THE PROTOTYPE CARBON FUND

Durban, South Africa
Landfill Gas to Electricity

Emission Reduction Study

Revised Draft
July, 2003

1. Purpose of the Emission Reduction Study

The purpose of the Emission Reduction Study (ERS) is to provide an estimate of the emission reductions from the Durban Landfill-gas-to-electricity Project for each year of the crediting period. Serving as basis for the purchase of emission reduction credits, the ERS shall give a realistic yet conservative estimate of the emission reductions to be expected. In addition, the ERS shall make transparent which are the main factors in determining the amount of generated emission reductions. The ERS thus is a tool for both, the seller and the buyer of emission reductions, to estimate future emission reductions and risks and to structure purchase contracts accordingly. It does not however replace the future metering of actual emission reductions.

The emission reductions are measured against the emissions of the baseline scenario which is described in the Baseline Study for the Durban Landfill-gas-to-electricity Project. To ensure consistency with the other documents, the emission reductions are calculated using the monitoring methodology detailed in the Monitoring Plan and the calculation spreadsheets provided with the Monitoring Plan.[1] Whenever necessary, default values as given by the Monitoring Plan are used to project future emissions.

2. Contents of the Calculation Spreadsheets

The calculation spreadsheets provided with the ERS contain the following sections:

Sheet 1: Summary of estimated emission reductions 2003-2024
This sheet contains the total of expected emission reductions as calculated in the other spreadsheets of the ERS workbook. It shows the amount of emission reductions resulting from avoided methane emissions and from displaced grid electricity for each landfill as well as for the project as a whole for each year of the crediting period.

Sheet 2-4: Calculation of emission reductions from avoided methane 2003-2024
These sheets calculate the expected emission reductions from avoided methane for Mariannhill (Sheet 2), Bisasar Road (Sheet 3) and La Mercy (Sheet 4). The basis for the calculations is the workbook provided with the Monitoring Plan, using default values from the Monitoring Plan and data input from sheets 5-7

Sheet 5-7: Estimation of gas flows and gas utilization 2003-2024
Sheets 5 (Mariannhill), 6 (Bisasar Road) and 7 (La Mercy) serve as input to the calculations in sheets 2-4. They provide an estimate of the yearly gas production in each landfill and hourly gas flows from project wells and from baseline wells. They also specify the amount of gas that is utilized for energy production and the amount of gas sent to flares.[2]

[1] Note however that the order in which the calculations are presented differ from the MP spreadsheet.
[2] This data has been provided by the independent landfill expert Bob Couth of the UK based company Enviros.

Sheet 8-10: Calculation of emission reductions from electricity displacement 2003-2024
These sheets calculate the expected emission reductions from displaced grid electricity for Mariannhill (Sheet 8), Bisasar Road (Sheet 9) and La Mercy (Sheet 10). The basis for the calculations is the workbook provided with the Monitoring Plan, using default values from the Monitoring Plan and data input derived from sheets 5-7.

3. Projection of Emission Reductions

Sheet 1 of the ERS spreadsheets summarizes the emission reductions that are expected from the project. It specifies the future emission reductions resulting from avoided methane emissions and from electricity displacement for each of the three landfills. The last two columns contain the total emission reductions for each year of the crediting period as well as the cumulative total.

Year	Methane ERs from Mariannhill	Methane ERs from Bisasar	Methane ERs from La Mercy	ERs from electricity production Mariannhill	ERs from electricity production Bisasar Road	ERs from electricity production La Mercy	Total	Cumulative Total
2003	11148	66889	50963	0	0	0	**129000**	**129000**
2004	29167	182379	56059	3560	21360	0	**292526**	**421525**
2005	35571	228347	61155	3560	28480	0	**357113**	**778638**
2006	41968	274328	57333	3560	35600	0	**412788**	**1191427**
2007	48940	275654	54021	7120	42720	0	**428454**	**1619881**
2008	55344	275365	51323	7120	42720	7120	**438992**	**2058873**
2009	58548	275386	47755	7120	42720	7120	**438649**	**2497521**
2010	64942	275407	44263	7120	42720	7120	**441571**	**2939093**
2011	71961	275428	41969	10680	42720	3560	**446319**	**3385411**
2012	75165	343484	38912	10680	49840	3560	**521641**	**3907052**
2013	81698	331994	36109	10680	49840	3560	**513881**	**4420933**
2014	84883	308446	33306	10680	42720	3560	**483595**	**4904528**
2015	88068	286022	31522	10680	42720	3560	**462573**	**5367101**
2016	91943	268335	29738	14240	35600	3560	**443417**	**5810517**
2017	95128	252536	27445	14240	35600	3560	**428510**	**6239027**
2018	98314	235719	25661	14240	35600	3560	**413094**	**6652121**
2019	101499	218031	23623	14240	28480	3560	**389433**	**7041554**
2020	104684	201723	21404	14240	28480	0	**370532**	**7412085**
2021	104684	190512	19875	14240	28480	0	**357791**	**7769876**
2022	107869	176901	18347	14240	21360	0	**338717**	**8108593**
2023	111054	165180	16818	14240	21360	0	**328652**	**8437245**
2024	114929	153458	15798	17800	21360	0	**323346**	**8760591**
Total	**1677507**	**5261525**	**803400**	**224280**	**740480**	**53400**	**8760591**	

