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

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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Durban Landfill-gas-to-electricity project – Mariannhill and La Mercy Landfills

Version 2005-09-10

A.2. Description of the project activity:

The project consists in an enhanced collection of landfill gas at two landfill sites of the municipality of Durban and the use of the recovered gas to produce electricity. The produced electricity will be fed into the municipal grid and replace electricity that the municipal electric company is currently buying from other suppliers. The project will be implemented on the Mariannhill and the La Mercy landfill sites.

The Mariannhill landfill is an active landfill site where waste will be deposited until 2024. It extends over 49 ha and receives 550 to 700 tonnes of waste per day. To date, the site has received approximately 850,000 tonnes. The Mariannhill landfill was officially designated a Nature Conservancy site in late 2002. It is the only landfill in South Africa granted such a status.

The second landfill site, La Mercy, is an old landfill, soon to be closed and far away from residential areas. It receives 350 tonnes of waste per day and has about 1 Mio. tonnes of waste in place.

The proposed project will newly implement landfill gas recovery at La Mercy and substantially upgrade the collection system at Mariannhill where 6 wells have been installed as a pilot activity. The project will also install 0.5 MW of electricity generation at each site for export to the municipal grid. After successful installation and depending on gas availability, electric generation may be subsequently augmented to up to 2MW of combined capacity.

With regard to the local environment the project has positive effects on air and groundwater quality. By displacing electricity from the grid the project reduces emissions related to coal-fired power production which include sulphur oxides, nitrogen oxides, and particulates. It also reduces the adverse impacts related to transportation of coal and coal mining (dust and acid mine drainage). Near the landfill sites the project improves the air quality by further reducing the amount of landfill gas released into the atmosphere and thus reducing the risk of exposure of neighbouring residents to odour.

With regard to local employment the project will result in a small increase in the area of skilled jobs for operation and maintenance of the equipment.

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)	- Durban Solid Waste (DSW), project developer and operator - eThekwini municipality, formerly known as Durban, project sponsor	No
TBD prior to project registration	International Bank for Reconstruction and Development as the Trustee of the Prototype Carbon Fund (PCF)	TBD

Please see Annex 1 for contact details.

Official contact for the CDM project activity is the PCF.

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

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

KwaZulu Natal, South Africa

A.4.1.3. City/Town/Community etc:

Municipality of eThikwini, formerly known as Durban

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

The La Mercy site is situated 35 km north of Durban, away from residential areas.

The Mariannhill landfill site is located in the western area of the Durban unicity around 20 km to the west of Durban in the Metro area formerly called the Inner West City Council (IWCC).

Durban is geographically located in the southeast region of South Africa on the Indian Ocean coast.

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

Sectoral Scope 13: Waste Handling and Disposal
Sectoral Scope 1: Renewable Energy

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

Durban Solid Waste (DSW) is the municipal agency responsible for management and operation of multiple landfills in the Durban metropolitan area. Under the proposed project, DSW will commission the installation of landfill gas extraction wells, flare units and landfill gas generators for the Mariannhill and La Mercy landfill sites. DSW will function as the technical advisor and operator of the project.

Specifically, the following technology will be installed:

- *Extraction wells*: Some 58 vertically driven gas wells (33 on Mariannhill and 25 on La Mercy) will be constructed during phased restoration of the site to extract the landfill gas as it is produced.
- *Gas collection pipework*: These pipes collect and transport the gas from the wells to the extraction plant from where the gas will be used for electricity generation, with any surplus gas being flared.
- *Gas extraction plant (blower):* A centrifugal blower is required to extract landfill gas from the wells and supply this to either the generation engines or the flare unit. The blower creates lower pressure inside the wells than in the landfill, thereby sucking the gas from the landfill into the wells and from there to the extraction plant.
- *Flare units:* A landfill gas flare with minimum capacity of 1,000Nm3/hr will be installed at each site
- *Landfill gas generators*: 500 kW moderate speed (1500 rpm) spark ignition engine generators will be provided at the sites to utilise the energy from the gas and generate electricity. These engines will be specified to the latest European Union standards for their design, notably for exhaust emissions.
- *Switch gears, transformers and cabling:* as needed for the interconnection with the Ethekwini Electricity grid

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

This project is composed of two complementary components as follows:

- Collection, flaring, and combustion of landfill gas, thus converting its methane content into CO2 and reducing its greenhouse gas effect; and,
- Generation and supply of electricity to the regional grid, thus displacing electricity generation from thermal (mainly coal) power plants.

The baseline scenario is defined as the most likely future scenario. Establishing the most likely future scenario requires an analysis and comparison of possible future scenarios using a baseline methodology that is justifiable and appropriate given the project circumstances. Based on this analysis (see sections B.2. and B.3. below), the most likely baseline scenario is expected to be a continuation of the current business-as-usual (BAU) situation where the Mariannhill landfill collects and flares a minimum portion of the generated methane, while La Mercy landfill continues passive venting solely in order to ensure that the landfill gas concentration remains below hazardous levels. It is not likely that economic, technical,

regulatory, or other types of incentives that could significantly change the current practice will develop in the foreseeable future.

The primary purpose of the project is electricity generation and it is characterized as a municipal auto-generation project. The project is additional because it will generate emission reductions that would not occur otherwise, since the project does not present an economically attractive investment opportunity. As energy generation by the proposed project is more costly than the continued purchase of electricity from the national utility company, Eskom, the project sponsor would not invest in the project in the absence of carbon finance.

It is estimated that the project will reduce an aggregated 480,000 tons of CO2 in the first 7 year crediting period.

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

	Mariannhill		**La Mercy**		**Total**	**Cumulative Total**
Year*	Methane destroyed	Electricity offsets	Methane destroyed	Electricity offsets		
2006	29,695	1,780	19,875	0	**51,351**	**51,351**
2007	28,480	3,560	36,031	0	**68,071**	**119,421**
2008	27,228	3,560	33,510	3,560	**67,858**	**187,279**
2009	42,036	3,560	30,299	3,560	**79,455**	**266,734**
2010	40,155	3,560	27,190	3,560	**74,465**	**341,200**
2011	38,551	3,560	25,865	3,560	**71,536**	**412,736**
2012	37,207	3,560	24,540	3,560	**68,867**	**481,603**

All values in tons CO2 equivalent

*as the starting date of the project activity is 1 February 2006, the years cover the period from 1 February to 31 January of the following year.

A.4.5. Public funding of the project activity:

This project will not be funded by international Official Development Assistance (ODA) or other sources earmarked for development assistance.

SECTION B. Application of a baseline methodology

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

Approved baseline methodology AM0010: “Landfill gas capture and electricity generation projects where landfill gas capture is not mandated by law”

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

The selected baseline methodology has been developed in the context of this project.

