# THE PROTOTYPE CARBON FUND

# Durban, South Africa
# Landfill Gas to Electricity

## Project Design Document

**Revised Draft**
**July 2003**

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## A. GENERAL DESCRIPTION OF PROJECT ACTIVITY

### A.1 Title of the project activity:

**Durban Landfill-gas-to-electricity project**

### A.2. Description of the project activity:

**NOTE: Please see the Durban Landfill-gas-to-electricity project Baseline Study and Monitoring Plan for more details and background information on all aspects of the project activity.**

The project consists in an enhanced collection of landfill gas at three 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. Currently, the Mariannhill and the Bisasar Road landfills collect and flare a portion of the methane generated for local, site-specific reasons. The third landfill site, La Mercy, which is located far away from residential areas, does not undertake methane recovery. The proposed project will substantially upgrade the current low 7.4% efficiency of the collection system (only a partial collection system), increasing to about 83% collection efficiency at the peak in 2012, and dropping to about 45% collection efficiency at the end of the commercial project life.

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. This is particularly relevant for the Bisasar Road and the Mariannhill landfill sites which are 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.

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:

- Durban Solid Waste (DSW), the municipal agency responsible for management and operation of multiple landfills in the Durban metropolitan area, will function as the technical advisor and the operational entity of the project.
- The eThekwini Municipality formerly known as Durban is the project sponsor.

- The Prototype Carbon Fund (PCF). The PCF is a CDM project facility. The International Bank for Reconstruction and Development is the Trustee of the PCF, and purchases Certified Emission reductions on behalf of the Participants in the Fund, comprised of several Annex I Parties and international corporations.
- The Republic of South Africa: Department of Environmental Affairs and Tourism (DEAT).[1]

Please see Annex 1 for contact details.

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 country 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 Durban

**A.4.1.4** Detail on physical location, including information allowing the unique identification of this project activity:

The La Mercy site is located at 35 km north of Durban. The Bisasar Road landfill site is situated 7 km from the Durban CBD (Central Business District). 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.

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[1] Currently DEAT is handling issues related to climate change and the Kyoto Protocol, though no formal DNA has been appointed. The Department of Minerals and Energy may take on the role of DNA. They have been briefed about the project.

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

Fugitive gas capture and renewable energy

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

**Landfill gas collection system:**
148 vertically driven gas wells will be constructed during phased restoration of the site to extract the landfill gas as it is produced. These will control and limit gas (methane) emissions to the atmosphere. Gas will be drawn from the wells through pipework to extraction equipment from where the gas will be used for electricity generation, with any surplus gas being flared.

**Energy generation technology:**
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.

**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 $CO_2$ 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.3. and B.4. below), the most likely baseline scenario is expected to be a continuation of the current business-as-usual (BAU) situation where the Mariannhill and the Bisasar Road landfills for local site-specific reasons collect and flare a 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 environmentally additional because it will generate emission reductions that would not occur otherwise, since the project does not present an economically attractive investment opportunity. Given that energy generation by the proposed

project is more costly than the continued purchase of electricity from the national utility company, Eskom, the project sponsor is unlikely to invest in the project in the absence of carbon finance.

It is estimated that the project will reduce an estimated 3,204,032 tons of CO2 in the first 7 year crediting period.

**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.

## B. BASELINE METHODOLOGY

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

There are no baseline methodologies available on the UNFCCC website at this point in time.

According to the modalities and procedures of the CDM, project participants should select the baseline approach that is most relevant for the proposed project. The baseline approach adopted for this project activity is option 48(b) of the Marrakech text. Accordingly, the baseline scenario is determined as the scenario that represents "emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment." Approach 48(b) must be interpreted and made operational in view of the project circumstances before it can be applied as a baseline methodology. Given that approach 48(b) assumes that economically rational behavior determines the most likely future baseline scenario, it seems appropriate to operationalize this approach in the form of an investment or financial analysis.

The following name is proposed for this methodology:

"Cost and Investment Analysis for Electricity Auto-Generation" (e.g. by municipalities)

The project circumstances permit the use of a cost-based investment analysis to determine the baseline scenario.

An explanation of this new methodology and the condition under which is can be applied is provided in Annex 3. A justification of the method's appropriateness given the project circumstances is given below.

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

Approach 48(b) seems most suitable for investment projects. The proposed project involves a considerable investment in power generation that must compete with other such investments. It is therefore reasonable to assume that the decision between alternative scenarios is based on

an investment calculus. This justifies an investment or financial analysis as an appropriate baseline methodology for this project type.

## B.3. Description of how the methodology is applied in the context of the project activity:

The methodology presented in Annex 3 is applied in the following way:

First it is necessary to confirm that all conditions for use of the methodology are met, namely:

A. The set of plausible alternative scenarios is comprised of two alternatives only: (1) the BAU scenario (*or* the BAU with minor changes and modifications) and (2) the proposed project alternative.

B. Durban municipality received the its power supply from Eskom, the quasi-statal utility Eskom that owns and operates 92 per cent of South Africa's generation and transmission capacity, with municipalities and private generators owning six and two per cent, respectively. Eskom's investments and operations are characterized by centrally coordinated sector planning and investment decisions aimed at providing electricity at the least economic cost.

C. The selected monitoring plan consists of two methodologies corresponding to each of this project category's two project components: (1) one methodology allows direct monitoring and calculation of the methane combusted in flares and generators; (2) the second methodology calculates ERs from the displacement of thermal generation by the electricity output from the generators installed and operated by the proposed project.

The baseline methodology is applied to the project in the analytical steps prescribed for the methodology in Annex 3. Further details are contained in the baseline study, which is attached as background information to this PDD.

1. The necessary conditions for application of the methodology are fulfilled.
2. The geographic and system boundaries for the application of the methodology were determined as described in B.5 below.
3. Several scenarios were identified as possible future developments, namely:
   (a) Business-as-usual (BAU): the continuation of landfilling of municipal and compliance with all relevant regulations, including partial flaring of landfill gas collected for safety reasons, and no generation of electricity from the landfill gas produced in the landfill.
   (b) The proposed project: continuation of landfilling of municipal waste, collection of most landfill gas, its use in for municipal power generation on the landfill site, and a equivalent reduction in power purchases from Eskom.
   (c) Continuation of landfilling of municipal waste and collection and flaring of most of the landfill gas without use of the gas for power generation.
   (d) Composting of municipal waste to partially replace the current landfilling operation.

