

MUNICIPAL LANDFILL GAS TO ELECTRICITY

eThekweni Municipality

Project: Bisasar Road and Mariannhill Landfill Sites grid-tied electricity generation

Gas engines at the Bisasar Road landfill site.
Commissioned: 6.5 MW (source eThekweni DSW)

The pioneering Durban landfill gas to electricity project has been an exercise in “learning by doing”; generating not only power but invaluable human expertise and capacity. Initial interest by Durban Solid Waste (DSW) as early as 1994 was held in check as low electricity prices made such a project financially unviable. In 2002 during the World Summit on Sustainable Development in Johannesburg, the Prototype Carbon Fund (PCF) of the World Bank approached DSW to discuss funding opportunities for this project. The gas to electricity projects at the two landfill sites – Mariannhill and Bisasar – were commissioned in 2006 and 2008 respectively. The sites have resulted in reduced emissions of 7.2 million tons of CO_{2eq}¹. Bisasar will stop receiving waste from 2015 but it is estimated to continue producing gas and thus generating electricity for another 15 years. Mariannhill landfill closes in 2022.

Project Overview

The potential for income generation for the Municipality through a carbon offset project (methane flaring and green electricity generation) and the additional financial benefits from electricity savings to be realised from generating their own electricity, made landfill gas to energy an attractive prospect for the City. Financial guarantees had to be in place to ensure that public money would not be put at risk and to do this the project had to be approved by the Designated National Authority (DNA) as a valid carbon offset project to ensure that carbon credits could be accessed as a viable revenue stream.

Sizeable teams, including in-house management, national departments, donor/financing agencies and foreign specialists

were deployed to put together the country's first registered and verified Clean Development Mechanism (CDM) project. Lengthy Environmental Impact Assessment (EIA) approval processes delayed development and saw Mariannhill developed first as a pilot project, and the lessons learnt were used in the second and bigger part of the project at Bisasar Road.

The project, comprising the Mariannhill and Bisasar sites, is successfully producing 45 000 MWh/year, and has resulted in the creation of 15 permanent technical jobs. However, the carbon finance which the project had banked on, has proven disappointing since the price of carbon has collapsed, rendering the efforts to secure the Certified Emissions Reductions (CERs) meaningless.

¹ Eq stands for equivalent. It calculates all greenhouse gas emissions (in the instance of landfill sites, mainly methane) into one aggregated “carbon equivalent” measure.

Key Project Data

Location

**Mariannhill
and Bisasart**
landfill sites, Durban



Technology

**Landfill gas
to electricity**



Key Actors

Owners

**eThekweni
Municipality**



Developers

Various



Financers

World Bank-
PCF, DTI/DOE,
eThekweni Municipality and
loans to eThekweni Municipality
(from the French Development
Agency and others)



Some Indicators

Powered mid income households

(based on an average
monthly consumption
of 500 kWh)

7 500



Average output per MW installed

6 000
MWh/MW installed/year



Capacity factor

[= ratio of actual output
to potential output at
full capacity, over the
same period of time]

68%



Capital cost per MW installed

(MZAR/MW installed)

**R 16.8
million**
(or 10 for the electricity component,
i.e. excluding gas extraction)



Operational cost per MW installed

(ZAR/MW installed/
month)

R 144 000



Operational costs per MWh

(ZAR/MWh)

R 290



Technical Description

At both sites the gas is collected using an array of wells and a pumping system. The harvested gas is burnt in spark ignition gas engines driving generators to produce electricity which is then fed into the municipal grid. Mariannhill takes 450 tons of refuse per day, peaking at 700 tons. It has 17 vertical and 6 horizontal wells. A 1 MW generator engine is installed here. Bisasar Road is one of the biggest landfills in South Africa, and takes 3 500 tons of refuse per day, peaking at 5 000 tons. The site is composed of 77 vertical and horizontal wells each and has 38 leachate pumps. It has the potential to generate 8MW, though installed engine capacity is currently 6.5 MW – this includes six 1MW engines and one 500kW engine. The organic waste component within the landfill is around 35%.

Ener-G systems gives the following three rules of thumb for estimating biogas production:

1. 100 000 ton of domestic waste in a landfill per annum is roughly equivalent to 1 MW
2. 600 m³/hour of gas can generate 1 MW of electricity
3. 1 ton of highly organic waste will produce at least 6 m³ of gas.

Different contractors were selected for Mariannhill and Bisasar Road, due to the time delay in advertising tenders for each site.

