{RG,h}$	kg/hr	770	112	59	0	0	63	142
$PE_{flare,y}$	t CO2	12,935	1,890	985	0	0	1,059	2,382
MD flared	t CH4	5,543	810	422	0	0	454	1,021
MD project	t CH4	5,543	6,561	7,119	7,708	8,277	8,825	9,392
MD,Baseline		0	0	0	0	0	0	0
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
collected m^3 LFG/hour	m3/hr	2,148	2,320	2,499	2,688	2,887	3,096	3,315
Total LFG to be flared	m3/hr	2,148	314	164	0	0	176	396
Total LFG combusted in power generation	m3/hr	0	2,006	2,336	2,688	2,887	2,920	2,920
Total CH4combusted in power generation	m3/hr	0	1,003	1,168	1,344	1,443	1,460	1,460
Potential MW	MW	3.55	3.84	4.13	4.45	4.78	5.12	5.48
Expected Installed capacity	MW	2.80	3.95	4.60	5.75	5.75	5.75	5.75
performance @ 84% capcity	MW	2.35	3.32	3.86	4.83	4.83	4.83	4.83
Emission reductions from methane destruction								
(MD project,y - MD reg,y)* GWP CH4	tCO_2e	116,412	137,777	149,509	161,866	173,817	185,329	197,236
Emission reductions from grid displacement								
Electricity generation EL_{LFG}	MWh/year	0	12,940	15,070	17,344	18,624	18,837	18,837
Electricity consumption	MWh/year	964	964	964	964	964	964	964
Electricity generation	tCO_2e	-897	11,138	13,118	15,233	16,424	16,622	16,622
Baseline emissions								
Baseline emissions	tCO_2e	115,516	148,915	162,628	177,099	190,242	201,951	213,858

a) Emission Reductions (First Crediting Period)

Linbro Park

Emission reduction ER y		2012	2013	2014	2015	2016	2017	2018
Emission reduction	tCO2e	89,475	88,066	84,485	81,056	77,773	74,628	71,616

Marie Louise

Emission reduction ER y	Units	2012	2013	2014	2015	2016	2017	2018
Emission reduction	tCO2e	99,806	104,810	118,699	124,880	121,653	116,615	111,795

Goudkoppies

Emission reduction ER y	Units	2012	2013	2014	2015	2016	2017	2018
Emission reduction	tCO2e	102,548	105,977	118,292	122,723	126,479	129,712	132,905

Ennerdale

Emission reduction ER y	Units	2012	2013	2014	2015	2016	2017	2018
Emission reduction	tCO2e	31,802	35,054	41,613	44,315	47,134	50,079	53,158

Robinson Deep

Emission reduction ER y	Units	2012	2013	2014	2015	2016	2017	2018
Emission reduction	tCO_2e	114,548	147,946	161,659	176,131	189,273	200,983	212,889

Year	Total Annual estimation of emission reductions in tonnes of CO2e
2012	438,179
2013	481,853
2014	524,749
2015	549,106
2016	562,312
2017	572,017
2018	582,363
Total estimated reductions (tonnes of CO2e)	3,710,580
Total number of crediting years	7 years (3*7)
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	530,083

b)

2. Financial analysis and benchmark determination

Project Benchmark WACC	
debt	69%
equity	31%
total	100%
debt cost	11.15%
equity return (pre-tax)	19.83%
WACC (pre tax)	**13.82%**
debt / equity	225%

equity benchmark expected market return	
risk free rate	9.07%
equity country premium	5.21%
beta	1.00
equity return (post-tax)	14.28%
equity return (pre-tax)	19.83%

a) Market return

b) Country risk premium

Determining Country Risk Premium

Average country premium: (Apr09/Oct08/Dec08/Oct07)	R 6.81

Country premium at time of decision	5.95%

Last 10 yrs before project implementation:		
a) Average market return	14.28%	
b) risk free rate	9.07%	
Conservative country Premium		5.21%