(e) Construction and operation of a waste incineration facility and closing of the current landfills.

(f) Closure and replacement of the current landfills with new landfill sites.

4. Existing landfilling capacity, cost considerations and regulatory requirements governing waste management were identified as the key factors that might influence the realization of the above scenarios.
5. The scenario (c) – (f) were rejected as implausible baseline alternatives for the following reasons:
   - Scenario (c): Currently no collection and flaring is required by South Africa's waste management regulations except for safety reasons and odour control as practiced by the three landfills, which fully comply with 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. Scenario (c) is therefore dominated by scenario (b), in which municipal power generation offsets some costs of installing the collection system
   - Scenario (d): Some limited composting is already done at the landfills to produce an input to the completed cell cover material. It is not financially viable to perform additional composting, since the market for the product is limited in the urban area. Additionally, the large amount of waste currently deposited at the three sites makes sorting and composting of the contained biomass not feasible.
   - Scenario (e): Given the very high financial cost of incineration systems and additional costs for transporting waste to suitable sites away from residential areas, plus environmental issues associated with waste incineration, makes the construction of a waste incineration plant not realistic.
   - Scenario (f): All three landfills have remaining capacity and, with the exception of La Mercy, can continue to operate throughout the crediting period. Considering the high costs of developing new landfill sites, it is not reasonable to expect that the municipality would close these landfills before they are full, nor are there any plans for the construction of replacement sites. The La Mercy site is scheduled to close during the project life, but the gas collection will continue throughout the project life.
6. This reduced the above list of possible alternative scenarios to only two plausible alternatives, namely BAU and the proposed project.
7. The expected cost of electricity generation by the project is calculated at US$ 0.0422/kWh.
8. Durban currently pays a tariff of US$0.0156 per kWh for peak load power and 0.00694 for off-peak periods. The long-run marginal costs of electricity generation in South Africa was

conservatively calculated at US$0.0225/kWh (in real terms) over a 10-year period, and at US$0.0365/kWh over the 21-year crediting period using the EPRI TAG calculation method.[2]

9. 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.

10. 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. In keeping with conditions C above, the project will monitor any regulatory changes that impact waste management in South Africa and adjusts the baseline scenario, for instance by re-designating some landfill gas production wells to safety/baseline wells.

<u>Note on current regulatory requirements:</u>

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 $CH_4$ 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 $CO_2$ 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. Currently, there is no indication that the DWAF will require gas capture and flaring from permit holders in the near future being aware of the high

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[2] Note that a large number of Eskom's coal-fired power plants are currently mothballed. These power plants provides reserve capacity at operating and maintenance costs for many years to come. Details are contained in the baseline study.

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 an active gas flaring system. Rather, ongoing discussions indicate that the upcoming revision of the permit requirements will loosen the acceptable standard for $CO_2$ concentration.

Note on the clarification of the baseline scenario:

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. This is a reasonable assumption for the following reasons:

- Current legislation does not require any methane capture.
- When the existing wells were put in place, the situation differed from today's in two important aspects: 1) The landfill did not possess a lining system, so that wells were installed to prevent migration of gas to neighboring residential areas. Today, the landfill has been lined with passive gas vents and odor control spray outlets located on top of the lining system. Gas capturing wells are no longer necessary to control for odor or guarantee local safety 2) Some of the existing wells have been put in place to investigate the use of the gas for electricity production. As it turned out that this option was uneconomical, DSW has abandoned all schemes. In addition, the municipal budget has been cut back drastically since 2000 and does not allow for any further experiments of that kind.

## B.4. 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 determination of the baseline scenario is explained above in steps 1-10 of the application of the baseline methodology. The proposed Project is environmentally additional because it reduces emissions relative to the projected emission level in the baseline scenario. The reply to question B.4 is provided as step 11 of the application of the baseline methodology:

11. 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.

Given that the business-as-usual scenario is the most likely baseline scenario, it is evident that the project meets the CDM's additionality requirement. The project therefore is considered additional.

## B.5. Description of how the definition of the project boundary related to the baseline methodology is applied to the project activity:

The boundary that is relevant for the application of the baseline methodology defines where alternatives to the proposed project are likely to be found. The baseline methodology determines the baseline scenario for the project within the following boundaries:

*The physical boundaries of the three landfills delineate the geographic project boundaries, and Durban's auto-generation and power purchase options define the system boundaries. The methodology also establishes expected long-term price developments; for this purpose, the South African interconnected system and its eventual expansion defines the system boundary.*

## B.6. Details of baseline development

### B.6.1 **Date of completing the final draft of this baseline section:**

April 2003

### B.6.2 **Name of person/entity determining the baseline:**

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## C. DURATION OF THE PROJECT ACTIVITY / CREDITING PERIOD

### C.1 Duration of the project activity:

C.1.1. **Starting date of the project activity:**

Expected before 1st July 2003

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 (at most seven (7) years per period)

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

As soon as monitoring system is in place:
Expected 1st July 2003 or thereafter.

C.2.1.2. **Length of the first crediting period:**

7 years

## D. MONITORING METHODOLOGY AND PLAN

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

Because this project has two sources of emission reductions (avoided methane emissions from landfills and displaced grid electricity), two monitoring methodologies will be applied by the proposed project. There are no monitoring methodologies available at the UNFCCC web site at this point in time, but this project requires only two straightforward monitoring methodologies, namely:

1) “Direct monitoring and calculation of ERs in landfill gas utilization or flaring projects” (submitted as a new methodology in April 2003), and
2) “Use of average annual carbon emission intensity factor for the grid.”

The description below covers both methodologies simultaneously.

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

One important feature of LFG collection and utilization projects such as the Durban landfill-gas-to-electricity project is that a significant part of the emissions that are not released to the atmosphere can be directly monitored. It follows from this that emission reductions achieved by the project do not have to be established through a comparison between baseline and project emissions: 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. Accordingly, it is justified and adequate to use a monitoring and ER calculation methodology that is not reliant on information on baseline emissions and, as a consequence, the quantity of emissions in the baseline scenario can remain unknown. This is convenient because monitoring of baseline emissions from landfills is unpractical, except on a sample basis. The proposed monitoring and ER calculation method is expected to be more accurate than attempting to derive ERs as the difference between monitored or estimated baseline, on the one hand, and project emissions, on the other.

