THE PROTOTYPE CARBON FUND

Durban, South Africa
Landfill Gas to Electricity

Monitoring Plan

Revised Draft
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1. The Monitoring Plan

1.1 Purpose of the MP

In the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol, monitoring describes the systematic surveillance of a project's performance by measuring and recording performance-related indicators relevant to the project or activity. Verification is the periodic auditing of monitoring results, the assessment of achieved emission reductions (ER) and of the project's continued conformance with all relevant project criteria.

This document contains the Monitoring Plan (MP) for the Durban Landfill-Gas-to Electricity Project. It describes the requirements for the collection, processing and auditing of data from the project for the purpose of calculating and verifying the ERs the project has produced.

1.2 Use of the MP

The MP is a working document that identifies key performance indicators and sets out the procedures for tracking, monitoring, calculating and verifying the impacts of the project.

This MP must be used for the planning and implementation of the project and during its operation. Adherence to the instructions in the MP is necessary to successfully measure and track the project's impacts and prepare for the periodic audit and verification process that will have to be undertaken to confirm the ERs achieved by the project. The MP is thus the basis for the production and delivery of ERs to the PCF or other buyers and for any related revenue stream.

The MP contains the requirements and instructions for:

- establishing and maintaining the appropriate monitoring system for the calculation of ERs;
- checking whether the project meets key sustainable development indicators;
- implementing the necessary measurement and management operations;
- preparing for independent, third party audits and verification of ERs.

The MP must be:

- adopted as key input into the detailed planning of the project, and
- included into the operational manuals of the project.

The data monitored as per this MP are to the extent possible in line with the kind of information routinely collected by the project operator. The MP can be updated and adjusted to meet operational requirements, provided such modifications are approved by the Verifier during the process of initial or periodic verification.

2. Calculation of Emission Reductions and Monitoring Obligations

The emission reductions from the Durban Project result from:

1. Avoided landfill methane emissions due to collection, utilization or flaring, and conversion to CO_2 of the methane in the landfill gas;
2. Avoided CO_2 emissions due to displacement of grid electricity with landfill gas-generated electricity

Each element of emission reductions will require a separate monitoring and calculation process, as outlined in the sections below. These emission reduction calculations will be carried out for each of the three landfill sites.

2.1 Avoided methane emissions from gas utilization and flaring

To calculate the emission reduction resulting from avoided methane emissions one needs to determine the total amount of both, methane combusted for electricity production and excess methane flared. From this, the amount of methane that would have been flared in the baseline scenario has to be subtracted.

The proportion of gas that is extracted from the baseline wells is changing over time and cannot be predicted with sufficient precision. It is thus necessary to clearly distinguish between the project wells and those wells that are necessary for local safety (baseline wells) and monitor the extracted volumes separately.

Figure 1 shows a model of the planned system of landfill gas extraction and utilization in the three landfills: Landfill gas is extracted through baseline (or safety) wells and production wells. Landfill gas from both types of wells is collected in a single pipeline system which delivers the main part of the gas to engines for production of electricity, while a minor part is flared.

Only landfill gas from the production wells is to be counted for the purpose of claiming emission reductions, since baseline wells would also operate without the project. The calculation system is complicated by the fact that engines and flares combust landfill gas with different efficiencies and it is unclear with which portion the gas from project wells is either flared or utilized.[1] However, in combination with known technical parameters, the system is fully determined if three out of the four gas flow variables (A, B, C, X) are metered and the methane content in the landfill gas is determined through gas analysis or

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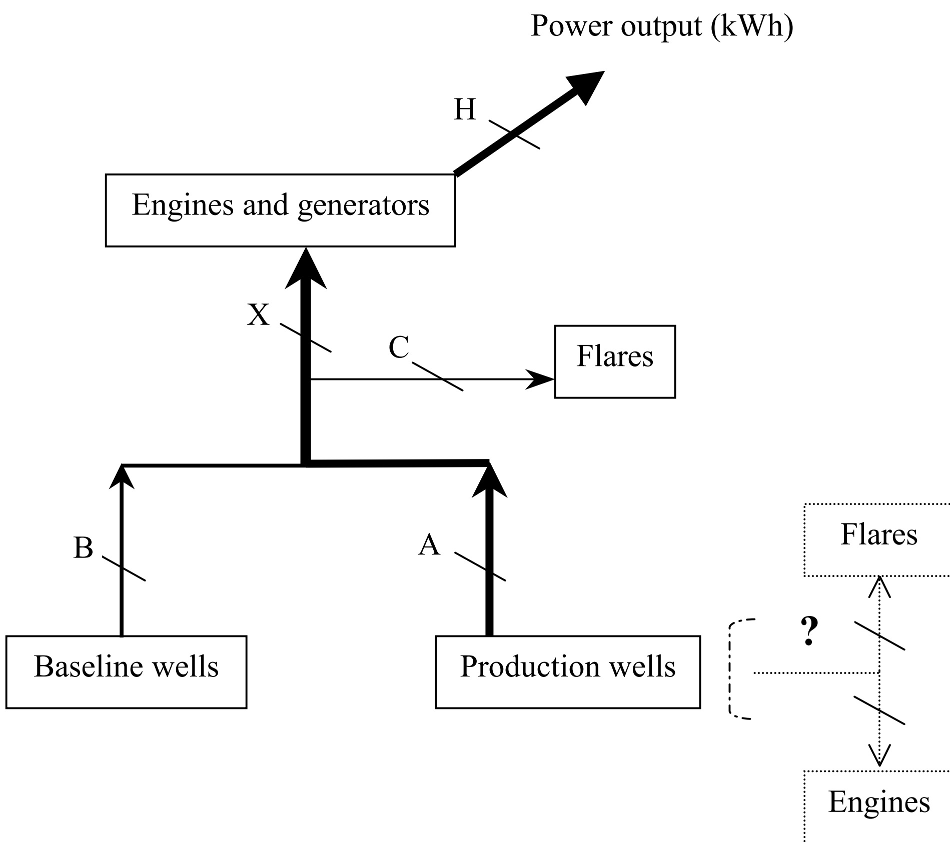
[1] While the gas engines are converting methane into CO_2 at a roughly 100% efficiency, the flares have a design efficiency of 99%. As they are blown out by the wind on average twice a month, a conservative assumption is an efficiency level of 97% in order not to overstate the emission reductions. Not all methane collected will thus be converted into CO_2 but a small portion will be emitted as methane into the atmosphere.