The project meets the application criteria that have been specified for the use of this methodology, namely:

- The landfill is subject to regulation of methane (CH4) concentration but landfill gas capture is not mandated by law
- The captured gas is used to generate electricity and the CO2 emissions intensity of this electricity is lower than the emissions intensity of the electricity displaced;
- The electricity generation capacity of the project does not exceed 15MW

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

Baseline scenario

AM0010 defines the baseline as the scenario reflecting all actions that have to be implemented in order to meet the regulations on methane concentration, as well as good management practice to address safety and odour concerns. If these actions correspond to the establishment of several "baseline" wells, the quantity of methane collected via these wells shall be monitored, and it should be demonstrated that the quantity collected is sufficient to meet the regulation on methane concentration during the entire crediting period.

In the below paragraphs, the baseline scenario for the Mariannhill and La Mercy landfills is determined following the four steps outlined in AM0010.

Step 1: Provide a convincing justification that there is no plausible baseline scenario except the project and the business as usual (BAU) scenario. If there is another plausible baseline scenario, this methodology cannot be used for the proposed project activity. The justification of the baseline scenario shall take into account whether national or local regulations require capture of landfill gas.

For Durban, several scenarios have been identified as possible future developments, namely:

(a) Business-as-usual (BAU): Currently, neither landfill has an active landfill gas collection and utilization system in place. Landfill gas is currently vented to ensure that the concentration of methane in any particular area of the landfill stays below hazardous levels. In the past, 6 collection wells were installed on the Mariannhill landfill as a pilot to investigate the feasibility of landfill gas recovery for electricity generation. However, as it turned out that this option was uneconomical, DSW has abandoned all further activities. The BAU scenario is the continuation of passive venting at both sites and the operation of 6 test wells with declining efficiency

(b) The proposed project: collection of most landfill gas, its use for municipal power generation on the landfill site, and an equivalent reduction in power purchases from Eskom.

(c) Collection and flaring of most of the landfill gas without use of the gas for power generation.

Existing landfilling capacity, cost considerations and regulatory requirements governing waste management were identified as the key factors that influence the realization of the above scenarios. Based on these factors, scenario (c) was rejected as an implausible baseline alternative.

Currently no collection and flaring are required by South Africa's waste management regulations. The installation of a gas collection and flaring system in excess of current practice and legal requirements would result in unnecessary costs without associated income (or cost savings) to offset these costs.

The South African Department of Water Affairs & Forestry (DWAF) requires all landfill operators to monitor CO2 and CH4 concentrations. The DWAF specifies the requirements for landfill operators as follows:

"The Permit Holder shall implement adequate measures to the satisfaction of the Regional Director, to ventilate or to prevent lateral migration of CH4 gas generated in the site so that build up of dangerous concentrations is prevented. The concentration of flammable gas outside the waste disposal area and inside the Site shall not exceed 1% by volume in air and the concentration of CO2 should not exceed 0.5% by volume in air, amended for Standard Temperature and Pressure." (from Landfill Permit Requirements)

The minimum requirements for waste disposal by landfill in South Africa include gas monitoring at all hazardous and large landfills, reporting to the department if the concentration of soil gas exceeds 1%, and permanent venting systems if the methane concentration exceeds 5% in air (per Minimum Requirements for Waste Disposal by Landfill, Second Edition 1998.)

In the past, the environmental standards for landfills have been tightened on average every four years with the last revision dating back to 1998. New Revised DWAF Minimum Requirements are scheduled to be issued on 21st October 2005. Currently, there is no indication that the revised DWAF requirements will require gas capture and flaring from permit holders being aware of the high costs that such a requirement would incur on landfill operators. The Bisasar Road, the Mariannhill and the Durban Mobeni landfills are currently the only landfill sites in South Africa which have installed limited gas flaring systems. Rather, ongoing discussions indicate that the upcoming revision of the permit requirements will loosen the acceptable standard for CO2 concentration.

Both landfills are operating in compliance with the mandatory requirements. In the absence of further regulatory or economic incentives to collect and destroy landfill gas, the plausible baseline alternatives are reduced to the project and the BAU scenario.

Step 2: Calculate the cost of a kWh of electricity generated by the project using conservative assumptions. The calculation must include the incremental investment cost, the operations and maintenance costs, and all other costs of upgrading the BAU scenario to the proposed project activity. Assumptions are conservative if they tend to reduce the cost of the electricity generated. Conservatism of the assumptions should be ensured by obtaining expert opinions and by the Operational Entity validating the project.

The expected cost of electricity generation by the project is calculated at US$ 0.0422 per kWh.

Details to the calculation are provided in Annex 3 (Baseline Information).

Step 3: Determine the long run marginal cost (LRMC) of continued electricity generation by the grid. The LRMC is expressed as a cost per kWh. To be conservative, assumptions used to calculate the LRMC should increase the cost per kWh.

Until the end of the project's first crediting period in 2012, the LRMC of electricity generation by the grid are conservatively estimated at US$ 0.0225 per kWh. Over the project lifetime, the LRMC are expected not to exceed US$ 0.0365 per kWh.

Details to the calculation are provided in Annex 3 (Baseline Information).

Step 4: Demonstrate that the cost of the electricity generated by the project (*Step 2*) is higher than the LRMC (*Step 3*). If that is the case, it can be assumed that generation by the grid (the baseline scenario) is financially more attractive than generation by the project and that the project is additional.

Based on current low power purchase prices and using the equally low LRMC for power production in South Africa as an approximation of future electricity prices charged to communities, it is concluded that, from an investment point of view, the auto-generation options using the landfill gas is not an economically attractive course of action for the municipality now or in any foreseeable future.

The baseline scenario, as determined above, is the continuation of the current practice of limited collection and flaring of methane from the landfills in compliance with applicable regulations. Given the long-run calculation performed in the baseline study, the BAU baseline is likely to be valid for the duration of the 21-year crediting period selected for this project. However, the BAU baseline includes the possibility that future South African waste management regulations will require the treatment of landfill gas, in which case the baseline scenario would have to reflect such new obligations. The baseline scenario therefore incorporates regulatory changes that would require a change in the current, business-as-usual operation of the landfill sites. The project will monitor any regulatory changes that impact waste management in South Africa and will adjust the baseline scenario by re-designating some landfill gas project wells to baseline wells.

Emission reductions

According to AM0010, the greenhouse gas emission reduction achieved by the project activity during a given year (ER_y) is the difference between the amount of methane actually destroyed during the year ($MDproject_y$) and the amount of methane that would have been destroyed during the year in the absence of the project activity ($MDbaseline_y$), times the approved Global Warming Potential value for methane (GWP_CH_4) plus the quantity of electricity sold to the grid during the year (ES_y) multiplied by the CO_2 emissions intensity of the electricity displaced ($EIgrid_y$).

$$ER_y = (MDproject_y – MDbaseline_y) \times GWP\_CH_4 + ES_y \times EIgrid_y$$

Where:

ER_y are the emission reductions in a year (tCO_2e/year).
$MDproject_y$ is the methane destroyed in a year (tCH4/year).
$MDbaseline_y$ is the methane that would have been destroyed during a year in the absence of the project (tCH4/year).
GWP is the approved Global Warming Potential for methane (21 tCO_2e/tCH_4)
ES_y is the quantity of electricity sold to the grid (MWh).
$EIgrid_y$, is the CO_2 emissions intensity of the grid (tCO_2e/MWh).