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 rate, measured as kgCO2/kWh, for the South African grid. This methodology has low transaction costs as it only involves computations based on data that are routinely collected by the project 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 2002 Eskom publicly reported that it emitted 0.89 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 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. Given the overcapacity in South Africa, peak load plants are mainly used as "shock absorbers". 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 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 purchases 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.

Project boundaries related to the monitoring of emission reductions:

*Geographic boundary*: The physical boundaries of the three landfill sites, which include the following project activities and emission sources:

- Landfill gas production from the landfills through production and safety wells,
- Landfill gas collection using gas pumps and pipelines,
- Landfill gas flaring, and
- Combustion of landfill gas in engines and electricity generation for on-site consumption and for sale to the grid.

It is assumed that other sources of greenhouse gas emissions within the project boundaries will not be affected by the project activity.

*System boundary*: The South African integrated electricity system for the purpose of assessing the emission reductions from displaced grid-electricity. South Africa's national grid is partly interconnected with neighboring countries. Because South Africa is a net exporter of power with unused excess capacity, the project's additional generation capacity effects only power generation in South Africa. Thus, the relevant system boundary is the national grid only.

*Time boundary*: The monitoring methodology can be used beginning with the first monitoring of emission reductions though the planned 21 year crediting period.

## D.3. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

*Not applicable, because the project directly monitors and calculates emission reductions. The following data will be collected:*

| ID number *(Please use numbers to ease cross-referencing to table D.6)* | 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] | *Data will be aggregated monthly and yearly* |
| 2 | landfill gas collected from project wells | $m^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |
| 3 | landfill gas collected from baseline wells | $m^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |
| 4 | Methane content of landfill gas | % | m (laboratory analysis) | Quarterly intervals | statistically significant samples | 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* |

| ID number *(Please use numbers to ease cross-referencing to table D.6)* | 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 |
|---|---|---|---|---|---|---|---|---|
| 6 | Emission intensity of South African grid | $CO_2$/ 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] | *Data will be aggregated monthly and yearly* |
| 8 | 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* |

**D.4. Potential sources of emissions which are significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources.**

No such emission sources have been identified. In addition, it is not possible to claim ERs for decreases in activity levels outside the project activity (i.e., decreased waste generation and/or collection and landfilling at the sites), as the landfills have a limited volumetric capacity. Altered activity levels would only impact the rate at which the landfills are filled and not the landfill gas emissions and the total emission reduction potential..

**D.5. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHG within the project boundary and identification if and how such data will be collected and archived.**

The determination of baseline emissions is not necessary, because the project directly monitors and calculates the emission reductions. However, the evolution of the baseline scenario is subject to monitoring in order to determine what effect new waste management regulations may have on the operation of landfills. The monitoring plan therefore monitors, on a continuous basis, any future changes in waste management regulations and their impact on the way the landfills would have to be operated in the absence of the project. If new regulations require more flaring of gas, the baseline will be adjusted to reflect this fact by redesignating landfill gas production wells as baseline wells, or by making other adjustments to the amount of gas that is considered to claim emission reductions. In particular, if gas flaring becomes a legally mandated activity within the lifetime of the project, this flaring becomes the baseline, and no or fewer emission reductions from flaring can be credited from that point on.

| ID number *(Please use numbers to ease cross-referencing to table D.6)* | 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 | Changes in waste management regulation | | | Continuous | 100% | Government regulations | always on file | *Stricter waste management regulation may lead to a re-designation of production to baseline wells* |

**D.6. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored.**

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

| Data *(Indicate table and ID number e.g. D.4-1; D.4-2.)* | Uncertainty level of data (High/Medium/Low) | Are QA/QC procedures planned for these data? | Outline explanation why QA/QC procedures are or are not being planned. |
|---|---|---|---|
| D3 – 1 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| D3 – 2 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| D3 – 3 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| D3 – 4 | Medium / Low | Yes | (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 | Yes | 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 | No | Depends on accuracy of annual Eskom reporting. |
| D3 – 7 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| D3 – 8 | Low | Yes | Meters will be subject to a regular maintenance regime to ensure accuracy. |
| B5 – 1 | Low | No | Regulatory requirements will be reviewed each time at verification. |

## D.7 Name of person/entity determining the monitoring methodology:

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# E. CALCULATION OF GHG EMISSIONS BY SOURCES

## E.1 Description of formulae used to estimate anthropogenic emissions by sources of greenhouse gases of the project activity within the project boundary:

This question does not apply well to this project for two reason.

First, as already explained, the project directly monitors and calculates the emission reductions from landfills. Greenhouse gases emitted from the landfills are not affected except as collected and directly monitored.

The source of emissions from the project is the combustion of landfill gas in the flares and in the gas turbines. When combusted, methane is converted into $CO_2$. As the methane is organic in nature these emissions are not counted as project emissions. The $CO_2$ released during the combustion process was originally fixed via biomass so that the life cycle $CO_2$ emissions of landfill gas are zero.

Second, emissions reduced in the national grid are calculated based on the electricity differential in the baseline and project scenarios times the emission rate for the South African electric grid. As explained above (confer D.2), Eskom calculates the $CO_2$ emission rate on an annual basis.

## E.2 Description of formulae used to estimate leakage, defined as: the net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the project boundary, and that is measurable and attributable to the project activity:

The Durban Landfill-gas-to-electricity Project does not result in significant leakage. The project is based on reducing on-site GHG emissions through the collection and combustion of landfill gas methane currently vented to the atmosphere. Emissions associated with on-site construction activities are not considered significant. The baseline wells and the system feeding the auto-generators (pipelines) are not likely to be the source of any leakage as the majority of the system is under negative pressure. If there are leaks in the pipeline, oxygen gets into the system which reduces the efficiency of the engines. Therefore, the project operator has a strict interest in reducing the amount of leakage. The oxygen content of the landfill gas is monitored on a routine basis. If any oxygen shows up in the sample, the project operator will search for the leak and fix it. In any event, no significant amounts of methane should leak from the system due to the negative pressure. In the shorter positive pressure part of the system between the methane evacuation pump and the engines the normal site monitoring for MBIENT methane would quickly identify and leaks and any such leaks would be rapidly found and repaired. If air enters into the system this will not affect the accuracy of the measurements using the output of the engines. Furthermore, the MP includes a regular monitoring of the composition of landfill gas.