Item	Mariannhill		Bisasar Road	
	Contractor	Cost	Contractor	Cost
Installation of Landfill Gas Extraction Wells and Flare Systems	Envirotech Solutions	R 7 million	Fountain Civil Engineering (<i>flare designed and manufactured by Swiss company, Hofstetter</i>)	R22 million
Installation of Landfill Gas Generation Systems	Envirotech Solutions	R 8 million	Enviro Fill (Pty) LTD	R25 million
Installation of additional gas extraction wells and pipes at Bisasar	-	-	Fountain Civil Engineering	R6 million
Additional 2 x 1MW engines at Bisasar	-	-	Enviro Fill (Pty) LTD	R25 million
Installation of the additional 2 x 1MW engines at Bisasar	-	-	Enviro Fill (Pty) LTD	R16 million

Project Business Model

The project was designed as a procurement project with outsourcing of operations and maintenance: eThekwini Municipality owns the asset and the operation of the power plants is outsourced to service providers. The investment was made by eThekwini Municipality. The capital and operating expenditures of the project are supported by two revenue streams: the sale of electricity and the sale of carbon credits.

Sale of electricity

The electricity sale was facilitated through a Power Purchase Agreement (PPA) between the eThekwini Cleansing and Solid Waste Department (as the project developers) and the municipality's Electricity Distribution Utility. Since this was an internal contract, there were no obstacles encountered. The sale is at a rate equivalent to the Eskom megaflex rate, which was below cost and meant that, without additional revenue, the project would not be financially viable.

Sale of carbon credits

The additional revenue to render the project financially viable was to be sourced from the sale of the carbon credits. However,

the development of a registered and verified CDM project added substantial complexity and involved a large array of participants: external stakeholders included the national government (Department of Trade & Industry and the Department of Energy); financiers (World Bank Prototype Carbon Fund and the French Development Agency); environmental consultants (EIA process); external auditors (emissions reduction) and a CER Purchaser (Trading Emissions PLC from the British Isles). Furthermore, the price of carbon collapsed between development and commissioning, burdening the municipality. Rising Eskom electricity prices may help to redress this problem.

Operations and Maintenance

Although one individual from the Durban Solid Waste Unit champions and oversees running of all facilities, the unit had to draw in substantial legal and technical expertise, including gas specialists, legal experts, civil engineers, and air quality monitoring services. The operation and maintenance of the gas extraction plant and the electricity generation facilities are outsourced to service providers. Contracts were initially in place for three years and now extended to five years.

Project Timeline

1994

Durban Solid Waste Department being to explore and consider flaring and generation projects.

2001

First contact with Prototype Carbon Fund of the World Bank.

2002

Letter from DNA of Conditional Approval for CDM project.

2003

MOU between eThekweni and PCF.
Council Approval and beginning of EIA.
Ad hoc Approval for funds from the municipality.

2004

Emissions Reduction Purchase Agreement Signed with World Bank (Conditional to EIA's).

(Component 1) Mariannhill only

(Component 2) Bisasar Road

2004

Records Of Decision (ROD - Environmental approval),
subsequent appeal and response.

Records Of Decision (ROD - Environmental approval).

2006

Construction starts.
CDM Registration.
Commissioning.

Final Revised ROD.

2007

Initial Verification (CDM).
Delivery of 1st CERs.

Construction starts.

2008

CDM verification Year 1.

Commissioning of Flare & Engines.

2009

2nd CDM Verification.
Installation of additional gas extraction wells and
engines.

CDM Registration + Initial Verification (CDM).
Commissioning of 6,5 MW.
Installation of additional gas extraction wells and
engines.

2011

3rd CDM verification.

First issuance (65 711 tons of CO₂).

2012

Commission Gas Chiller.

2013

1st (16 764 tons of CO₂), 2nd (39 472), 3rd (59 260) and 4th
(33 431) issuance.
4th CDM verification.
Reregistration (ACM 001).

2nd CDM verification.

2014

5th verification.
5th issuance (33 937 tons of CO₂).
6th verification.

2nd issuance (749 633 tons of CO₂).

Challenges, enablers and lessons learnt

As the project was the first of its kind in South Africa, several barriers had to be overcome throughout the process. At the same time the capacity developed and lessons learnt have been invaluable for the country.

Permit and licensing processes

Environmental Impact Assessment processes, including community opposition and design criteria appeals, affected conditions of project approval and resulted in project delays, necessitating a two-phase project, with accompanying procurement complexities, time delays and costs. Community opposition at Bisasar Road (where the issue was not the gas to electricity project, but the landfill itself and the politics of carbon finance) resulted in project approval delays of 18 months. Since 2011, a full EIA for landfill gas projects that are less than 10MW are not required as the negative social and environmental impacts of landfill gas to electricity projects are now well known and the impacts deemed to be small.