4. Basic Assumptions and Risk Analysis

When estimating the emission reductions resulting from the project, different types of assumptions have to be formed. These include:

1) Assumptions regarding operation of the project
2) Estimates of parameter values
3) Estimates of measured data

The specific assumption underlying the estimation of emission reductions from the project are detailed in the following paragraphs.

4.1 Assumptions regarding operation of the project

Regarding the operation of the project, the ERS assumes that the landfill operator DSW will install an estimate of 180 wells for gas extraction and 10 MW capacity to generate electricity. The ERS also assumes that DSW will be able to feed the generated electricity into the municipal grid and to secure power purchase agreements with eThikwini Electricity for all three landfills.

The first risk factor regarding the operation of the project is whether and in which timeframe the landfill operator will install the envisaged number wells. Given that DSW has already gathered experience with the installation of production wells in the past this risk is perceived as low.

The second risk factor is whether DSW will be able to secure power purchase agreements for all sites as assumed. So far, no agreement has been signed with eThikwini Electricity. The risk seems highest for the remote site La Mercy where access to substations of the grid is limited. The ERS takes this risk into account by assuming electricity delivery to the grid only after 2008.

4.2 Estimates of parameter values

In the orange cells of the calculation spreadsheets parameter values have to be entered which remain constant over defined periods of time. With the exception of the efficiency of the flares (97%) and the weight and calorific value of methane, all parameter values will only be specified once the project becomes operational. Some of them will have to be revised regularly. For the purpose of projecting the emission reductions the parameter values are estimated as follows:

- Methane content of landfill gas: 50%
- GWP of methane: 21
- Generator heat rate: 14000 kJ/kWh
- Emission intensity of the South African grid: 0.89 t CO_2/kWh

The projection of emission reductions is primarily based on what is termed the confirmation method in the Monitoring Plan using estimates of landfill gas extraction and

methane content of the gas. The primary method which calculates the emission reductions partly from the electricity output is used only to cross check the results. Thus, the estimated parameter value for generator heat rate plays no major role for the ERS.

An important factor in the projection is the methane content of the landfill gas. An average of 50% methane content however seems a safe estimate given the characteristics of the landfills (inter alia age and capping). Test drillings at the Mariannhill landfill site seem to confirm this estimate.

The assumed emission intensity of the grid is based on today's data from Eskom. In future, the emission intensity is expected to go up in the early years when mothballed coal-power plants are revitalized and to drop in the long-run when more gas-fired power plants are introduced into the system. It is not envisaged that this will have a major impact on the expected amount of emission reductions.

There is currently no indication that the IPCC would change the revised GWP of 23 for methane.

4.3 Estimates of data measurements

The most crucial assumption for the ERS are the estimates of data inputs that will be entered into the yellow cells of the spreadsheets. These estimations have thus been made with particular caution and conservativeness.

The data inputs are based upon a projection of gas flows done by the UK based company Enviros. The gas production was computer modeled using industry standard assumptions based on the known characteristics of the existing landfills and land fill practices, test well production results, plus projecting what the future composition of the waste stream will be. The model results can be categorized as conservative by nature of the assumptions used by the industry in such models.

4.4 Summary of risks

The following table summarizes the identified risk areas and evaluates their impact on the projected amount of emission reductions.

Assumptions in the ERS	Risk High, Medium or Low	Impact High, Medium or Low
Landfill operator will install envisaged number of wells	Low	High
Landfill sites are able to secure power purchase agreement	Medium	Medium-high
Methane content equals 50%	Low	Medium
On average, grid emission intensity equals 0.89 t CO_2/kWh	Medium	Low
Model computations are a conservative estimate of real flow of landfill gas	Low	High

Annex 1: ERS Spreadsheets