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

Not applicable, because the project directly monitors and calculates ERs. The only discernable and significant difference between baseline and project emissions comes from the collection and destruction of methane contained in LFG, which is monitored and calculated directly. The only discernable yet insignificant (indirect) modification of emissions is associated with the physical construction of the project (see discussion under D.4 above).

### <u>E.4 **Description of formulae used to estimate the anthropogenic emissions by sources of greenhouse gases of the baseline:**</u>

Not applicable, because the project directly monitors and calculates the ERs.

### <u>E.5 **Difference between E.4 and E.3 representing the emission reductions of the project activity:**</u>

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

<u>(1) Calculation method for emission reductions from landfill gas combustion:</u>

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 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 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* | *Methane combusted in flares*

**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) (15,000 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)**

**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 $CO_2$e 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 production 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 production 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 ($CO_2$equiv) by converting methane volume into tons of methane and multiplication with the global warming potential.

**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**

**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)**

**Tons of $CO_2$e reduced from methane**

<u>(2) Calculation method for emission reductions from grid electricity displacement:</u>

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:**

Due to the nature of the ER monitoring and calculation process most appropriate for this category of project, the above formula cannot be directly used to complete the table below.

The following project of emission reductions is based on a variety of assumptions regarding waste volume and deposition rates, methane generation profile, LFG collection efficiency, methane contents in LFG, flare efficiency, engine heat rates, and so forth:

**Estimated Emission Reductions 2003-2010, Durban LFG to electricity**

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| **Methane ERs from Mariannhill** | 11,148 | 29,167 | 35,571 | 41,968 | 48,940 | 55,344 | 58,548 | 64,942 |
| **Methane ERs from Bisasar** | 66,889 | 182,379 | 228,347 | 274,328 | 275,654 | 275,365 | 275,386 | 275,407 |
| **Methane ERs from La Mercy** | 50,963 | 56,059 | 61,155 | 57,333 | 54,021 | 51,323 | 47,755 | 44,263 |
| **ERs from electricity production Mariannhill** | 0 | 3,560 | 3,560 | 3,560 | 7,120 | 7,120 | 7,120 | 7,120 |
| **ERs from electricity production Bisasar Road** | 0 | 21,360 | 28,480 | 35,600 | 42,720 | 42,720 | 42,720 | 42,720 |
| **ERs from electricity production La Mercy** | 0 | 0 | 0 | 0 | 0 | 7,120 | 7,120 | 7,120 |
| **Total** | **129,000** | **292,526** | **357,113** | **412,788** | **428,454** | **438,992** | **438,649** | **441,571** |
| **Cumulative Total** | **129,000** | **421,525** | **778,638** | **1,191,427** | **1,619,881** | **2,058,873** | **2,497,521** | **2,939,093** |

## F. ENVIRONMENTAL IMPACTS

### F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts (*please attach the documentation to the CDM-PDD)*

An environmental impact analysis will be undertaken by the project operator as part of the detailed project design. Detailed Terms of Reference have been issued, comments elicited from World Bank experts, and the EIA will commence in end-April. (The Bisasar Road site is the oldest and largest landfill with perhaps 10 - 13 million tons of waste already deposited there. It was in its early days of operation more a dump than landfill Since that time the site has been transformed into a sanitary landfill fully lined with leachate collection and limited gas collection for flaring that comprises the baseline. This site is also appropriately permitted and has also been subjected to the formal EA process as a landfill.)

### F.2. If 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 that has been undertaken in accordance with the procedures as required by the host Party.*

No significant negative environmental impacts are expected to result from the project activity, or to be identified in the EIA to commence shortly. On the contrary, the project will upgrade the local waste management practice to a higher standard and will lead to a significant reduction in local pollution along with a significant reduction in GHG emissions (as described elsewhere). Moreover the project will lead to considerable reduction in methane gas escaping from the landfills which creates a nuisance odor to some of the residential areas, and will reduce the potential for groundwater pollution from leachate.

## G. STAKEHOLDERS COMMENTS

### G.1. Brief description of the process on 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 1996, the Bisasar Road site (which is the site closest to a community) received a permit from the National Government to operate in accordance with set engineering plans and management requirements. 6 monthly audits became a legislation requirement as did regular 3-monthly meetings with the community, termed "the Monitoring Committee".

By 2001, the final rehabilitation of the Bisasar Road Landfill commenced and in response to stakeholder comments, a "green carpet" operation proceeded to move northwards away from the Clare Estate community.

In early April, the nominated Head of the Clare Estate Rate Payers Association, namely Mr. Arun Edwards has stated "The community accept that the landfill is in their area, but wish to continue to voice their rights and comment on how it should be operated". In this regard, the environmental and social specialists who are currently bidding on the Environmental Impact Assessment for the project, will have access to the Councillor of the Clare Estate Area as well as with community representatives, from both the middle-income communities and the informal settlements surrounding the landfill.

## G.2. **Summary of the comments received**

In the 30 day posting of the preliminary baseline documents on the PCF website, comments were received as follows:

**From individuals:** A letter in her own handwriting has been received from Mrs Sajida Khan, who lives adjacent to Bisasar Road landfill site. She has longstanding concerns about the landfill's operation, believing the serious health problems of both herself and a family member to stem from pollution at the landsite. This letter has been reproduced in typewritten form on the CDM Watch website. This concern does not arise from the proposed power generation component of the Project; rather, it is due to the ongoing operations of the existing landfill. However, the Project is seen as strengthening the commercial viability of the landfill, thus making it more difficult to oppose it.

**From NGOs interested in international trade in emissions reductions.**

- SouthSouthNorth has requested clarification on various methodological and procedural issues, and expressed concerns about stakeholder representation.
- CDM Watch, which has said that the stakeholders have not been properly consulted, complained that the Monitoring Committee currently in place is a "rubber stamp," and that an "elitist tool" - a website – has been used to solicit comments. CDM Watch has also organized an email campaign, and the PCF has received seven letters supporting the position of CDM Watch.
- Carbon Trade Watch, whose concerns are similar to those of CDM Watch.[3]

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[3] Prior to the posting of the Baseline Study on the PCF website, a study was published in January 2003 by Carbon Trade Watch, entitled: "The Sky is not the Limit: The Emerging Market in Greenhouse Gases" Section 1.2 of the report is entitled Dumping on South Africa, and discusses the proposed Project.