indirectly in combination with input variable X by metering the electric output variable H. This MP makes use of the system's inherent redundancy for quality assurance purposes.

Figure 1 – Model of gas extraction and utilization or flaring



Based on the system configuration depicted in Figure 1, this MP proposes two monitoring and calculation methods to determine emission reductions. The first method 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 (e.g. leaks in gas pipelines). This method is used as the preferred and primary monitoring method. 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. Please note that meters must be read regularly. Monthly aggregates of metered data is used in all spreadsheet calculations.

The following description refer to Figures 2 and 3; the variables are defined in Figure 1 and in the annexed spreadsheet.

2.1.1 Calculation from electricity production (primary method)

The primary method uses the monthly aggregates of the following four metered variables: Gross electricity production in kWh (H), volume of LFG sent to engines in m^3 (X), volume of landfill gas flared in m^3 (C), and volume of LFG extracted from baseline wells in m^3 (B). The calculation method is shown in Figure 2, exact formulas are contained in the attached spread sheet. The method assumes that equal proportions of LFG from baseline and production wells is sent to engines and flares.

The method first calculates the quantity of methane combusted in engines using engine kWh output and technical parameters (Steps 1 – 3 in Figure 2). The amount of electricity produced is routinely recorded by the project operator and also by the electricity purchaser (net of the self-use component, or parasitic load). As methane is the only energetic component of landfill gas, the measuring of the electricity output allows to estimate the tons of methane burnt. First, one needs to calculate the calorific input that is necessary to produce the measured amount of kWh. For this, the electricity production figures have to be multiplied by the generator heat rate as specified by the manufacturer[2,3] Using the calorific value of methane (37,000 kJ/m^3 CH_4), the amount of methane combusted can then be calculated. One cubic meter of methane weighs 0.000714 tons.[4]

Secondly, the method calculates the tons of methane combusted in flares (Steps 4-6, Figure 2). Step 4 calculates the methane content in LFG by dividing the volume of methane burnt in the engines (as derived from the kWh output) by the volume of LFG sent to engines. This proportion is used in Step 5 to calculate the tons of methane combusted in the flares. For this, the volume of LFG flared has to be multiplied by the proportion of methane in LFG, the default efficiency of 97% of the flares and the weight of methane.

Step 6 calculates the proportion of LFG collected from production 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 net amount of methane combusted by the project activity for which credits can be claimed. Step 8 concludes the calculation by multiplying with the global warming potential (GWP) of methane. The GWP attributed to methane by the IPCC has lately been increased to 2~~3~~1.

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2 For the purpose of projecting the emission reductions, a heat rate of 15000 kJ/kWh is assumed.

3 The efficiency level may drop if the engines are poorly maintained or not operated at optimal load factor e.g. in times of fuel shortage. Using the design efficiency is conservative because in times of under-performance more methane is combusted per kWh output than what is claimed for as emission reduction.

4 The heating value and the weight per unit volume are a function of temperature and other factors with several options that are acceptable industry standards available for referencing. It is important to identify the standards being used in any documentation and to make sure that appropriate conversions are made at the conditions the materials are handled. European and US temperature standards vary as do the use of lower and higher heating value (LHV & HHV).

If combusted, methane is converted into CO_2. As the methane is organic in nature these emissions should not count as project emissions. The CO_2 released during the combustion process was originally fixed via biomass so that the life cycle emissions of landfill gas are zero.

Figure 2 – Key steps of the primary calculation method

Methane combusted in engines

Step 1

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

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Step 2

Obtain total energy input to engines (in GJ) – (I) by multiplying with generator heat rate. Use manufacturer information for heat rate – (h) (15,000 kJ/kWh as default).