Grid emission factor

In compliance with approved baseline methodology AM0010, the CO2 emission intensity of the grid is calculated as the average annual CO2 emission intensity of the grid, which is obtained from the grid operator. The use of an average annual emission rate for grid electricity is justified if it is determined in a conservative manner, i.e. it is very unlikely to overstate the emission reductions.

For this project, the grid emission rate is determined using Eskom's reported data for annual CO_2 emissions and power output. This method averages the coal-fired power plants and other less carbon-intensive power sources in South Africa.

In its 2003 Annual Report (published in 2004) Eskom publicly reported that it emitted 0.90 kg of CO2 per kWh of electricity produced. To calculate the emission reduction from displacement of grid electricity by the project, the project's annual power sales (in kWh) will be multiplied with the annual average emission rate for that year (as derived from Eskom's annual reports).

This methodology is adequate because it is highly improbable that the project will significantly affect the dispatch of peak load plants, but will primarily displace electricity from base load suppliers. Due to overcapacity in South Africa, peak load plants are mainly used as "shock absorbers". Because of the project's character as must-run-capacity and its very small contribution to meet the overall Durban metro-area demand, it is expected that Eskom will reduce the generation of the base load power plant with the highest marginal costs in its regional supply mix to adjust for a reduced power purchase by eThekwini Electricity.

The methodology for the calculation of the emission factor is conservative for the following reasons:

- Averaging the emissions across all Eskom power plants includes the low emission intensity of more efficient coal-fired plants. The project however displaces the plant with highest marginal costs in its territory and hence is likely to displace the least efficient and most emission intensive coal power plant in that region.
- Being located close to the Durban municipality, the project feeds electricity directly into the low voltage municipal grid. Most of Durban's electricity is supplied from the high voltage system. By displacing electricity from the high voltage system the project also reduces the amount of transmission losses that occur over longer distances and at the substations where the voltages are reduced.
- The emissions from the Eskom power stations' parasitic load are not included in the Eskom data and are therefore not included in the emission rate.

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

The baseline is defined as the scenario, in which the currently existing wells continue to operate with a declining efficiency, but no further wells would be installed, unless national legislation tightens. The proposed project is additional because it reduces emissions relative to the projected emission level in the baseline scenario.

In the absence of the project, only about 7.4% of the gas produced in the landfills would be collected and flared. The project upgrades the methane recovery system to 83% in 2012, and thereafter progressively dropping in parallel to diminishing gas production to 44.3% in 2025 at the probable end of the commercial project life. In addition, the displacement of mainly coal-based electricity with renewable energy from landfill gas would not take place in the absence of the CDM activity.

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

The boundary of the project is the site of the project activity where the gas is captured and destroyed, the Mariannhill and the La Mercy landfill sites.

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

Sandra Greiner/Robert Chronowski/Johannes Heister

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1818 H Street, NW
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sgreiner@worldbank.org
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jheister@worldbank.org

Completion date: 2005-09-10

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:

1st February 2006

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

21 years

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

C.2.1. Renewable crediting period

Chosen

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

1st February 2006

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

Not chosen

C.2.2.1. Starting date:

Not applicable

C.2.2.2. Length:

Not applicable

SECTION D. Application of a monitoring methodology and plan

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

Approved baseline methodology AM0010: "Landfill gas capture and electricity generation projects where landfill gas capture is not mandated by law"

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

The selected methodology has been developed in the context of this activity.

1) For a landfill methane gas capture project such as the Durban Landfill-gas-to-electricity project it is adequate and most accurate to directly measure the methane combusted in flares and generators, i.e. the emission reductions attributable to the project. Each ton of methane collected and destroyed equals one ton of methane not released to the atmosphere and, thus, one ton of methane emissions reduced. Emission reductions do not have to be established through a comparison between baseline and project emissions and, as a consequence, the quantity of emissions in the baseline scenario can remain unknown.

2) The greenhouse gas emissions achieved through displacement of grid electricity can be estimated by multiplying the amount of kWh injected into the grid by an appropriately conservative carbon emission factor for the South African grid, measured as kgCO2/kWh. This methodology has low transaction costs as it only involves computations based on data that are routinely collected by the project operator.

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

Not applicable, because the project directly monitors and calculates emission reductions.

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

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

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

Not applicable

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

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

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

Not applicable

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

The following data will be collected in conformance with approved monitoring methodology AM0010:

ID number	Data type	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
1	Flow of landfill gas to flares	m^3	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Measured by flow meter. Data will be aggregated monthly and yearly. Temperature and pressure must also be measured with volume adjusted to standard temperature and pressure.*
2 $MDproject_y$	landfill gas collected from project wells	m^3	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Measured by flow meter. Data will be aggregated monthly and yearly. Temperature and pressure must also be measured with volume adjusted to standard temperature and pressure.*

ID number	Data type	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
3 $MDbaseline_y$	landfill gas collected from baseline wells (Mariannhill only)	m^3	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Measured by flow meter. Data will be aggregated monthly and yearly. Temperature and pressure must also be measured with volume adjusted to standard temperature and pressure.*
4	Methane content of landfill gas	%	m (laboratory analysis)	Quarterly intervals	statistically significant samples, delivering confidence level of 95%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*The methane content is also calculated using generator output and gas input to engines*
5	Gross electricity produced (engine / generator output)	MWh	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Data will be aggregated monthly and yearly*
6 $EIgrid_y$	Emission intensity of South African grid	Kg CO_2 / kWh	c	annually	based on reported data	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*The project operator shall recalculate emission factor annually based on Eskom's publications of CO_2 emissions*
7	Flow of landfill gas to engines	m^3	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Measured by a flow meter. Data will be aggregated monthly and yearly. Temperature and pressure must also be measured with volume adjusted to standard temperature and pressure.*

ID number	Data type	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
8 ES_y	Net electricity produced (electricity delivered to grid)	kWh	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	*Data will be aggregated monthly and yearly*
9	Flare working hours	%	m	Continuous	100%	Electronic (spreadsheet)	2 years [and duration of the project crediting period in files]	
10	Combustion efficiency	%	m and c	Semi-annual, monthly if unstable	N/a	Electronic	2 years [and duration of the project crediting period in files]	*Methane content of engine/boiler exhaust gas.*
11	LFG Temperature and Pressure							
12	Flare temperature							

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

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

The project does not cause any emissions of greenhouse gases other than negligible emissions associated with the construction works and the operation of the blower.

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

Not applicable (see D.2.2.1).

D.2.3. Treatment of leakage in the monitoring plan

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

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

No increase in emissions outside the project boundary – leakage – is expected as a result of the project activity.