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

The Project validator has responded to comments and these comments will be addressed through public meetings, and a written response to the claims in the paper by Carbon Trade watch has been circulated. The social and environmental specialists performing the Environmental Assessment will pay visits to community members without access to technological means to ascertain their views and suggestions. Moreover, the community will be asked to select a project or program , in conjunction with eThekwini Municipality, that will be funded through a direct, additional contribution (about $760,000) by the carbon purchaser to benefit the lower income communities either living near the landsite or working at the landsite as informally organized waste collectors.

## ANNEX 1: CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
| Organization: | Durban Solid Waste |
| Street/P.O.Box: | 17 Electron Road, Springfield, PO Box 1038 |
| Building: | |
| City: | Durban |
| State/Region: | |
| Postfix/ZIP: | 4000 |
| Country: | South Africa |
| Telephone: | |
| FAX: | |
| E-Mail: | |
| URL: | |
| Represented by: | |
| Title: | Project Manager |
| Salutation: | Mr. |
| Last Name: | Strachan |
| Middle Name: | J. |
| First Name: | Strachan |
| Department: | Unicity Landfills |
| Mobile: | 27 (0)83 631 2682 |
| Direct FAX: | 27 (0)31 263 13107 |
| Direct tel: | 27 (0)31 263 1371/2 |
| Personal E-Mail: | lindsay@dmws.durban.gov.za |

| | |
|---|---|
| Organization: | World Bank Prototype Carbon Fund |
| Street/P.O.Box: | 1818 H Street, NW |
| Building: | MC Building |
| City: | Washington |
| State/Region: | DC |
| Postfix/ZIP: | 20043 |
| Country: | United States of America |
| Telephone: | +1-202-473 6010 |
| FAX: | +1-202-522 7432 |
| E-Mail: | knewcombe@worldbank.org |
| URL: | www.carbonfinance.org |
| Represented by: | |
| Title: | Manager |
| Salutation: | Mr. |
| Last Name: | Newcombe |

| | |
|---|---|
| Middle Name: | - |
| First Name: | Kenneth |
| Department: | ENVCF |
| Mobile: | |
| Direct FAX: | +44 (0) 1865 251 438 |
| Direct tel: | +44 (0) 1865 202 635 |
| Personal E-Mail: | knewcombe@worldbank.org |

| | |
|---|---|
| Organization: | Ethekwini Municipality |
| Street/P.O.Box: | No address |
| Building: | |
| City: | |
| State/Region: | |
| Postfix/ZIP: | |
| Country: | South Africa |
| Telephone: | |
| FAX: | |
| E-Mail: | |
| URL: | |
| Represented by: | |
| Title: | Municipal Manager |
| Salutation: | Dr. |
| Last Name: | Sutcliffe |
| Middle Name: | O. |
| First Name: | Michael |
| Department: | |
| Mobile: | |
| Direct FAX: | 27(031) 311 2170 |
| Direct tel: | 27 (031) 311 2100 |
| Personal E-Mail: | msmdb@mweb.co. za |

| | |
|---|---|
| Organization: | Durban Metropolitan Unicity Municipality |
| Street/P.O.Box: | West Street / PO Box 1014 |
| Building: | 2nd Floor City Hall |
| City: | Durban |
| State/Region: | |
| Postfix/ZIP: | 4000 |
| Country: | South Africa |
| Telephone: | |
| FAX: | |

| | |
|---|---|
| E-Mail: | |
| URL: | |
| Represented by: | |
| Title: | Mayor |
| Salutation: | Councillor |
| Last Name: | Mlaba |
| Middle Name: | |
| First Name: | Obed |
| Department: | |
| Mobile: | |
| Direct FAX: | 27 (031) 311 2121 |
| Direct tel: | 27 (031) 311 201627 |
| Personal E-Mail: | |

| | |
|---|---|
| Organization: | Ethikwini Electricity |
| Street/P.O.Box: | 1 Jelf Taylor Crescent |
| Building: | |
| City: | Durban |
| State/Region: | |
| Postfix/ZIP: | 4000 |
| Country: | South Africa |
| Telephone: | |
| FAX: | |
| E-Mail: | |
| URL: | |
| Represented by: | |
| Title: | Director Technical Services |
| Salutation: | Mr. |
| Last Name: | Wienand |
| Middle Name: | |
| First Name: | Roy |
| Department: | |
| Mobile: | |
| Direct FAX: | 27 ( 031) 300 1010 |
| Direct tel: | 27 (031) 300 1003 |
| Personal E-Mail: | wienandrf@elec.durban.gov.za |

| | |
|---|---|
| Organization: | South African Department of Environmental Affairs and Tourism |
| Street/P.O.Box: | Private Bag x447 |
| Building: | |
| City: | Pretoria |

| | |
|---|---|
| State/Region: | |
| Postfix/ZIP: | 0001 |
| Country: | South Africa |
| Telephone: | |
| FAX: | |
| E-Mail: | |
| URL: | |
| Represented by: | |
| Title: | Director Global Climate Change and Ozone Layer Protection |
| Salutation: | Mr. |
| Last Name: | Luboyera |
| Middle Name: | |
| First Name: | Festus |
| Department: | |
| Mobile: | |
| Direct FAX: | 27 ( 012) 320 0488 |
| Direct tel: | 27 ( 012) 310 3679 |
| Personal E-Mail: | fluboyera@ozone.pwv.gov.za |

## ANNEX 2: INFORMATION REGARDING PUBLIC FUNDING

There is no Official Development Assistance in this project.

## ANNEX 3: NEW BASELINE METHODOLOGY

### 1. Title of the proposed methodology:

“Cost and Investment Analysis for Electricity Auto-Generation” (e.g. by municipalities)

### 2. Description of the methodology:

**2.1.** General approach *(Please check the appropriate option(s))*

? Existing actual or historical emissions, as applicable;

? X Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;

? The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

**2.2.** Overall description (other characteristics of the approach):

The underlying behavioral assumption of the proposed methodology is that of a rational investor who, in the absence of the CDM, would choose the most economically attractive option. In order to assess the most economic attractive option one has to compare the economics of each option from an investor’s perspective, taking into account all revenues and costs that accrue in the course of implementing and operating the project. The proposed methodology thus simulates the decision making process of the investor.