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Step 3

Convert total energy input (in GJ) – (I) 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)

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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)

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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)

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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)

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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~~3~~)

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Tons of CO_2e reduced from methane

2.1.2 Calculation from flow meters (quality assurance method)

While the approach outlined above serves as the primary method to calculate the emission reductions that the project will claim on a monthly basis, the project operator should periodically confirm his monitoring and calculations results through the use of data collected from upstream flow meters and periodic (quarterly) laboratory analysis of methane content in landfill gas. As the landfill gas is extracted at different sites of the landfill and as the extraction is optimized for electricity generation, the average methane content is not expected to vary significantly over time. A quarterly analysis of gas samples is thus considered sufficient for quality assurance purposes. The gas samples must be sufficient in number and drawn at locations that allow to arrive at a statistically significant result.

The confirmation method uses the monthly aggregates of the following three metered variables: Volume of landfill gas flared in m^3 (C), and volume of LFG extracted from baseline wells in m^3 (B), and volume of LFG extracted from production wells (A). The method also uses quarterly laboratory values for the methane content in landfill gas (Y).[5] The calculation method is shown in Figure 3, exact formulas are contained in the attached spread sheet. The method assumes that equal proportions of LFG from baseline and production wells is sent to engines and flares.

The starting point of the confirmation method is the extracted gas from project wells. It then 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_2e) by converting methane volume into tons of methane and multiplication with the global warming potential.

[5] For projection purposes, a value of 50% methane content is assumed.

Figure 3 – Key steps of the quality assurance method

from flow meters at project wells

from flow meters at project wells, baseline wells and flares

Step 1
Take the volume of extracted landfill gas from project wells (m3) – (A)

Step 2

Calculate the proportion of landfill gas combusted – (b), using gas flow at baseline wells – (B), and production wells – (A), and gas sent to flares – (C), as well as flare efficiency – (a)

Step 3
Calculate volume of combusted gas collected from project wells – (D), using proportion of all gas combusted – (b), and gas extracted from project wells – (A)

Step 4

Calculate methane combusted by project – (E), using volume of combusted gas from project wells – (D) and methane content of landfill gas obtained through quarterly sampling – (Y)

Step 5
Convert into tons of methane – (F), using volume of methane combusted by project – (D) and weight of methane – (e) (= 0.000714 t CH4/m3)

Step 6
Obtain emission reductions – (G) by multiplying tons of methane combusted – (F) with the global warming potential of methane – (f) (factor 21~~3~~)

Tons of CO_2e reduced from methane

In the event that the quality assurance method shows significant differences (larger than 5 per cent deviation), the project operator will investigate and identify the source of the deviation and either repair or adjust the gas collection and utilization system or correct and improve the monitoring and metering system. If a significant deviation occurs the lower results have to be taken until the error has been identified.

2.1.3 Development of the baseline scenario over time

The baseline scenario considers the possibility that new regulations may require upgrading of the landfills as they would operate in the absence of the project. Currently, landfill operators in South Africa are not required by law to collect landfill gas but only have to make sure that the monitored and reported concentration of CO_2 and methane stays below a certain threshold. If the national or regional law eventually requires the collection and flaring of landfill gas, the baseline scenario needs to be reexamined and potentially adjusted. The adjustment can, e.g., be done by reassigning some production well as baseline wells. At any point in time, the baseline scenario needs to include the wells that would have to be installed in order to comply with national or regional regulations. The project developer thus needs to monitor for changes in the regulation.

2.1.4 Monitoring obligations

The project operator DSW must implement the following data measurement and monitoring requirements for the key variables that determine the emission reductions from the combustion of methane:

- *Landfill gas flow from project and from baseline wells*: The project operator should clearly distinguish between project and baseline wells and install gas flow monitoring devices which allow for separate measurements of gas flows for baseline and ER determination purposes. Gas flows have to be constantly measured with aggregated totals recorded at monthly intervals for verification purposes. The hourly and/or daily flow records will be properly stored for easy access for verification, if and when needed. The gas flow meters should be specified to some South African or other recognized international standards including calibration, accuracy, and other such factors. To determine the volume of methane flared it will also be necessary to monitor the functionality of the flare itself. This should include at a minimum consideration of the specified flare efficiency and a record of all flare outage times for any reason. (e.g., through ignition control).
- *Landfill gas combusted in flares*: The volume of landfill gas sent to flares has to be measured and recorded at monthly intervals. Care must be taken that all aggregate date always covers the exactly the same time period.
- *Methane content of landfill gas*: The project operator needs to analyze the average percentage of methane in the landfill gas from the Bisasar Road, the Mariannhill and the La Mercy site. Samples need to be drawn from all three landfill at quarterly intervals. Samples must be drawn in such a way as to permit statistically significant laboratory result.
- *Gross electricity production*: The project operator must install electric meters to record the kWh output of each gas engine. The meters must be read and the metered data recorded at appropriate intervals, but at least at the end of each

month. The meter should be able to record daily data, ideally in electronic form, that can be automatically processed and reported.[6]

- *Heat rate of gas engines*: Record the design heat rate according to manufacturer's information in the spreadsheets and keep the heat rate updated in case if engine efficiency drops or engines are replaced.
- *Regulatory framework for landfill operators*: monitor development of regulatory system and adapt the baseline scenario to changes in the regulation (if collection and flaring of landfill gas is required by law) and adjust impact of regulation on emission reduction calculation, e.g. by reassigning production wells as baseline wells.

All monthly figures have to be recorded in the electronic workbook provided in Annex I. Care must be taken that monthly aggregated data always strictly covers the same time period.