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

Not applicable (see D.2.3.1)

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

Various formulas and calculations are needed to obtain the emission reductions from the project. On an aggregate level, emission reductions are calculated according to the formula:

ER_y = ($MDproject_y$ – $MDbaseline_y$) x GWP_CH_4 + ES_y x $EIgrid_y$

Where:

ER_y are the emission reductions in a year (tCO_2e/year).
$MDproject_y$ is the methane destroyed in a year (tCH4/year).
$MDbaseline_y$ is the methane that would have been destroyed during a year in the absence of the project (tCH4/year).
GWP is the approved Global Warming Potential for methane (21 tCO_2e/tCH_4)
ES_y is the quantity of electricity sold to the grid (MWh).
$EIgrid_y$, is the CO_2 emissions intensity of the grid (tCO_2e/MWh).

Section E5 contains a comprehensive step-by-step-diagram how the variables MDproject and MDbaseline are calculated from the measurements.

In order to estimate emission reductions *ex ante*, one has to calculate the prospective methane generation of the landfill sites. The IPCC First Order Decay Model or other landfill gas models can be used to this effect. In the case of the Mariannhill and the La Mercy sites, landfill gas generation has been simulated by the UK based company Enviros Ltd using the GasSim model.

The grid emission factor of the South African grid is not calculated by the project participants but by the South African national utility company Eskom.

Furthermore, once the project is operating and directly monitoring the emission reductions, calculations are needed to translate the various data measurements into the parameter values needed in the above formula. A comprehensive description as to how the parameter values are obtained from the data measurements is provided in E5 below.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
D3 – 1	Low	Flow meters will be subject to a regular maintenance regime to ensure accuracy
D3 – 2	Low	Flow meters will be subject to a regular maintenance regime to ensure accuracy
D3 – 3	Low	Flow meters will be subject to a regular maintenance regime to ensure accuracy
D3 – 4	Medium / Low	(a) Samples will be drawn from different parts of the landfills and averaged, (b) methane contents will be back-calculated based on kWh output, heat rate of engines and volume of gas input into engines.
D3 – 5	Low	Meters will be subject to a regular maintenance regime to ensure accuracy. Their readings will be double-checked by the electricity distribution company (power purchaser)

D3 – 6	Medium	Depends on accuracy of annual Eskom reporting.
D3 – 7	Low	Flow meters will be subject to a regular maintenance regime to ensure accuracy
D3 – 8	Low	Meters will be subject to a regular maintenance regime to ensure accuracy.
D3 - 9	Low	Meters will be subject to a regular maintenance regime to ensure accuracy.
D3 – 10	Low	Meters will be subject to a regular maintenance regime to ensure accuracy.

Quality assurance procedures involve calculation of emissions reductions using two different methods and two partially different sets of monitored variables.

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

DSW is the project operator. To ensure effective monitoring of the emission reductions, DSW will implement a well-defined management and operational system which includes data handling, staff training, reporting and quality assurance. Specifics of the management system are provided in the annexed Monitoring Plan.

In addition, DSW and the PCF are organizing an initial verification at the start of the project activity to ensure that the monitoring system is fully functional at the onset of the project.

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

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Completion date: 2005-09-10

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

Emission reductions are estimated directly

E.2. Estimated leakage:

Not applicable

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

Emission reductions are estimated directly

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

Emission reductions are estimated directly

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

The greenhouse gas emission reduction achieved by the project activity during a given year (ERy) is the difference between the amount of methane actually destroyed/combusted during the year (MDprojecty) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity (MDbaseliney), times the approved Global Warming Potential value for methane (GWP_CH4) plus the quantity of electricity sold to the grid during the year (ESy) multiplied by the CO2 emissions intensity of the electricity displaced (EIgridy).

ERy = (MDprojecty – MDbaseliney) x GWP_CH4 + ESy x EIgridy

The monitoring plan provides for the calculation of emission reductions from avoided methane emissions and from displaced grid electricity. The calculation formulas are contained both explicit and programmed in the annexed self-calculating Excel spreadsheets. The calculations are done in the following ways (please refer to the Monitoring Plan and the spreadsheets for details):

(1) Calculation method for emission reductions from landfill gas combustion (MDprojecty – MDbaseliney) x GWP_CH4:
Two methods are used for the calculation of emission reduction from landfills. The first is based on down stream metering wherever possible, i.e. meters are placed as closely as possible to the location of combustion of methane gas or measure minor quantities thus avoiding sources of error. The second method relies on up-stream metering and on quarterly laboratory analysis of the methane content in landfill gas. This method is used as backup and for quality control purposes.

The primary method uses the monthly aggregates of the following four metered variables: Gross electricity production (kWh), volume of LFG sent to engines, volume of landfill gas flared, and volume of LFG extracted from baseline wells (all in m^3). The method first calculates the quantity of methane combusted in engines using engine kWh output and technical parameters (Steps 1 – 3 in Figure 2). Step 4 calculates the methane content in LFG using the quantity of LFG sent to engines, which is then used in

Step 5 to derive methane combusted in flares from LFG quantity sent to flares. Step 6 calculates the proportion of LFG collected from project wells using the above information about LFG sent to engines and flares as well as LFG collected from baseline wells. This proportion is used in Step 7 to calculate the net amount of methane combusted by the project activity and for which credits can be claimed. Step 8 concludes the calculation by multiplying with the global warming potential of methane.

Key steps of the primary calculation method

Methane combusted in engines

Step 1

Take the metered gross annual electricity production (kWh) – (H)

Step 2

Obtain total energy input to engines (in GJ) – (l) by multiplying with generator heat rate. Use manufacturer information for heat rate – (h) (14,000 kJ/kWh as default).

Step 3

Convert total energy input (in GJ) – (l) to tons of methane – (J), using calorific content of methane – (j) (37,000 kJ/m3) and weight of methane – (e) (0.000714 t CH4/m3)

Methane combusted in flares

Step 4

Calculate proportion of methane in LFG – (c), using volume of methane combusted in engines – (V) and LFG sent to engines (H)

Step 5

Calculate tons of methane combusted in flares – (K), using methane sent to flares – (C), flare efficiency – (a) (default 0.97), methane content in LFG – (c), and weight of methane – (e) (0.000714 t CH4/m3)

Step 6

Calculate proportion of project wells to total landfill gas collected – (k), using volumes of LFG sent to engines – (X), to flares – (C), and collected from baseline wells – (B)

Step 7

Calculate net amount of methane – (M), by adding methane combusted in engines – (J) and in flares – (K), and correcting for contribution of baseline wells to total landfill gas collected – (k)