The methodology uses the current and future electricity price paid by the decision maker. The project would not be implemented and thus is not part of the baseline scenario if the auto-generation costs exceed expected market prices. With the exclusion of the proposed project, the single (often business-as-usual) alternative is the most likely baseline scenario, and provided the project reduces emissions against this baseline, it is environmentally additional.

The above methodology can accurately determine the most likely baseline scenario under the following conditions and in the following way:

A. The set of plausible alternative scenarios is comprised of two alternatives only: (1) the proposed auto-generation of electricity, and (2) the BAU scenario or an investment option unrelated to power generation.[4]

B. Purchase of a significant amount of electricity by the project proponent from electricity suppliers (e.g. national utility) at predetermined electricity prices, e.g. a power purchase agreement.

C. The baseline and monitoring methodologies are complementary in the sense that monitoring identifies relevant elements of the baseline scenario that are not (fully) determined *ex ante* and described for the baseline scenario, such as future regulations and electricity prices.

<u>The proposed baseline methodology is applied following these steps</u>:

1. Confirm that the above conditions are fulfilled.

2. Determine the relevant boundaries for the establishment of the baseline.

3. Produce a comprehensive list of all possible alternative scenarios including the proposed project, alternative investment options, and the BAU scenario (if relevant).

4. Identify the conditions, such as legislation, cost, technology, etc., that might influence the realization of any of the listed options.

5. Based on 4, eliminate those options whose implementation is not plausible.

6. In keeping with condition A, establish that the set of plausible alternative scenarios is only comprised of the proposed project and one other alternative.

7. Calculate the expected cost (US$/kWh) of electricity generation by the proposed auto-generation project.

8. Identify the relevant price of the electricity that the autogenerator would have to purchase in the absence of the project and, if possible, the likely future price trends. As an alternative, future price levels can be monitored on a continuous basis and used to update the baselines scenario. Methodologies to identify price trends are discussed below.

9. Comparing the project's expected kWh costs with the relevant electricity price paid by the autogenerator (and the future price trend) conclude that the project is either:

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[4] BAU is understood to mean the continuation of key present policies and practices. If BAU is conceived of as a set of concentric circles, this implies that no changes are expected to take place at the "core"—the "core" is constituted by the key present practices and policies. Changes at the "periphery", however, may likely happen over time, as for instance minor regulations and policy adjustments. But such minor changes will not have any impact on the "core" which therefore will remain intact and unchanged.

a. economically not attractive and thus unlikely to be implemented as part of the baseline scenario (generation costs higher than the electricity price). This confirms that the alternative scenario is the most likely future development and therefore the relevant baseline scenario. Or,
b. economically at least as attractive as the alternative and hence can be expected to be implemented as part of the baseline scenario (generation costs equal to or lower than the electricity price). In this case, the baseline and the project scenarios are identical: the project would not yield additional emission reductions and is therefore not environmentally additional.

10. Describe the baseline scenario and its expected development over time, identifying key baseline aspects that need to be monitored as per condition C above, such as developments in the following areas:
    a. relevant legislation, policies and practices affecting the baseline scenario or the project,
    b. electricity prices paid by the self-generators and/or comparable electricity buyers (see note below).

11. Determine that, in comparison with baseline scenario, the project scenario will have lower emissions and that, therefore, the project is environmentally additional (cf. No. 6 below).

If successfully applied, the methodology determines the only alternative scenario as the most likely baseline scenario, because, first, the proposed project is not the most economically attractive course of action and, second, because no other plausible project alternative are available.

Notes:

(1) Future electricity prices can be forecast using different methods and depending on the relevant sector and project circumstances. One methodology would be to identify the likely future capacity expansion and the associated long run marginal cost (LRMC) of the system using official expansion plans or by modelling system expansion and then use the increase in generation costs as a indicator of price increases. Another method would be to use or forecast price increases as reflected in long-term power purchase agreements that may for instance use price escalator clauses and the like.

(2) **LRMCs are systematically higher than average future generation costs. For the purpose of assessing additionality of the project, the LRMC are thus a more conservative proxy for future tariffs than average future costs, as the project's generation costs need to exceed the expected future tariff for purchasing electricity from the grid.**

(3) **LRMC can be considered an appropriate proxy for the development of the project operator's future tariff, if a) tariffs in the sector are not excessively higher than generation costs or b) the investor is a large customer.**

(4) Monitoring of baseline variables is not necessary if project generation costs are significantly higher than long term expected the electricity price. In this case, a reassessment of the baseline situation is only needed after the first and, if the situation persists, after the second crediting period.

**3. Key parameters/assumptions (including emission factors and activity levels), and data sources considered and used:**

The above baseline methodology requires at least the following information, the correctness of which is to be confirmed by a Designated Operational Entity.

- Conservative cost calculation for the proposed project (as explained above). *Data sources*: Project proponent, feasibility study, and other relevant project planning information.
- Information on power prices paid by the auto-generator. *Data sources*: PPAs, market data.
- Information on key factors with an impact on future electricity prices (unless directly monitored), such as power sector conditions, system expansion options, LRMC, technologies. *Data source*: National utility or sector planning authority, information from technology suppliers, independent experts, planned power projects in the country etc.

The baseline methodology does not require information on other than the above-mentioned aspects, in particular information on emissions factors and activity levels as well as future regulation is not needed because it can be monitored in real time or calculated *ex post* during project operation. However, a projection of the expected ERs requires making appropriate assumptions about this and other information.

**4. Definition of the project boundary related to the baseline methodology:**

CDM (and JI) projects have two different boundaries: one for the determination of the baseline scenario, and another for monitoring and the calculation of ERs. These boundaries do not have to coincide. The determination of the project boundaries depends on the project circumstances under which a baseline methodology is used. The baseline determination boundaries most often used for electric power capacity expansion projects define where possible alternatives to the proposed project are likely to be found:

- *Geographic boundary*: The project site.
- *System boundary*: The autogeneration option and the power purchase option available to the autogenerator. For the purpose of projecting long-term price developments the national or regional interconnected electric system.
- *Time boundary*: Current situation and planning cycle for a reasonable number of years (e.g. 7 or 10 year and up to 21 years in line with the CDM crediting periods).