2.2 Avoided Emissions from Displacing Electricity Generation

By feeding electricity into the Durban municipal grid, the Durban landfill-gas-to-electricity-project displaces emissions at other fossil fuelled power plants that supply electricity to the South African grid. In order to calculate the emission reductions achieved through the project one needs to estimate the effect on the other power suppliers.

As will be seen below, the characteristics of the South African power system permit a simplified approach to the calculation of emission reductions achieved through replacing grid power. For the calculation of emission reductions emission factors are used that are annually reported by Eskom. This is convenient as it lowers monitoring costs and it is appropriate for this project as the amount of emission reductions from the displacement of electricity generation is relatively small. In order to safeguard environmental integrity, these emission factors are estimated in a conservative fashion and have to be reexamined at regular intervals.

2.2.1 Grid Electricity Carbon Emission Factor

When operative, the gas engines at the three landfill sites will run continuously. Due to the high acidity of landfill gas, the operation of the engines at other than optimal temperatures is not recommended as it results in accelerated deterioration. Hence, the project operator will avoid switching off the engines except for maintenance purposes. Furthermore, the capacity installed at the three landfill sites is determined by fuel availability. Additional 0.5 or 1 MW units will only be added if enough landfill gas is

[6] The project operator will also meter the electricity sold to the municipal grid (Section 2.2.2). The difference between gross and net electricity production equals the parasitic losses of the power plant. Since parasitic consumption is predictable (manufacturer numbers), comparing gross and net meter readings adjusted for parasitic losses is an excellent confirmation procedure.

available to sustain a constant load. The gas engines to be installed by the project can thus be classified as must-run capacity.

Through the purchase of the landfill derived power, eThekwini Electricity will reduce the amount of power it purchases from the national electricity utility company Eskom. While normally small-sized power generation facilities can be assumed to replace marginally dispatched power in the grid, it is highly improbable that the project will significantly affect the dispatch of peak load plants. Due to the overcapacity of power generation and the high cost differential between base load and peak load power plants in South Africa – the fuel costs of fully depreciated coal power plants serving as base load are as low as US$0.004 per kWh as opposed to generation costs of US$0.03 per kWh for peak load gas turbines – the dispatch of peak load plants is always minimized by Eskom and serve only as a "shock absorber" in the South African grid. Given the character of the project as must-run-capacity and because of its very small contribution to meet the overall Durban metro-area demand, it can be expected that Eskom will reduce the dispatch of the base load power plant with the highest marginal costs in its regional supply mix to adjust for reduced power purchases by eThekwini Electricity. The project is therefore highly likely to displace electricity primarily from other base load suppliers.

To calculate the emission factor the emissions from coal-fired power plants in South Africa are averaged. The regional dispatch mix could be evaluated, but it is expected that the overall average and the regional average will not differ significantly. ~~Eskom publicly reported for the year 2001 that it emitted 169,300,000 tons of CO_2 from the sales of 181,511,000 MWh of electricity. From this it can be calculated directly that for every MWh sold by Eskom a minimum of 0.9327 tons of CO_2 were emitted.~~ Eskom publicly reported for the year 2002 that for every kWh it produced, 0.89 kg of CO2 were emitted (Eskom Annual Report 2002).It is expected that Eskom and any supplier that may replace Eskom will continue to make this data available in the future, which allows a simple calculation of the emission reductions achieved by the project from displacement of electricity:

The calculation of emission reduction from displacement of electricity is done on a monthly or annual basis by multiplying the electric power delivered by the project to eThekwini Electricity (or some other buyer) with an emission factor that is derived from data reported for by Eskom for the same year. The previous year's emission factor can be used on a provisional and temporary basis, provided that the results are corrected as soon as the actual data for the year in question is released by Eskom.

The approach adopted here for the calculation of the emission factor is conservative meaning that it will most probably underestimate the emission reductions achieved for the following reasons:

- Averaging the emissions across all Eskom power plants includes the low emission intensity of more efficient coal-fired plants as well as of power plants that do not use coal. The project however is likely to displace power from 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 its generated 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 data as reported and therefore in the emission factor as calculated above.

2.2.2 Monitoring obligations

The project operator DSW must implement the following data measurement and monitoring requirements for the key variables that determine the emission reductions from the displacement of electricity:

- *Net electricity production*: The project operator must record the net electricity delivered to the Durban grid at monthly intervals. The data can be obtained either directly from readings of meters installed at the substations where electricity is fed into the municipal gird. The data can also be obtained by metering parasitic load and subtracting it from the generators' power output.[7]
- *Eskom's publications of CO_2 emissions*: Eskom publishes its MWh sold and the CO_2 emissions related to its electricity production on a yearly basis. The project operator must calculate the emission factor each year based on these publications. Such information is available at the Eskom website, www.eskom.co.za under the publications section. The CO_2 information is published in the annual reports.

The calculation method used to obtain the emission factor will remain a conservative approach as long as the Eskom capacity mix does not change dramatically and the dispatch of natural gas turbines is limited to peak hours. Given the available projections of demand and the availability of moth-balled coal power plants, this is likely to be the case at least over the next seven years, the length of the first crediting period. With the renewal of the crediting period, a reexamination should be done to forecast the time when the surplus capacity is expected to be fully engaged. At that time, a reexamination of the method of deriving the carbon emission factor will be required. It is expected that, by this time, a suitable method will have been developed and approved that will allow for an easy calculation of emission reductions from displacement of grid power in South Africa.