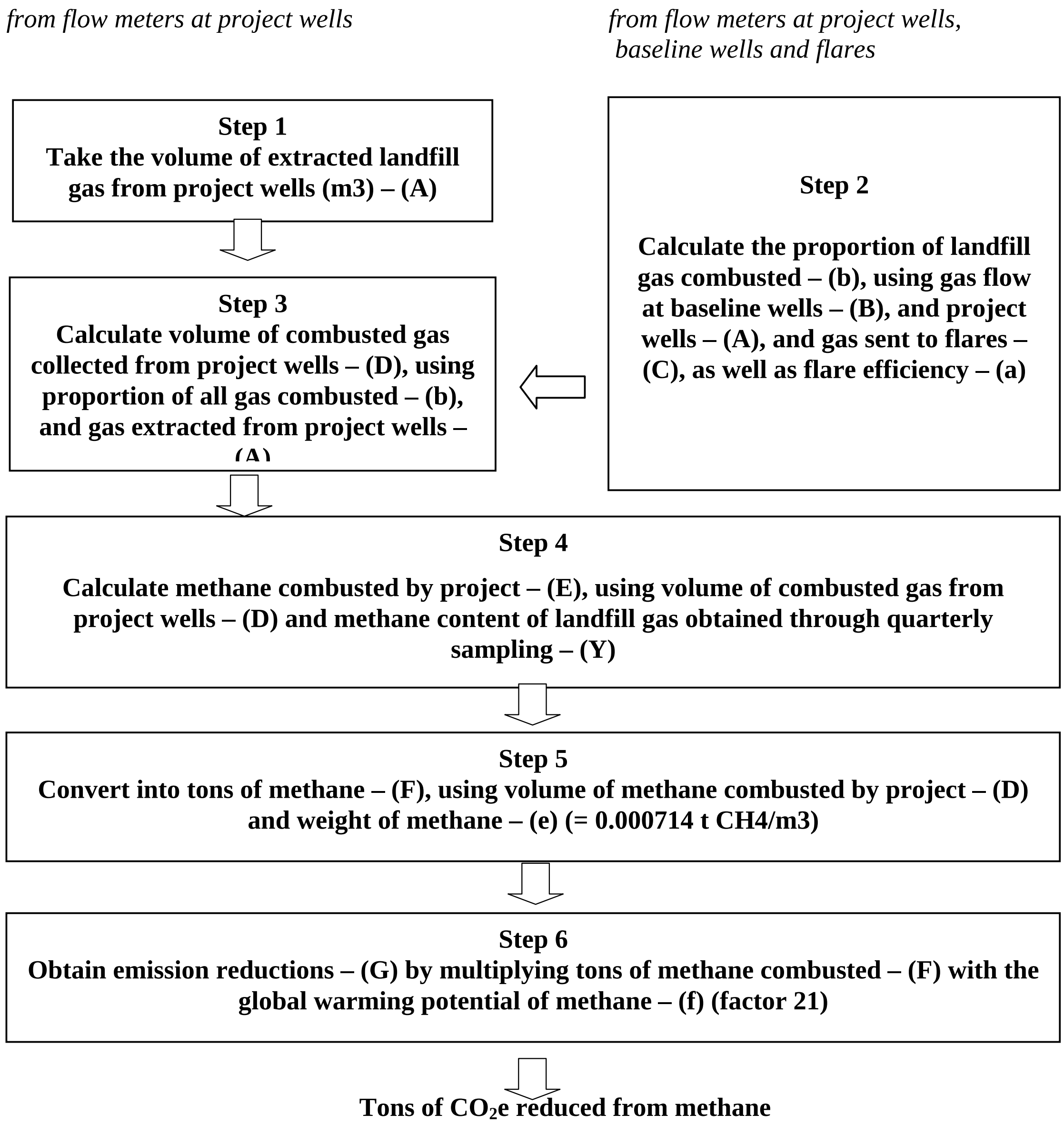
Step 8

Obtain emission reductions – (N) by multiplying net amount of methane combusted – (M) with the global warming potential of methane – (f) (GWP factor: 21)

Tons of CO_2e reduced from methane

The confirmation method uses the monthly aggregates of the following three metered variables: Volume of landfill gas flared, volume of gas extracted from baseline wells, and volume of gas extracted from project wells (all in m^3). The method also uses quarterly laboratory values for the methane content in landfill gas. The method first calculates the proportion of LFG combusted using the above gas flow information together with the flare efficiency (Step 2). In Step 3, this proportion is used to derive the volume of combusted gas that is collected from project wells. Step 4 calculates the volume of methane combusted from the volume of combusted gas using the laboratory values for the methane content in LFG. Step 5 and 6 complete the calculation of emission reductions (CO_2equiv) by converting methane volume into tons of methane and multiplication with the global warming potential.

Key steps of the quality assurance method



(2) Calculation method for emission reductions from grid electricity displacement (ESy x EIgridy):
The project operator determines the applicable annual grid carbon emission factor based on Eskom reports and multiplies with the metered electricity delivered to the grid.

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

The following projection of emission reductions is based on a variety of assumptions regarding waste volume and deposition rates, methane generation profile, LFG collection efficiency, methane content in LFG, flare efficiency, engine heat rates, and so forth. The generation of landfill gas at the two sites has been estimated by the UK based company Enviros Consulting Limited. The full report is made available to the validator.

Emission reductions from the Mariannhill and La Mercy sites in tonnes CO2e

	Mariannhill		**La Mercy**		**Total**	**Cumulative Total**
Year*	Methane destroyed	Electricity offsets	Methane destroyed	Electricity offsets		
2006	29,695	1,780	19,875	0	**51,351**	**51,351**
2007	28,480	3,560	36,031	0	**68,071**	**119,421**
2008	27,228	3,560	33,510	3,560	**67,858**	**187,279**
2009	42,036	3,560	30,299	3,560	**79,455**	**266,734**
2010	40,155	3,560	27,190	3,560	**74,465**	**341,200**
2011	38,551	3,560	25,865	3,560	**71,536**	**412,736**
2012	37,207	3,560	24,540	3,560	**68,867**	**481,603**

All values in tons CO2 equivalent

*as the starting date of the project activity is 1 February 2006, the years cover the period from 1 February to 31 January of the following year.

SECTION F. Environmental impacts

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

eThekwini Municipality sought legal advice and held a subsequent meeting with the competent authorities overseeing the application of ESIA legislation in KwaZulu Natal province, the conclusion of which was to confirm that a full ESIA process is required. The Bank team wished to ensure that the current ESIA team (Felehetsa Consultants) include expert and seasoned personnel regarding public consultation and conflict case mediation. The Manager of Environment for eThekwini Municipality responded that she herself, and the Municipality more generally, would play a strong role in the preparation of the ESIA, and that other steps had been taken to ensure that such expertise was included in the ESIA team.

The Bank team met with the consultants undertaking the study and recommended that the following sections on social issues be included in the ESIA:

- A clearer description of the participatory and consultative process carried out with communities living around Bisasar Road and Mariannhill landfills.
- An annex (standard in ESIAs) indicating a list of all such meetings/discussions, the main points covered, and the participants.
- A description of community interaction with landfill management (e.g., involvement in monitoring committees, scavenger permits, history of complaint responses, attendance of meetings by community, past clashes over specific issues and how they were/were not resolved.)
- Summary of discussion with the surrounding communities of the proposed Carbon Credit Community Fund **-** including an explanation of the Fund guidelines and the soliciting of ideas from the community.

The World Bank will engage an expert on environmental conflict resolution during project preparation. To insure inclusion of the relevant issues during finalization of project design, World Bank social and environmental safeguards specialists will continue their involvement with the project.