**5. Assessment of uncertainties:**

The proposed methodology can lead to an erroneous baseline scenario if:

– Any of the conditions set out in No. 2.2 above is not met. The careful assessment of the project circumstances and confirmation by a designated operational entity of the validity of the discussion and the conclusions drawn is imperative to mitigate risks and ensure credibility of the result.

- Any of the key assumptions/parameters listed under 3. above are incorrect or incomplete, in particular project costs and current or future price levels are not determined correctly or conservatively. The designated operational entity must carefully check all assumptions used to ensure a conservative result.
- The future price of electricity charged to large customers such as municipalities is lower than the LRMC (if used), for instance, because the power utility's pricing policy subsidizes large consumers.

- **6. Description of how the baseline methodology addresses the calculation of baseline emissions and the determination of project additionality:**

(1) The methodology for the calculation of baseline emissions and project emissions is contained in the monitoring plan, which, together with reasonable assumptions about data to be monitored, should be used to estimate the emission reductions generated by the project activity.
(2) In LFG-to-energy projects (such as the above), project-related reductions in methane emissions can often be directly monitored and calculated. Hence, monitoring emissions in the baseline scenario and in the project are not necessary.
(3) The baseline methodology does typically not address the determination of additionality. Project additionality requires a compelling demonstration of additionality (i.e. the project results in ERs). Additionality may often be obvious after the baseline scenario has been determined and information about technology or fuel use in the baseline and project scenarios has been considered. The estimation of an *exact* quantity of expected ERs is irrelevant for the assessment of additionality. Showing that a reduction in emissions below the baseline (and not offset by leakage) occurs is sufficient in order to demonstrate additionality.

**7. Description of how the baseline methodology addresses any potential leakage of the project activity:**

Leakage is addressed by defining the monitoring boundary (see above) and identifying relevant sources of emissions outside of these boundaries. Leakage can only be accounted for by including an appropriate method in the monitoring plan that corrects the ERs for any difference in baseline and project emissions that occur outside of the monitoring boundaries and which are measurable and attributable to the project.

**8. Criteria used in developing the proposed baseline methodology, including an explanation of how the baseline methodology was developed in a transparent and conservative manner:**

The proposed baseline methodology is a simplified application of investment analysis. Investment analysis produces a ranking of plausible investment options to identify the baseline scenario as the most economically attractive course of action (cf. Art. 48b) using some measure of attractiveness such as the internal rate of return or the costs of the various options. The methodology compares investment options directly with each other without recourse to some

outside measure of economic attractiveness such as an acceptable rate of return for the country and sector.

The proposed methodology differs from the investment analysis method in as much as the electricity price is used as a benchmark to determine economically attractive alternatives.

The following criteria were used in developing this methodology:

(a) *Realistic reflection of decision-making*: Potential autogenerators are assumed to minimize the economic cost of meeting their electricity needs.

(b) *Availability of information*: The methodology permits the determination of a baseline scenario in cases where cost information is available on the proposed project (usually from the feasibility study) and on the price of electricity charged to municipalities or other large consumers. Assuming that the future electricity price will reflect electricity generation cost, LRMC can be used as a proxy indicator of the future electricity price.

(c) *Reduction of project preparation costs*: A demonstration showing that the project's total generation costs exceed the price of electricity charged to the auto-generator.

(d) *Potential for replication and standardization*: The methodology has the potential to be replicated for similar projects or bundles of projects in the same country.

(e) *Increased accuracy*: The proposed baseline methodology potentially minimizes reliance on projections of future developments. The methodology leads to a more accurate calculation of ERs, because it refrains from the *ex ante* determination of aspects of the baseline scenario that can be monitored *ex post*.

The proposed baseline methodology is transparent and conservative, because:

- It can be applied in a transparent manner, because it relies on conventional cost analysis and actual electricity prices, which Designated Operational Entities can check to ensure completeness, correctness, plausibility and conservative assumptions.
- It can be applied in a conservative manner provided the above conditions for its use are met and the costs comparison relies on conservatively calculated cost indicators.

## 9. Assessment of strengths and weaknesses of the baseline methodology:

*Strengths*:

– See No. 8 above, in particular: simplicity, low project preparation cost, replicability.

*Weaknesses*:

– The methodology does not consider non-cost related motives of investing in any particular power sector expansion project. While this may in some cases lead to a less than complete picture regarding the components of the baseline scenario, this simplification appears appropriate in that it disregards idiosyncratic motives, which cannot be validated, from the methodology.

– The methodology assumes a direct correlation between market price for electricity and LRMC (only relevant if LRMC is used to forecast electricity prices).

**10. Other considerations, such as a description of how national and/or sectoral policies and circumstances have been taken into account:**

The methodology takes national and sectoral regulations into account in that the baseline scenario must be in compliance with existing regulation and must be updated to comply with new regulations and evolving economic/sectoral conditions. Project participants shall justify that the ex post monitoring of regulatory changes and their application to the baseline scenario is appropriate for the project and its circumstances.

# ANNEX 4: NEW MONITORING METHODOLOGY

Note that the project involves two sources of emission reductions, and thus two monitoring methodologies. Each methodology is described below.

The methodology for calculation of avoided methane emissions used in this project is identical to the methodology used in the NovaGerar Landfill Gas to Energy Project submitted as a new methodology before the deadline of April 15, 2003. It is reproduced here for information and completeness only.

## (1) Methodology for calculation of avoided methane emissions

**Proposed new monitoring methodology:**

"Direct monitoring and calculation of emissions reductions in landfill gas utilization or flaring projects"

### 1. Brief description of new methodology

The methodology allows the direct monitoring and calculation of ERs from projects that directly prevent the release of a measurable quantity of GHGs without affecting the emission of other significant GHG quantities in the baseline and project emissions. (Those quantities would cancel out if ERs are determined as a difference between calculated baseline and project emissions.)

The methodology is described in Section D above. It is currently mainly applicable in waste management projects involving methane destruction. In principle, all project types that involve a treatment of measurable GHG quantities that would otherwise be released are conducive to the application of modified forms of the proposed direct monitoring methodology. Such project types are: geological sequestration of $CO_2$ (e.g. in oil wells) and other applications that directly bind $CO_2$ or destroy or modify GHGs in a chemical or physical process that removes or diminishes their global warming potential.