3. Sustainable Development MP

The project is expected to improve the environmental and social conditions at the project site. It is therefore expected to meet the CDM sustainable development requirement on a

[7] The second method remains accurate as long as the electricity consumed by the landfill site (beyond parasitic load) is purchased back from eThekwini Electricity as is current practice.

long-term basis. To demonstrate the sustainable development contribution of the project is, the project operator is required to monitor and report on the following sustainable development indicators annually:

Environmental indicators:

- *Impact of the project on ground water quality*: The operator will monitor and report on the leachate collected from production wells and its proper disposal
- *Impact of the project on ambient air quality*: The operator will monitor and report on a reduction in incidences of bad air quality caused by landfill emissions.

Socio-economic indicators:

- Number of sustainable jobs created over the lifetime of the project

The waste management operations at the three landfill sites are already making other contributions to improve the environmental and social conditions in their vicinity. These contributions, although not a direct consequence of the CDM project activity, are likely to be positively influenced by the project and are therefore included here for reporting purposes. The operator will monitor and report on the following indicators once every four years.

Additional environmental indicators:

- *Local vegetation*: The operator will monitor and report on the vegetated area in per cent of total denuded area within the landfill sites.
- *Protection of biodiversity*: The operator will monitor and report on the number of indigenous species protected / reintroduced in the area of the landfill sites.

Additional socio-economic indicators:

- *Waste recycling*: The operator will monitor and report on the recycling of waste and the resale value of recycled goods.

The workbook provided with this MP includes a worksheet on sustainable development indicators which needs to be filled in on an annual basis. The expected project performance as measured by these indicators must be detailed in the worksheet by the project operator before the initial verification of the project.

The project must comply with all future environmental laws : for example, possible new regulations on air quality. The abovementioned indicators should be confirmed, and if necessary, supplemented by the sustainable development criteria currently under development in South Africa.

4. Management and Operational Systems MP

In order to ensure the successful operation of the project, and the credibility and verifiability of the ERs achieved, the project must have a well-defined management and operational system. It is the obligation of the project operator to put such a system in place. The system must include the operation and management of monitoring and record keeping as described in this MP. The proper functioning of the management and operational system must be monitored by the project operator and will be subject to third party verification.

It is the responsibility of the project operator to develop and implement a management and operational system that meets the requirements of the project and of this MP. This MP can only offer general guidance in this regard. This includes:

Data handling:

- The establishment of a transparent system for the collection, computation and storage of data, including adequate record keeping and data monitoring systems is required. The system should allow automated recording and reporting of data. The project operator must develop and implement a protocol that provides for the above functions and processes, which must be suitable for independent auditing.
- For electronic and paper based data entry and record keeping systems, there must be clarity in terms of the procedures and protocols for collection and entry of data, use of workbooks and spreadsheets and any assumptions made, so that compliance with requirements can be assessed by a third party. Stand-by processes and systems, e.g. paper based systems, must be outlined and used in the event of, and to provide for, the possibility of system failures. The record keeping system must provide a paper trail that can be audited.

Quality assurance:

- The project operator must designate a competent manager who will be in charge of and accountable for the generation of ERs including monitoring, record keeping, computation and recording of ERs, audits and verification.
- The project manager must officially sign off on all worksheets used for the recording and calculation of ERs.
- Well-defined protocols and routine procedures, with good, professional data entry, extraction and reporting procedures will reduce costs and time needed, while making it considerably easier for the auditor and verifier to do their work - the more organized and transparent the organization, the easier it is to track, monitor, audit and verify.
- Proper management processes and systems records must be kept by the project, as the auditors will request copies of such records to judge compliance with the required management systems. Auditors will accept only one set of official information, and any discrepancies between the official, signed records and on-site records will be questioned.
- Procedures should refer, as far as possible, to quality classes for equipment and standards for measurements and calibration. Insofar as possible, procedures should

refer to national and international standards. Many applicable standards are provided by the South Africa Bureau of Standardization.

Reporting:

- The project operator will also report to the PCF as per the Emission Reduction Purchase Agreement with the PCF.
- The project operator must prepare reports as needed for audit and verification purposes.

Training:

- The project operator will ensure that the required capacity and internal training is made available to its operational staff and that monitoring staff is properly trained to enable them to undertake the tasks required by this MP. Appropriate staff training must be provided before the project starts operating and generating ERs.

Preparation for operation:

- The management and operational system and the capacity to implement this MP must be put in place before the project can start generating ERs.
- This will be verified before the project can start to generate ERs acceptable to the PCF.

5. Auditing and Verification Procedures

Periodic auditing and verification of project results is a mandatory component for all CDM projects and a PCF requirement. The chief objective of the audit is to independently verify that the project has achieved the ERs reported. Audits are an integral part of the verification process and are undertaken in conjunction with verification and by the same firm.

This section of the MP outlines the auditing and verification procedures and prerequisites, in particular as they pertain to the project. The section provides instructions on how the monitoring work undertaken by the project operator as well as project performance and compliance with CDM requirements will be audited and verified.