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

The Durban La Mercy and Mariannhill Landfill Gas to Energy project has **positive effects on local air and groundwater quality and safety**. By displacing electricity from the grid the project reduces emissions related to coal-fired power production which include sulfur oxides, nitrogen oxides and particulates. It also reduces the adverse impacts related to transportation of coal and coal-mining (dust and acid mine drainage). Near the landfill sites the project improves local air quality by further reducing the amount of landfill gas released into the atmosphere and thus reducing the risk of dangerous methane gas concentrations and of exposure of neighboring residents to odor. This is particularly relevant for the Mariannhill landfill site which is located close to residential areas. All gas capturing wells to be installed will be equipped for leachate removal which contributes to the protection of groundwater. The provision of up to 2MW in electricity **will reduce local pollution from fossil-fuel plants**, the generation source for most electricity at present.

With regard to **local employment** the project will result in a small increase in the area of skilled jobs for operation and maintenance of the equipment at the landfill and the power generation units.

The PCF will be making an additional payment to support community programs for stakeholders. Stakeholders living near the landfills or involved in waste collection will be invited to participate in selecting a program or programs, in conjunction with eThekwini Municipality, that will be funded through an additional 20 cents per t/CO_2e, to be paid into a Carbon Credit Community Fund. The total amount of this direct, additional contribution is about $760,000 if the full purchase of 3.8 million t/CO_2e by the PCF is made. (Some of this money could be provided up front, depending on the nature of the project or program selected). This funding is not to be provided as “compensation”, but is rather meant to ensure that those who are affected by the landfill operations which form the basis of the PCF project derive some benefit, and have the advantage of proactive outreach, from the project.

SECTION G. Stakeholders’ comments

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

eThekwini Municipality and national legislation calls for the establishment and regular meeting of a Monitoring Committee, comprising interested and affected parties. This committee meets on a quarterly basis. The proposed project was discussed in the Committee Meeting held in November 2002. Documentation to support this is available in the form of minutes. The environmental and social impacts of the construction and operation of the project were described.

In July 1997 the Mariannhill Landfill Site was commissioned to receive “General” (G) waste in accordance with a permit issued by the Department of Water Affairs and Forestry (DWAF, 1994 and updated 1998). The Mariannhill Landfill Monitoring Committee was formulated in 1996 and commenced meetings prior to the site opening, to ensure upon public ‘buy-in’ from the onset of disposal operations. 6 monthly audits became a legislation requirement as did regular 3-monthly meetings with the community, termed "the Monitoring Committee".

The Monitoring Committee is a body established by all parties interested and/or affected by the landfill site which includes stakeholders, and meets on a regular basis to discuss issues related to the landfill at Mariannhill Landfill. Due to La Mercy’s isolated location in an uninhabited area no Monitoring Committee was established for this site, nor has it been called for by DWAF.

The Mariannhill Landfill Conservancy was established in 1998, and received National Conservancy Certification status in 2003.

The Mariannhill and La Mercy sites received positive Records of Decision (RODs) from the Provincial Department of Agriculture and Environmental Affairs (DAEA) on 9 July 2004, but an appeal was issued by a member of the public, Mr Allan Childs, on 2 August, 2004 (the details of which are summarised in G2). This appeal was rejected by the DAEA in early 2005, following a review period of some 5 months. However, the DAEA imposed conditions on this decision to reject the appeal that are detailed in G.3.

G.2. Summary of the comments received:

Mr Allan Childs, a member of the public, submitted the following grounds for appeal against the RODs for the sites at Mariannhill and La Mercy:

a. Clauses in the Key Decision Factors of the RODs and the benefits of the projects to city residents

i. Mr Childs had no objection to the proposals overall but felt that they were aimed at increasing the prestige of the eThekwini Municipality rather than combating global warming. The benefits to residents of the city if any would be miniscule in his view. The appreciation of the Rand has already reduced the benefits by 20%.

b. Clauses related to design criteria and atmospheric impacts in the Key Decision Factors of the RODs

i. Clauses 8.6.2 and 8.6.3 of the ROD state that the spark ignition engines will be specified to the latest European design notably for exhaust emission but these actual specifications will not be finalized until the contracts are awarded. Clauses 8.8.1.2 requires an independent air monitoring exercise to be undertaken to assess the actual impact of any emissions and clause 8.8.1.3 says that the emission limits

will be set and the engines managed and monitored to ensure emission levels set (presumably as a result of the monitoring exercise) are not exceeded. Mr Childs found this to be unacceptable.

Setting the specification for exhaust based on the results of tests carried out after commissioning was equally unacceptable to Mr Childs.

Finally, he noted that there are no test facilities in South Africa for dioxin and furans. Consequently unless it is recognized that these materials could be present in the exhaust no effort will be made to test for them. He requested, therefore, that these requirements be specified in the ROD.

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

Based on the comments received above, and an expert analysis of the merit of those comments, the appeal submitted by Mr Childs was rejected, with the imposition of certain conditions. The projects on the Mariannhill and La Mercy landfill sites were granted authorization to proceed as pilot plants for a period of 2 years only.

Existing conditions of approval were amended and amplified as follows:

- The applicant (project sponsor) must undertake the air quality monitoring exercise stipulated in condition 9.2.2 of the ROD in consultation with the DAEA. The DAEA must be consulted with respect to the establishment, operation, assessment and analysis of the air quality monitoring systems.
- The air monitoring exercise prescribed in condition 9.2.2 of the ROD will constitute an initial assessment. The applicant must develop an ongoing air quality impact assessment program to monitor emissions over the 2 year period, as envisaged in conditions 9.2.8 and 9.2.9 of the ROD.
- The results of all air quality monitoring must be incorporated into the prescribed landfill site audits for the Mariannhill and La Mercy landfill sites, and these results must be presented to the monitoring committee forums for each site.
- The air quality impact assessments undertaken for each site must upon completion, be submitted to the DAEA's sub-directorate on air quality, and also to the applicant's own environmental health unit (air quality management section) for comments.
- The results of the ongoing air quality impact assessment process conducted over the 2 year period must be measured against the baseline condition 9.2.2 of the ROD, and results reported to the DAEA.
- Pending the establishment of South African air quality standards, the applicant will be obliged to ensure that their emission limits do not exceed those established in the "Guidance of Monitoring Landfill Gas Engines, United Kingdom Environment Agency, Draft for Consultation, 2002"

.

- At the end of the 2 year pilot period of the project the DAEA will consider the results of the air quality monitoring and assessment programmes to inform future decisions regarding the continued operation of the projects.

- EIA applications for the permanent operation of the LFG capture and electricity generation and distribution facilities on both the Mariannhill and La Mercy landfill sites will be considered by the DAEA at the end of the 2 year pilot project period.