Procurement

Due to this being the first project of its kind in the country, the municipality's supply chain management was unsure of how to handle Section 33 of the MFMA which sets out conditions for different contractual timeframes. For contracts longer than three years additional obligations, including a public engagement process, are required before signing the contract. Being unprepared for this, the initial O&M contract was only set for three years, after which the management was able to motivate, and follow proper procedure in accordance with the conditions in MFMA, for the establishment of a five year contract.

Finance

The business model depended on revenue from both the sale of electricity and carbon credits through the CDM process – and initially more revenue was expected from the carbon credits. Carbon credit prices were high at the time of the project development - €15/ton of CO₂. The project agreement was for the sale of 3.8 million tons of emissions reduction over 21 years. Using these prices, the payback period was estimated to be 5 years. However, the carbon credits' prices have drastically dropped from €15 to a few cents per ton of CO₂ and the project has now lost an important revenue stream, affecting financial viability.

The cost of verification is significantly more than the financial benefit of the credits. This process of registering the CDM project with the UNFCCC Executive Board was felt to be long, tedious and costly – emissions reduction monitoring is onerous and gas emissions data needs to be collected every few seconds using rigorous monitoring methods and expensive software packages. The data requires in depth analysis to explain irregularities for verification purposes. In addition, the municipality experienced communication problems with foreign companies that were contracted by UNFCCC for the purposes of verification. The collapse of the carbon price rendered these efforts unviable.

Operational and technical challenges

Effective and optimal management of operations at the landfill site is crucial for the successful extraction of gas and consequent production of electricity. As a first of its kind some service suppliers and consultants lacked the necessary expertise and experience and a lot has been learnt "by doing". Incorrect equipment, not suitable for Durban's climate, caused the system to overheat continuously and rectifying the problem caused the project costs to increase substantially. Several spare parts are difficult to source in South Africa and often need shipping from overseas especially if they are big. eThekweni now keeps spare parts on hand for those that are required regularly. The cost of oil to run the engines was also underestimated.

Enabler

The Durban landfill gas to electricity project clearly demonstrated the importance of strong political and institutional commitment from the municipality. Good internal communication and buy-in at the highest level (the mayor was directly involved) was a key factor in getting the project implemented. Important drivers within the City included the city's Electricity Department and a dedicated and committed champion in the City's Cleansing and Solid Waste Department.

The project has created permanent jobs within the City. The City also visibly demonstrates its very strong commitment to carbon mitigation and carbon abatement, as well as to improving air quality for the surrounding community. Important lessons around international carbon finance have also been learnt: a CER Purchase Agreement was vital in obtaining the initial finance; however, as it turned out these funding streams cannot be considered risk free. Further, before engaging in these funds, the relative cost of that engagement needs to be very carefully considered.

In light of the financial constraints the municipality has decided not to continue with these projects in other landfill sites. Instead, the municipality is exploring green fuel from their landfill gas. For example, carbon dioxide can be sold to industry and methane gas could provide a green fuel type for the municipal vehicle fleet.



Generation unit at Mariannhill landfill site
Source: eThekweni municipality

Key Project Data

Start of operations

2006 / 2008

Capacity

7.5 MW

Average electrical output

45 000
MWh/year

Business Model

Project delivery model

Municipal project, with O&M contract outsourced to a service provider

Electricity production

Electricity is fed into the municipal grid. Internal power purchase agreement with eThekweni Electricity department (megaflex rate)

Cost

Capital cost

R 126 million

(R74 million for the electricity component, i.e. excluding gas extraction)

Operational cost

R 13 million / year

Published by:

The South African Local Government Association (SALGA) in partnership with SAGEN. SAGEN is the South African German Energy Programme implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Sustainable Energy Africa (SEA) was commissioned by GIZ to develop the case studies, in close partnership with SALGA and GIZ.

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Acknowledgement:

The authors would like to thank the municipal officials and representatives of the project developers / implementers who provided a lot of information and without whom the publication of these case study would not have been possible.

Links:

<http://www.dbnlandfillgas2elec.co.za/>

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John Parkin, Department of Solid Waste, eThekweni Municipality
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<https://cdm.unfccc.int/Projects/DB/TUEV-SUED1214927681.45>

Design and Layout:

Twaai Design

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