While the PCF will select and contract the verifier, Durban Solid Waste is expected to coordinate the audit and verification process.

5.1 The PCF Audit and Verification Regime

The PCF submits every project to third party validation and verification, which is conducted by independent firms specializing in environmental auditing services (auditors,

validators, verifiers, certifiers). As soon as possible, PCF will use auditors that have obtained accreditation as Designated Operational Entities for CDM projects under the Kyoto Protocol regime.

The PCF verification system for CDM projects consists of four activities:

Validation of project design: PCF projects undergo validation of the project's design, baseline and MP against CDM requirements and modalities. Validation is a CDM requirement. PCF will not sign a contract for a project unless a validator has confirmed that the project design is in compliance with all relevant CDM requirements. The validated MP for a project must be followed by the project operator. This MP can be adjusted or amended, if necessary, in order to improve consistency with its objectives, general concepts and project circumstances, but such amendments are subject to approval by the project verifier. A renewal of validation is not necessary in this case.

Initial audit and verification of project readiness: The PCF requires that each PCF project successfully complete an initial audit and verification process before the PCF will commission the project and accept ERs delivered by it. While initial verification is not a CDM requirement, the PCF regards it as an essential and the final step in the PCF project preparation and implementation cycle. To prevent conflicts of interest, verification must not be conducted by the same firm and individuals that have provided validation services for the project. But the initial auditor / verifier may also provide subsequent verification services to the project. Initial verification provides an opportunity for verifiers to become familiar with the project, its context, the project operator and management.

The purpose of the initial audit and verification process is threefold:

- ensure that the project has been implemented as planned, that the monitoring system is in place and that the project is ready to generate and record GHG emission reductions.
- approve adjustments and amendments to the MP that may have become necessary during the detailed design and construction of the project.
- assist meeting PCF / World Bank supervision obligations and clear the way for generation of high quality ERs.

During initial verification auditors are expected to do the following. They will:

- familiarize themselves with the project and project circumstances,
- introduce the project staff to the audit and verification process,
- check whether the project has been implemented as planned,
- check whether assumptions that have an impact on the monitoring and verification processes and its outcomes are still reasonable, in particular baseline assumptions,
- confirm system readiness: that the MP has been implemented in the project's management and operational procedures and that all necessary monitoring elements are in place to ensure generation of verifiable emission reductions.

Periodic verification of emission reductions: All PCF projects must undergo periodic audits and verification of emission reductions. This is a CDM requirement and the basis for issuance of Certified Emission Reductions (CERs) and for their value in the market place. Verification is arranged by the PCF and conducted at annual or longer intervals as appropriate for the project.

The purpose of periodic audits and verification is to confirm that:

- the project has achieved the ERs claimed for the verification period in compliance with the methodology laid down in this MP.
- the claimed ERs are real and additional to any that would have occurred in the baseline scenario as interpreted and developed in the baseline study and this MP.
- the operation of the project continues to be in compliance with all Kyoto Protocol, PCF and host country requirements and modalities for CDM projects.
- the project maintains a high quality monitoring systems consistent with the MP.

As part of the periodic audit and verification process auditors are expected to:

- review and audit relevant monitoring records and reports,
- verify that the required measurements and observations have been made for all monitorable indicators in this MP and that all data inputs necessary for calculation of ERs are available,
- check whether the MP methodology has been applied correctly and consistently,
- check whether achieved ERs have been computed correctly using the provided spreadsheets, and, if necessary, recalculate achieved ERs,
- verify that the management and monitoring system, including data handling, record keeping and reporting, is in place and remains adequate,
- verify that the social and environmental targets in this MP have been met and that the project assists the host country in achieving sustainable development,
- consult with the operator on the continued adequacy of the monitoring system and approve any modifications that need to be made to ensure a high quality monitoring operation,
- undertake any other activities required by this MP, by the Kyoto Protocol requirements and modalities for the CDM, by the appropriate host country authorities or by professional auditing and verification standards and practice.

Verification concludes with a formal verification report. The report may include a statement that may permit the renewal of the project's crediting period twice every seventh year in line with applicable CDM rules and modalities (yet to be developed). In the absence of detailed requirements governing the renewal of the credit period, compliance with this monitoring plan and successful verification is considered sufficient basis of the renewal of the crediting period.

Certification of emission reductions: A successfully completed verification process and the related verification report provide the basis for the issuance by the verifier of an ER certificate. The certificate is a legally binding statement which confirms, if successful, the verification report's conclusion that the project has achieved the stated quantity of ERs in

compliance with all relevant criteria and requirements. The verifier's certificate constitutes sufficient confirmation for the PCF as to the project's ER performance.

The certificate is issued by the verifier for the project only and it does not automatically constitute or create Certified Emission Reductions (CERs) in the sense of Art. 12 Kyoto Protocol. However, the verifier's certificate may be used by the verifier, the PCF and/or South African authorities or authorized entities in the process of issuance and registration of CERs by the competent authority in line with applicable CDM and Kyoto Protocol modalities and procedures.