Annex 1

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City:	
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No ODA is involved in the project

Annex 3

BASELINE INFORMATION

A: Factor used for converting methane to carbon dioxide equivalents[1]

Factor used (CO_2e/CH_4)	Period Applicable	Source
21	1996-present	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

B: Conversion volume of methane to weight of methane

	Factor	Unit	Period Applicable	Description/Source
Methane Density	At standard temperature and pressure (0 degree Celsius and 1,013 bar) the density of methane is 0.000714 tCH_4/m_3CH_4 tonnes	t CH_4/m_3CH_4	Default	Mark's Standard Handbook for Mechanical Engineers Ninth Edition McGraw-Hill Book Company page 4-30, Table 4.1.7*

* The density of methane is given in that table as: **0.0416** pounds per cubic foot at **68 degrees F** and **14.70 pounds per square inch**. To convert that to kilograms per cubic meter at **1.013 bar and 0 degrees Centigrade**: 293 degrees Kelvin/273 degrees Kelvin = 1.0732 which is the weight addition ratio at a constant volume, therefore 0.0416 x 1.0732 = **0.0446** pounds per cubic foot. 1 cubic meter = 35.31 cubic feet, therefore 0.446 x 35.31 = 1.5748 pounds per cubic meter / 2.2046 pounds per kilogram = 0**.7143 kilograms per cubic meter**

C: Project power generation costs:

The total cost for the total integrated 3 site project[1] is estimated at US$12.20 million based on adjusted budget quotes.[2] Because there are multiple sites in the integrated project this can be broken down to and estimated cost of US$1.35 million per MW of electricity capacity installed at any of the 3 landfill sites. This total includes all development costs including the Environmental Impact Assessment (EIA) preparation, the generation system installed costs, the interconnection costs, the gas well costs (not including the baseline wells), the financing costs including interest during construction, and an appropriate contingency of less than 10%. The US$ price per MW installed is an appropriate way to budget this project by DSW since it is simply a staged procurement process for a multi-component integrated project.

[1] The original investment plan includes landfill gas recovery on the Bisasar Road landfill.

[2] As reported in the DSW project spreadsheets prepared by Engineer Lindsay Strachan. The budget quotes suggested a price of over US13 million but historically final prices have been lower than the budget quotes received from these suppliers, hence a small downward adjustment has been made.

The project is being structured to enable contracting for a firm annual delivery of 67.8 GWh from all 3 sites or 7.5GWh per MW installed. It is possible that the integrated project will deliver more MWh per year if the buyer will accept it, but the (maximum annual) guaranteed amount will be 67.8 GWh per year.

The first order indicator of the cost of production per kWh in a case wherein the fuel is considered free (other than capital cost recovery for the wells) is the debt service requirement for 100% debt finance.

Assumptions:

1. The Power Purchase Agreement will be for 10 years with options for 2 additional 5 year extensions.
2. The debt period is assumed to be 8 years to meet risk management criteria of typical financing sources.
3. The interest rate is assumed as 10% in US$ terms.

The annual debt service requirement (including repayment of principal) on a debt of US$12.20 million with an 8 year loan at 10% interest would be US$181,440 per million of debt or US$2,213,568 per year. That translates into a debt service component in the cost of production of US$0.0326 per kWh. A 10 year, 10% loan would reduce this down to US$0.0283 per kWh for sensitivity purposes. Because the lifetime of the engines (which form the main component of investment costs) is around 10 years, it can be assumed that a new loan will come into effect to purchase replacement engines at about the time when the first loan is fully repaid. Alternatively, equity financing of continued operation (including replacement engines) would arrive at a similar result, when taking depreciation and a reasonable return on investment into account.

The O&M cost per long term use of the piston engine generators is estimated to be US$0.008 per kWh produced including all labor and materials charges for routine maintenance and for major overhauls. Adding the O&M component cost to the debt service component cost results in an estimated cost of production of US$0.0406 per kWh. Adding in an administrative and insurance burden of US$0.0016 per kWh results in a total estimated cost of production of **US$0.0422 per kWh**.

Since the project development process started there has been a significant change in the ratio of the South African Rand to the US$. The August 15, 2005 value of 6.46 Rand = 1 US$ has been used to re-evaluate the project costs and revenues. The majority of the generation equipment is imported but the majority of components for the gas side of the project are available locally. No expatriate expertise is required for the operations and maintenance of the equipment. A re-evaluation of the cost of generation shows an essentially equal projection under the revised monetary conditions, hence the above number remains valid.

While inputs such as equity can change the answer somewhat, this value is considered as an accurate, yet ***conservative*** indicator of the cost of production for the proposed facility. The cost calculation is considered conservative, in particular because it does not include considerations of risks associated with the operation of a landfill gas-to-electricity project such as technology and resource risks.

Cost items	
Annual generation (GWh)	67.8 GWh
Estimated total cost of project (mill. US$)	12.2

Annual debt service payment (8-year loan, 10% interest) on a per kWh basis (US$/kWh)	0.0326
Operations & Maintenance (US$/kWh)	0.008
Administration & Insurance (US$/kWh)	0.0016
Total generation cost (US$/kWh)	**0.0422**

D. Current power prices and LRMC of South African grid

The municipal electric company, eThekwini Electricity, purchases its electricity primarily from Eskom, the national electricity utility company. Eskom electricity is among the lowest cost sources of electricity in the world, and the vast majority of Eskom generated electricity is derived from fully depreciated, mine-mouth coal-fired power stations. Ninety percent (90%) of the MWh generated by Eskom are derived from coal-steam power plants.

As of August 2005, the 24 hour weighted average tariff Eskom charges eThikwini Electricity is about 9.7 Rand cent (US$0.0150) per kWh with off peak tariffs being as low as US$0.0092 at 6.46 Rand per US$ and after a total Eskom tariff structure revision lowering peak hour tariffs and raising off-peak tariffs. This compares with the initial PDD weighted average value of 13.7 Rand per kWh (US$0.0156) at 8.78 Rand per US$ under the old Eskom tariff regime.

Current tariff level (US$/kWh):

Off - peak	0.0092
Weighted averaged	0.0150

In order to estimate the long-term market price for electricity one needs to look at the development of the long run generation costs. If generation costs go up so will the price charged to customers. It is assumed, that Eskom will meet the demand for electricity at least cost. The least cost technology that can satisfy the projected demand over the project crediting period thus gives an indication for the development of the market price.