### 2. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived

The proposed methodology utilizes direct monitoring of the emission reductions from the project activity. The emission reductions due to the project activity are monitored and calculated as a differential. Accordingly, the methodology does not monitor the emissions in the project and baseline scenarios in order to calculate the emission reductions as the difference between the two amounts of GHG emissions released.

The data to be collected depend crucially on project type. Typically, the quantity of destroyed, modified, or sequestered GHG either is directly measured (flow meters) or a proxy indicator is

measured (e.g. power output) that allows easy back calculation of the GHG quantity involved in the process.

In LFG-to-energy projects one will typically monitor the following variables:

| 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 |
|---|---|---|---|---|---|---|---|---|
| 2-1 | Flow of landfill gas to flares | $m^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |
| 2-2 | landfill gas collected from project wells | $m^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |
| 2-3 | landfill gas collected from baseline wells | $m^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |
| 2-4 | Methane content of landfill gas | % | m (laboratory analysis) | Quarterly intervals | statistically significant samples | 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* |
| 2-5 | 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* |
| 2-6 | Flow of landfill gas to engines | $M^3$ | m | Continuous | 100% | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *Data will be aggregated monthly and yearly* |

**3. Potential sources of emissions which are significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources**

The project boundary, for the purpose of defining the monitoring domain of a project, shall encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the project activity.

When applying the proposed methodology to LFG-to-energy projects the physical site of the project typically constitutes the project boundary. Only the construction of the LFG collection and utilization system will lead to some GHG emissions that would not have occurred in the absence of the project. These emissions are however insignificant and would likely also occur if alternative power generation capacity were to be constructed at alternative sites. No increases in emissions are discernable other than those targeted and directly monitored by the project. Moreover, because the project employs direct monitoring of ERs, indirect emissions will not distort their calculation.

**4. Assumptions used in elaborating the new methodology:**

The proposed methodology makes use of the technical and physical processes involved in the project to reduce the complexity of monitoring and calculation of ERs.

There are no specific assumptions used in elaborating the monitoring methodology, however its application in concrete project cases may involve specific assumptions.

The proposed projects makes a conservative assumption about the operating efficiency of the flares.

**5. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored.**

Procedures for quality control and quality insurance are greatly dependent on the specifics of individual project categories and the project configuration in the individual case. Such procedures can only be elaborated for a concrete application. To illustrate, the table below summarizes the quality control and quality assurance procedures developed in the text of a LFG-to-energy project, the Durban Landfill-gas-to-electricity project, and incorporated in the monitoring plan.

| Data | Uncertainty level of data (High/Medium/Low) | Are QA/QC procedures planned for these data? | Outline explanation why QA/QC procedures are or are not being planned. |
|---|---|---|---|
| 5 – 1 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| 5 – 2 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| 5 – 3 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |
| 5 – 4 | Medium/Low | Yes | (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. |
| 5 – 5 | Low | Yes | 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) |
| 5 – 6 | Low | Yes | Flow meters will be subject to a regular maintenance regime to ensure accuracy |

**6. What are the potential strengths and weaknesses of this methodology?**

- Direct measurement of methane combusted and thus of emission reductions.
- Simplification, cost reduction and accuracy

**7. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?**

The methodology was validated for the PCF Latvia: Liepaja Municipal Waste Management Project. A similar monitoring methodology is also used for the PCF NovaGerar project. However, experience with the use of the monitoring for the calculation of ERs does not yet exist.

(2) Methodology for calculation of displaced grid emissions

**Proposed new monitoring methodology:**

“Use of average annual carbon emission intensity factor for the grid”

**1. Brief description of new methodology**

The methodology allows for an easy assessment of emission reductions by simply multiplying the electricity delivered by the project to the grid by the average annual carbon emission rate for the grid. The emission rate can be derived from data on electricity production and associated $CO_2$ emissions of the national utility.

**The methodology assumes that each kWh generated by the project and delivered to the grid or consumed by an auto-generator results in an average equivalent reduction in generation by grid-connected power plants. The methodology is considered a conservative approach for base load displacing projects in countries, where base load is more emission intensive than peak load.**

**The methodology can, in principle, be applied to provincial as well as national grids. In the application of the methodology, the choice of the grid should be justified.**

**2. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived**

| 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 |
|---|---|---|---|---|---|---|---|---|
| 2-1 | Grid emission rate | $CO_2$/ kWh | c | annually | based on reported data | Electronic (spreadsheet) | 2 years [and duration of the project crediting period in files] | *This figure can be calculated based on publicly available information on total generation and associated GHG emissions for the electric system.* |
| 2-2 | 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 can be aggregated monthly and yearly* |

**3. Potential sources of emissions which are significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources**

This question can only be answered meaningfully in the context of concrete project circumstances, in particular regarding emissions associated with project construction. Replacement of grid-connected electricity does usually not lead to leakage.

**4. Assumptions used in elaborating the new methodology:**

The methodology can only be used under country-specific circumstances that ensure that the calculated emission rate does not overestimate the carbon intensity of the energy not produced by other grid-connected power plants as a consequence of the projects power input to the grid.

**5. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored.**

Can only be answered for a concrete application. Yet, an example is provided in the table below.

| Data | Uncertainty level of data (High/Medium/Low) | Are QA/QC procedures planned for these data? | Outline explanation why QA/QC procedures are or are not being planned. |
|---|---|---|---|
| 5-1 | Medium | No | Depends on accuracy of annual reporting. |
| 5-2 | Low | Yes | Meters will be subject to a regular maintenance regime to ensure accuracy. |

**6. What are the potential strengths and weaknesses of this methodology?**

Strengths: Simplification, cost reduction and conservativeness
Weaknesses: Reliance on availability of key data. Potential changes in operational conditions of grid such that the emission rate would not be a conservative reflection of the avoided emissions.

**7. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?**

No.

## ANNEX 5: BASELINE DATA

### A: Project power generation costs:

| 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** |

### B. Current and future power prices

**Current tariff level (US$/kWh):**

| | |
|---|---|
| Off - peak | 0.00694 |
| Peak | **0.0156** |

**LRMC in relation to MW demand**

| System condition | Demand | Tariff / LRMC (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** |

**Generation costs of a simple and a combined cycle gas turbine**

| | | |
|---|---|---|
| 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** |