5.2 Auditing Criteria and Needs

Verification includes an audit of the project's output information and data and management systems on the basis of the following established criteria:

– Completeness
– Accuracy
– Coverage
– Risk Management Controls

Auditors and verifiers will request information (in the form of records and documentation) from the operator to determine if key performance indicators meet the objectives of the project as set out in this document. The operator is required to record all such indicators, and provide satisfactory documentation and an audit trail for verification purposes. The information that will be needed includes

- **Records on reported GHG emission reductions** including the electronic spreadsheets / workbooks and supporting documentation (assumptions, data estimations, measurement methods, etc)
- **Records on reported social and environmental performance** as measured by indicators and targets laid down in this MP
- **Records on project management,** including monitoring, data collection and management systems

The audit process followed, as with other management systems, is interactive, iterative and participatory. The auditors will determine the credibility and accuracy of the reported performance through spot checks of data measurement and collection systems and interviews with the key project participants. It is necessary for all involved in an audit to understand the audit process and verification requirements.

5.3 Audit and Verification Process

Audits procedures used to verify CDM projects are similar to audits of other environmental management systems (ISO 14000, EMS) and should complement these established processes where they are already in use by a project. Auditors / verifiers are

generally free to apply any method that represents good auditing practice and internationally accepted standards. Auditors typically conduct risk-based spot checks, which are checks of the key parameters and systems with the highest risks for data measurement and collection problems.

Audit preparation and requests for information: The auditor will familiarize himself with the project documentation, project reports, project requirements and expected project performance. The auditor will use this MP to prepare the audit process. He will make telephone contact, and if necessary, will request additional information from the project operator, the PCF and other project partners, relevant organizations and individuals. Two weeks should be allowed for the receipt of this information.

Development and delivery of an audit checklist: The auditor will develop checklists to guide the audit process. The checklists will cover the key points of the audit. The appropriate checklist will be sent to the project operator (auditee) accompanied by explanatory materials prior to a site visit. Two weeks should be allowed for review, comments and preparation by the auditee.

The audit: A visit will be made to the site to undertake the audit. The length of the audit visit is to be agreed between the auditor and PCF and depends on the complexity of the project and its monitoring system and on previous performance based on experience with the project and the operator. Audits on site do normally not require more than two days. The audit time will be spent checking records and undertaking interviews with staff and other individual, which will allow the auditor to complete the audit checklist. These activities are the basis for completing the verification process and for preparing the verification report.

Audit and draft verification reports: The auditor will produce an audit report and a draft verification report for the project, which summarizes the audit findings. The draft verification report will state the number of ERs achieved by the project and will point to areas of possible non-compliance if warranted. The report will also include conclusions on data quality, the monitoring and management and operational system, and other areas where corrective action may be required to come into compliance, improve performance or mitigate risks. The draft report will be submitted to the PCF; a copy will be sent to the project operator. All parties will be given opportunity to comment on the report.

Final verification report: The auditor will revise the draft report taking into consideration reviewers' comments and further findings and issue the final verification report, if possible within two weeks of receiving all comments. If justified, the final verification report will conclude and explain that, within the verification period, the project has generated the stated quantity of ERs in compliance with all applicable CDM and other requirements. The final verification report is the basis for the issuance of a certificate by the verifier, which will state and confirm the conclusions of the report.

Non-compliance and dispute settlement: In the event of non-compliance findings, the non-complying auditee will be given sufficient time to demonstrate compliance. An eight week period from the issuance of the draft report is recommended for the operator to

address identified deficiencies and come into compliance. It is the responsibility of the verifier to ensure that dispute over any non-compliance issue is communicated clearly and that any attempt is made to resolve it. The verifier will have final decision over the process. The verifier will also provide guidance as appropriate on how identified deficiencies can be corrected so that the operator can come into compliance in the following period.

Audit and verification schedule: Audits and verification of the project will be conducted annually at first, then at intervals over the life of the project. The audit schedule will be determined by the PCF in consultation with verifiers and the project operator. Audit intervals will depend on audit outcomes and experience with the project's performance and compliance with the MP, the quality of its monitoring management and operational systems, and the type and number of corrective actions required by the verifier.

5.4 Audit Responsibilities

Audit responsibilities are allocated between the project participants as follows:

The PCF:
– The PCF will make the arrangements for the audit and verification and select an auditor/verifier in accordance with CDM modalities and PCF requirements and selection criteria and in consultation with the relevant host country CDM authority. [has consultation with GoSA been agreed? Or can we drop this.]
– It is the PCF's obligation to ensure that the audit process is fair, that auditors/verifiers are fully independent of the project operator and other project participants and that all possible conflicts of interests are avoided. The PCF requires details of the experts to be used on the audit/verification team.
– The PCF will facilitate the audit work and verification process and will work with the project participants to ensure co-operation.

The project operator:
– The SP operator will prepare for the audit and verification process to the best of his abilities.
– He will facilitate the audit through providing auditors with all the required information, before, during and, in the event of queries, after the audit.
– The project operator will fully cooperate with the auditors and instruct staff and management to be available for interviews and respond honestly to all audit questions.
– It is the contractual obligation of the project operator and in his best interest to fully cooperate with auditors and verifier, since only successful verification will enable the delivery of ERs to the PCF in fulfillment of the operator's contract with the PCF.