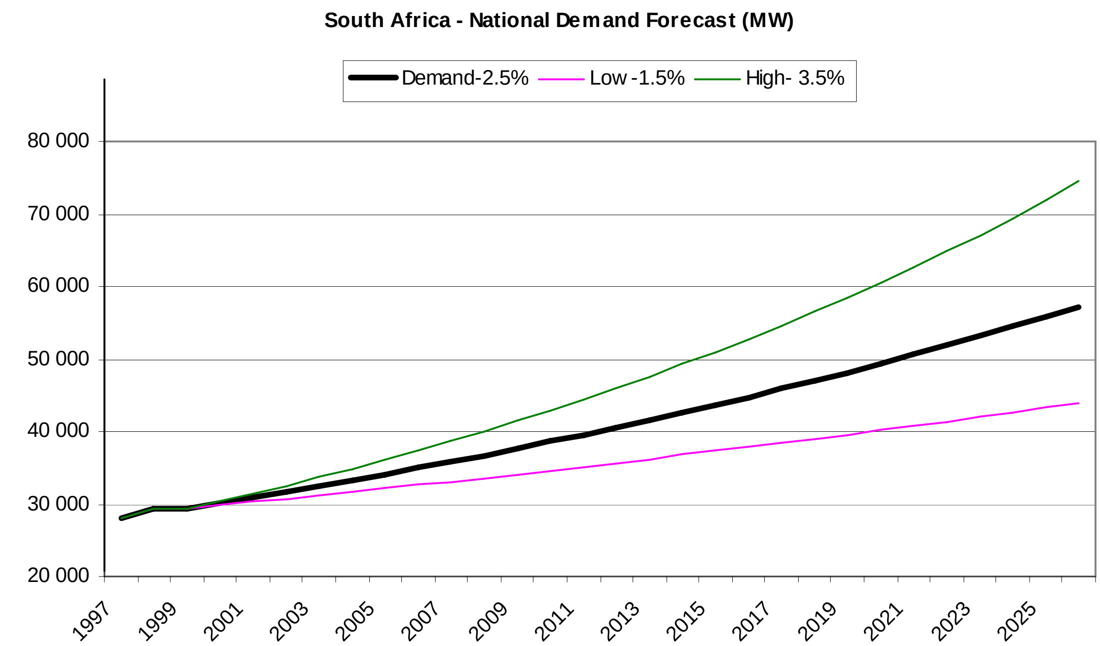
Supply and demand forecast

Today, South Africa's power generation capacity exceeds demand due to a decline in economic activity starting in the late 1980s and South Africa's large investment in power capacity in the 1970s and early 1980s. Assuming reasonable growth of 2.5%, the demand for electricity can be met by existing capacity over the next eight to nine years. South Africa has about 30,000 MW operating capacity and another 10,000 MW fully amortized excess capacity consisting of moth-balled coal-fired steam power plants which are being reactivated as needed. As South Africa is currently investing in new gas pipeline capacity, it is possible that, at the time when demand has caught up with capacity (anticipated to occur in eight or nine years), the country would accelerate the building of new gas-fired power capacity to meet the growing demand. Alternatively, the coal-fired power generation capacity could be expanded or some mixture of gas and coal derived power could be added.

According to Eskom's annual reports and statistical reports the 4 year average electricity demand growth from 1996 –2000 was only 1.5%, but the 1 year growth between 1999-2000 was 2.8%. Eskom's forecast

of electricity demand is based on three scenarios of economic growth at 3.5%, 2.5% and 1.5%. With actual annual GDP growth of 2.7% (treasury department), the middle scenario was deemed the most likely for demand projections. Recent year (through 2004) growth statistics suggest that a middle to high range is more likely.

Electricity demand forecast, South Africa 1997-2025



Source: NER

Long run marginal costs with excess supply

The long run marginal costs of the South African grid are determined by the generating costs of the existing capacity up to the point where investment in new capacity is required. That is, until existing capacity is exhausted and new capacity must he installed, the long-run marginal costs in South Africa are equivalent to the short-run marginal costs. The current generation costs per kWh in a fully depreciated Eskom power plant are estimated to be US$0.004. Depending on coal price, heating content and plant efficiency this could range from US$0.003 to US$0.005 per kWh. The reactivation of the moth-balled power plants is not at this time leading to even slightly higher generation costs. For the World Bank Renewable Energy Program being developed in South Africa, the current Eskom generation costs are conservatively assumed to be US$0.0105 per kWh rising to no more than US$0.0225 – in 5 to 7 years at the soonest – including the reactivation of moth-balled capacity and some new gas-fired capacity.[3]

Long run marginal costs to meet growing future demand

[3] See World Bank (2002) South Africa: Renewable Energy Market Transformation, Project Concept Document (PCD) Africa Regional Office, AFTEG

Natural Gas from Mozambique is a possible least cost expansion option for Eskom to develop within South Africa after the electricity demand has outgrown existing capacity, including the moth-balled coal-fired capacity. No political obstacles are to be expected since South African firms are already controlling many gas fields in Mozambique. This assumes that no new coal-fired capacity would be developed in South Africa. However, South Africa maintains the option to increase coal-fired power capacity and may pursue this option, if such coal-based capacity results in lower power generation costs than the use of pipeline gas. The coal-based option therefore serves as a low-cost fall back option, e.g. if gas prices increase significantly. Assuming gas-fired power expansion, with which landfill gas-derived electricity would have to compete, appears therefore as a conservative assumption.

The most likely US$ value for the gas transmitted by pipeline from the relatively nearby gas fields would be in the vicinity of US$2.00 – 2.50 per million Btu, before considering the petroleum product market price impact on gas pricing. At the value assumed that would put it close to the point where a Combined Cycle plant would be competitive with a Simple Cycle plant. For purposes herein, both cases will be considered as will gas prices of $2.00 and $2.50 per million Btu, based on the calculation given in table 3. The financing term is a 10 years period.

Generation costs of a simple and a combined cycle gas turbine

	Simple Cycle	Combined Cycle
Capital Cost – US$/MW	0.55	0.85
Efficiency - %	38	49
Heat Rate – Btu/kWh	8,980	6,965
Fuel Cost/kWh ($2 gas) - $/kWh	0.0179	0.0139
Fuel Cost/kWh ($2.5 gas) - $/kWh	0.0224	0.0174
O&M + admin... Cost - $/kWh	0.0025	0.0030
Debt Service - $/kWh	0.0104	0.0161
Estimated LRMC	**US$0.0308 – 0.0353**	**US$0.0330 – 0.0365**

Source: Own calculations

The projected increase in power demand over time and the options to meet this demand results in an increase over time of generation costs in the South African power system (Table 3). The Table shows in Line (1) the current demand, which is met by existing mostly coal-based capacity in a situation of excess generation capacity, and the associated costs (mainly operating and maintenance costs). Line (2) shows the costs at a time when demand growth has caught up with existing capacity (projected in eight to nine years). And Line (3) shows the long-run marginal costs that include the addition of new capacity to the system in order to meet further growing demand.

LRMC in relation to MW demand

System condition	Demand	LRMC in US$ per kWh
(1) Current demand	Up to 30.000 MW	0.004-0.0105
(2) Demand catches up with existing capacity	Up to 40.000 MW	0.0225
(3) New capacity added	> 40.000 MW	0.0308-0.0365

Source: Own calculations based on World Bank (2002) South Africa: Renewable Energy Market Transformation, Project Concept Document (PCD) Africa Regional Office, AFTEG and Table 2.

There seems to be no shortage with respect to South Africa's natural gas purchase from Mozambique and Namibia, and coal as a fall-back option is abundant and low cost in South Africa. It is thus safe to assume that over the project lifetime, long run marginal costs of the South African grid will not exceed US$0.0365. For the period until 2012 the generation costs will not likely exceed US$0.0225 and current Eskom tariff trends confirm this hypothesis.

E. Grid Emission Factor

0.90 kg of CO_2 per kWh (2003 Eskom Annual Report)

Annex 4

MONITORING PLAN

Attached to this document

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