3. **Grid Emission Factor of the South African Electricity Grid** (Please see attached Grid Emission Factor Calculator)

Plant name and type	Fuel	OM plant?	2004 BM plant? (1=yes)	2005 BM plant?	Date of commission	Licensed capacity (MW)	Net energy sent out *MWh*				Fossil fuel consumption *(various units - see separate column)*				
							2002	2003	2004	2005	2002	2003	2004	2005	*Unit*
Grand Total						43 034	204,511,108	219,198,686	226,393,919	226,346,226	173,221	178,408	184,716	187,998	
Eskom generation						39 810	196,067,796	210,218,785	217,919,213	217,754,872	93,823	96,460	104,370	109,898	
Coal fired stations		1				35 607	181,749,299	194,046,490	203,564,592	206,605,894	93,823	96,460	104,370	109,898	
Arnot	Coal	1			1971/09/21	1 980	11,974,764	14,135,237	13,032,188	11,798,514	5,595	5,799	6,655	6,609	*kt*
Camden	Coal	1		1	2005-2006	1 520				768,108	-	-	-	390	*kt*
Duvha	Coal	1			1980/01/18	3 450	23,320,444	21,384,335	25,450,613	25,034,970	10,560	10,682	9,989	11,908	*kt*
Grootvlei	Coal	1			1969/06/30	1 130				-	-	-	-	-	*kt*
Hendrina	Coal	1			1970/05/12	1 895	12,752,987	12,329,325	12,037,179	12,513,689	6,475	6,551	6,432	6,644	*kt*
Kendal	Coal	1			1988/10/01	3 840	26,006,905	27,820,202	27,005,053	26,897,931	13,518	14,156	15,746	15,430	*kt*
Komati	Coal	1			1969/06/30	891				-	-	-	-	-	*kt*
Kriel	Coal	1			1976/05/06	2 850	19,165,265	18,347,304	19,866,814	20,120,150	10,033	10,020	9,307	9,297	*kt*
Lethabo	Coal	1	1	1	1985/12/22	3 558	22,019,627	23,505,543	22,807,524	24,041,645	15,309	15,368	16,410	17,042	*kt*
Majuba	Coal	1	1	1	1996/04/01	3 843	4,600,976	10,015,560	12,539,663	17,170,166	2,593	2,370	5,539	6,363	*kt*
Matimba	Coal	1	1	1	1987/12/04	3 690	25,145,393	26,510,802	26,894,454	28,401,085	12,362	12,960	13,803	13,786	*kt*
Matla	Coal	1			1979/09/29	3 450	25,577,292	25,802,219	25,673,648	23,938,437	12,884	12,924	13,169	13,445	*kt*
Tutuka	Coal	1	1		1985/06/01	3 510	11,185,646	14,195,963	18,257,456	15,921,199	4,493	5,629	7,320	8,984	*kt*
Gas turbine stations		1				342	-	341	350	77,942					
Acacia	Kerosene	1			1976/05/13	171	0	299	305	47,848	7	18	43	17,488	*kl = m3*
PortRex	Kerosene	1			1976/09/30	171	0	42	45	30,094	1	106	17	10,999	*kl = m3*
Hydro power stations		-				661	2,356,753	777,041	777,041	725,360					
Gariep	Hydro	-			1971/09/08	360	1,164,640	383,991	383,991	402,432	-	-	-	-	
Vanderkloof	Hydro	-			1977/01/01	240	1,192,113	393,050	393,050	322,928	-	-	-	-	
Colleywobbles(Mbashe)	Hydro	-				42	-	-	-	-	-	-	-	-	
First Falls	Hydro	-				6	-	-	-	-	-	-	-	-	
Second Falls	Hydro	-				11	-	-	-	-	-	-	-	-	
Ncora	Hydro	-				2	-	-	-	-	-	-	-	-	
Nuclear stations		-				1 800	11,961,744	12,662,591	13,365,123	11,292,654					
Koeberg	Nuclear	-			1984/07/21	1 800	11,961,744	12,662,591	13,365,123	11,292,654	-	-	-	-	