Auditor / verifier:
– The auditors / verifiers must be designated operational entities accredited in accordance with CDM modalities (as soon as this is possible). They must be

professional organizations with a proven track record in environmental auditing and verification, experienced with CDM projects and work in developing countries. The audit firm must guarantee professional work and assure the quality of the audit and verification team.

– Auditors / verifiers must undertake the audit to the best of their professional ability. The auditor's responsibilities include to (a) provide the checklists and request for information in good time, (b) allow adequate time for sufficient review and preparation, (c) provide publishable reports in the agreed format, (d) work with the operator, host country authorities and PCF as appropriate, (e) report on lessons learnt during the course of the project.

6. Roles of Project Partners

Table 1 summarizes the roles and responsibilities of the project partners with regard to the monitoring system for the project.

Table 1– MP Management and Operation System: Roles of Project Partners

Task	SP Operator	PCF
Monitoring system	• Review MP and suggest adjustments if necessary • Develop and establish management and operations system • Establish and maintain monitoring and reporting system and implement MP • Establish or confirm sustainable development indicators and performance targets • Prepare for initial verification and start of project operation	• Review monitoring and management system
Data Collection	• Establish and maintain data measurement, collection and record keeping systems for landfill gas collection, power supply and sustainable development indicators • Check data quality, collection and record keeping procedures regularly	• Review data collection systems
Data computation	• Complete MP workbook • Or develop and use equivalent recording, calculation and reporting tool for ERs	• Review completed worksheets
Data storage systems	• Implement record maintenance system • Store and maintain records (paper trail) • Implement sign-off system for records and completed worksheets	• Receive copies of annual worksheets and reports • Maintain PCF records
Performance monitoring and reporting	• Analyze data and compare project performance with project targets • Analyze system problems and implement improvements (performance management) • Prepare and forward annual report and worksheets to PCF	• Review reports • Evaluate performance and assist with performance management
MP training and capacity building	• Develop and establish MP training, and skills review and feedback system • Ensure that operational staff is trained and enabled to meet the needs of this MP	• Assist with MP training and capacity building, if necessary and as agreed
Quality	• Establish and maintain quality assurance system with a view to ensuring transparency and allowing for	• Ensure project meets PCF / WB requirements and safeguards

Task	SP Operator	PCF
assurance, audit and verification	a view to ensuring transparency and allowing for audits and verification • Prepare for, facilitate and co-ordinate audits and verification process	requirements and safeguards • Ensure World Bank supervision • Arrange initial and periodic verification

Annex 1: Electronic workbook

This MP provides an electronic workbook that must be used to record monthly generation and avoided methane emission data and calculate monthly ERs. The project operator may use this workbook or will develop or obtain an equivalent tool for automatic recording, reporting and calculation of ERs. The tool should be integrated with the metering and reporting system.

The workbook contains three active sheets:

- Monthly Methane Avoided and Emission Reductions
- Monthly Power Supplied and Emission Reductions
- Sustainable Development Indicators

The workbook follows the steps outlined in the MP to calculate the emission reductions and uses the values specified there.

The following fields have to be completed by the project operator:

- **Project Name, Year:** To be completed when a new worksheet is started.
- **Signature and Date:** These fields are to be completed after every entry into the worksheet.

The following fields must be completed by the operator in the appropriate worksheet to record metered and/or otherwise determined data, which serve as input into the automatic calculation of emission reductions:

- **Gross Electricity Production:** Records monthly power output from engines (in kWh).
- **Volume of landfill gas combusted:** Records measurements from flow meters installed at wells, engines and flares.
- **Methane content of landfill gas:** Records quarterly laboratory analysis of landfill gas based on samples.
- **Net Electricity Production:** Records monthly electricity supplied by the project to the grid (in kWh) (measured by the project operator or power purchaser).
- **Sustainable Development Indicators:** Records the project's environmental and social performance in comparison to expectations using water and air quality as well as job creation as indicators. The worksheet records also non-project related sustainable development indicators (vegetation cover, biodiversity, waste recycling).

The project operator also has to determine and insert the values of the following (technical) factors:

- **Generator heat rate:** use manufacturer's information
- **Carbon Emission Factor:** This factor needs to be revised on a yearly bases as described in the MP

Upon completion, the workbook automatically calculates the emission reductions achieved by the project in each month.

The workbook uses the following color codes:

- **Title Field (gray):** Light gray fields describe data and are the headings for the worksheet sections.
- **Equation Fields (white):** Where appropriate, algebraic representations of the calculations being performed are included in the tables in the white fields.
- **Input Field - from database (yellow):** Yellow fields indicate cells in which the project operator is required to input and record monitored data
- **Input Field - from other sources (orange):** Orange fields indicate cells to which data is transferred from other calculations or reports (in particular technical parameters).
- **Calculation Fields (green):** Green fields contain formulas that automatically calculate an output once the project operator has entered the input data in the yellow and orange fields.

Each workbook must be saved with a unique name reflecting the year for which monitoring has been carried out. Paper or electronic records such as meter output and monthly energy billings must be kept available for inspection; the monthly recording must tally with the monthly billings.

The monthly workbooks together with the project operator's database and monitoring records form the "paper trail", which is essential for auditing purposes. These monthly workbooks will be a transparent record of electricity supplied, ERs, sustainable development data, etc. A copy of the monthly workbooks must be transmitted to the PCF.