Pumped-storage stations		1				1 400	-	2,732,322	212,107	(946,978)					
Drakensberg	Hydro	1			1981/06/17	1 000	-	1,787,554	-	-	-	-	-	-	
Palmiet	Hydro	1	1	1	1988/04/18	400	-	944,768	212,107	-	-	-	-	-	
Municipal generation						1 837	1,218,826	1,326,122	1,040,945	1,476,686	11,772	10,148	10,031	10,890	
Coal fired stations		1				1 323	1,201,006	1,038,433	1,027,337	1,110,036	11,685	10,104	9,996	10,800	
Athlone	Coal	1			n/a	180	76,596	76,596	10,230	(84)	745	745	100	(1)	*TJ*
Kroonstad	Coal	1				30					-	-	-	-	*TJ*
Swartkops	Coal	1				240					-	-	-	-	*TJ*
Bloemfontein	Coal	1			n/a	103	8,233	19,444	5,931	16,890	80	189	58	164	*TJ*
Orlando	Coal	1				300					-	-	-	-	*TJ*
Rooiwal	Coal	1			n/a	300	949,078	826,217	895,000	985,000	9,234	8,039	8,708	9,584	*TJ*
Pretoria West	Coal	1			n/a	170	167,099	116,176	116,176	108,230	1,626	1,130	1,130	1,053	*TJ*
Gas turbine stations		1				330	7,189	3,654	2,976	7,445	86	44	36	89	
Roggebaai	Kerosene	1			n/a	50	2,787	2,787	1,141	7,037	33	33	14	84	*TJ*
Athlone	Kerosene	1			n/a	40	867	867	1,827	229	10	10	22	3	*TJ*
Port Elizabeth	Kerosene	1			n/a	40	-	-	8	279	-	-	0	3	*TJ*
Johannesburg	Kerosene	1			n/a	176	3,535	-	-	(100)	42	-	-	(1)	*TJ*
Pretoria West	Kerosene	1				24					-	-	-	-	*TJ*
Hydro power stations		-				4	10,632	10,632	10,632	10,632	-	-	-	-	
Lydenburg	Hydro	-			n/a	2	6,000	6,000	6,000	6,000	-	-	-	-	
Ceres	Hydro	-			n/a	1	1,082	1,082	1,082	1,082	-	-	-	-	
Piet Retief	Hydro	-			n/a	1	3,550	3,550	3,550	3,550	-	-	-	-	
Pumped-storage stations		1				180	-	273,403	-	348,573	-	-	-	-	
Steenbras	Hydro	1			n/a	180	-	273,403	-	348,573	-	-	-	-	
Private generation						1 387	7,224,486	7,653,779	7,433,761	7,114,668	67,627	71,800	70,314	67,210	
Bagasse / coal fired stations		-				105	259,317	259,317	192,337	192,337	-	-	-	-	
Tongaat-Hulett Amatikulu	Bagasse-coal	-			n/a	12	26,781	26,781	26,781	26,781					
Tongaat Hulett - Darnall	Bagasse-coal	-			n/a	12	21,704	21,704	21,704	21,704	(Assumed pure bagasse by conservativeness) => Fossil fuel consumption = zero				
Tongaat Hulett - Felixton	Bagasse-coal	-			n/a	32	66,510	66,510	66,510	66,510					
Tongaat Hulett - Maidstone Mill	Bagasse-coal	-			n/a	29	67,397	67,397	67,397	67,397					
Transvaal Suiker Ltd	Bagasse-coal	-			n/a	20	76,925	76,925	9,945	9,945					
Coal fired stations		1				1 279	6,950,506	7,379,448	7,226,761	6,907,668	67,627	71,800	70,314	67,210	
Kelvin	Coal	1			n/a	540	1,721,353	1,721,353	1,568,666	1,568,666	16,748	16,748	15,263	15,263	*TJ*
Sasol Synth Fuels	Coal	1			n/a	600	4,421,074	4,738,677	4,738,677	4,606,484	43,016	46,106	46,106	44,820	*TJ*
Sasol Chem Ind	Coal	1			n/a	139	808,079	919,418	919,418	732,518	7,862	8,946	8,946	7,127	*TJ*
Hydro power stations		-				3	14,663	15,014	14,663	14,663	-	-	-	-	
Friedenheim	Hydro	-			n/a	3	14,663	15,014	14,663	14,663	-	-	-	-	

Calculation of fuel emission factors:				
	NCV GJ/t fuel	EF tCO2/TJ	Density t / m3	=> Emission factor
Coal	19.9	89.5		1.781 tCO2/t coal
Kerosene	42.4	70.8	0.804	2.414 tCO2/m3

Conversion factor:	277.78	MWh/TJ

Emission factors (tCO2/MWh)	**2004**	**2005**
OM	0.900	0.908
BM	0.950	0.951
CM	**0.925**	**0.930**

Sources and Assumptions made for the grid emission calculation

Sources:		
1a/b/c/d. NERSA (2005/2006/2007/2008) Electricity supply statistics for South Africa 2002/2003/2004/2005 (brochures, with 2004 & 2005 electronic versions copied in tabs 1c, 1d)		
2. Eskom (2008) Website (http://www.eskom.co.za/live/content.php?Item_ID=4226)		
	%	i.e. MWhprod /TJcons
3a. Using CDM Tool default efficiency for old oil-fired gas turbines	30%	83.3
3b. Using CDM Tool default efficiency for old subcritical coal-fired plants	37%	102.8
4. IPCC (2006) Guidelines on National GHG Inventories, table 1.2 of Chapter 1 of Vol. 2 (Energy) Default values at the lower limit of the uncertainty at a 95% confidence interval		
5. Engineers Edge (2008) - See http://www.engineersedge.com/fluid_flow/fluid_data.htm		
Areas shaded: where net electricity sent out is negative, it is set to zero		

Note: White and grey cells are for calculations

Annex 4

MONITORING INFORMATION

Table: CDM Monitoring System Procedures

Procedure	Description	Scope
CDM Staff training	This procedure outlines the steps to ensure that relevant staff receive adequate training to collect and archive complete and accurate data necessary for CDM monitoring.	This procedure will be adhered to by all staff on site prior to performing monitoring duties for the CDM project.
CDM data and record keeping arrangements / day-to-day records handling	This procedure provides details of the site data and record keeping arrangements. The arrangements ensure that complete and accurate records are retained. Data and records will be stored and archived according to this procedure.	All relevant data and records will be managed as per this procedure. Staff are responsible for ensuring that any data or records are dealt with as per this procedure.
CDM data quality control and quality assurance	Data and records will be checked prior to being stored and archived. Data from the project will be checked for possible errors or omissions, and for completeness on a regular basis.	Staff are responsible for ensuring the collection and archiving of complete and accurate data and records.
Internal audits	This procedure will outline the process of internal audits, where the performance of the project will be assessed. It will also provide details on the follow-up of forward actions arising from third party verification(s).	This procedure will be adhered by all CDM staff involved in internal audits.
Equipment failure	This procedure details the process of data collection in the unlikely event that a problem with relevant monitoring equipment occurs.	This procedure will be established by the project developer.
Equipment calibration	This procedure details the process of organising and managing the calibration process as per	Meter calibration will be conducted according to manufacturers' recommendations. The Project Developer is

	manufacturer recommendations.	responsible for organising calibrations and ensuring that records are retained.

The above procedures will be documented as part of the monitoring support materials.