Africa's first landfill gas clean development mechanism project

earns commendation

The management team of the Department of Cleansing and Solid Waste of eThekwini Municipality have turned conventional thinking on running landfills on its head with the revolutionary 'closed-loop' design and operation introduced at the Mariannhill landfill. The approach is to ensure that once waste comes onto site, nothing leaves. This entails constructing a good lining system, treating the liquid (leachate) produced, capturing and utilising the gas produced, and managing the odours that are always present with seven-day-old waste. The project was entered by the Durban Branch and earned a commendation in the category Technical Excellence

MARIANNHILL LANDFILL

Commendation in the category Technical Excellence

KEY PLAYERS

Client eThekweni Municipality (Durban Solid Waste)
Lead Consultant Siyenza Engineers
Consultant Enviros (UK)
Sub-consultants SLR (UK), Wilson & Pass (RSA)
Contractors Envitech Solutions
LFG flares Organics UK
Gas engines/generators G E Jenbacher

THE MARIANNHILL LANDFILL, in the eThekwini Municipality of KwaZulu-Natal, presents a landfill development where landfill engineering methods have been successfully combined with the daily operation to realise South Africa's first landfill site conservancy.

The application of naturalistic engineering to landfill development is crucial to environmental acceptance of the landfill site – specifically where a conservation site is to be created and sustained. Naturalistic engineering encompasses many landfill facets, for example the provision of landfill capping layers that would stimulate vegetation growth; the use of simple and low-cost, yet robust, natural systems to treat landfill leachate; and the installation of wetlands to reduce storm-water energy and to simultaneously re-introduce valuable bird life into the site.

In addition, landfill gas-to-electricity generation has become financially viable. Methane gas is a distinctly serious greenhouse gas and projects of this kind will assist towards global emission reductions of carbon dioxide.

CELL CONSTRUCTION

Natural biodegradation processes within waste bodies give rise to landfill leachate (produced as a result of rainfall passing through the waste body) and landfill gas. The protection of the receiving environment from these potentially harmful landfill emissions is addressed in the form of a barrier system (so called because it incorporates a number of engineered layers).

Two types of barrier systems are currently adopted at the Mariannhill landfill site, depending on the grade of the natural ground. On valley slopes, the barrier system consists of a stabilised sand layer onto which a geomembrane (FPP – flexible poly propylene) liner and geogrid is placed. A stabilised sand protection layer is then constructed on the liner/geogrid. Crushed dump rock aggregate is placed on this protection layer to facilitate the collection and removal of leachate.

In the valley basal areas, an additional component is added to the barrier system described above. As the inflow of leachate into the strata below the landfill is critical in the valley base, two low permeability clay layers, between which a layer of 19 mm stone is placed, are constructed below the system described above. The 'sandwiched' stone layer serves as a leachate leakage detection system and provides further environmental protection.

'CLOSED-LOOP' LANDFILL DESIGN

Plant rescue unit

The value of the original soil profile at the Mariannhill landfill was identified from the onset of a conservancy creation plan as a vital component to environmental equation that must be rescued for effective rehabilitation to be realised. This led to the creation of a large holding nursery for the storage of all indigenous vegetation, along with the surrounding soil profile, rescued from within the landfill footprint development area.

This rescue operation to the holding nursery is referred to by DSW as 'PRUNIT' (plant rescue unit). PRUNIT has proven to be both environmentally and economically successful and has provided indigenous vegetation for the remediation of the peripheral buffer-zone areas of Mariannhill, as well as the ongoing rehabilitation of the Bisasar Road landfill site. In fact, the PRUNIT growth has realised the low-cost remediation of several defunct 'dumps' throughout the eThekwini Municipality.

Landfill conservancy

The Mariannhill landfill site is an excellent example of an ecosystem restoration project which has become an increasingly important part of biodiversity conservation.

Continuing human population growth ultimately results in the loss of natural ecosystems, either directly through the development of land, or indirectly through inappropriate land use practice. Restoration has become an essential tool for improving ecosystem functioning, minimising biodiversity losses and increasing the connectivity in nature reserve networks. Some of the results achieved through the landfill conservancy are:

- Mariannhill was the first landfill site – arguably in the world – to be incorporated into an ecosystem restoration site and be a registered national conservancy site
- The indigenous ecosystem biodiversity loss in the area is being managed
- The landfill site serves as an important natural corridor for species migration
- Significant near- and long-term cost savings are realised for landfill rehabilitation

TREATMENT AND RE-USE OF LANDFILL EMISSIONS

The construction of the barrier system at the Mariannhill landfill site not only provides environmental protection, but also facilitates the collection and treatment of landfill emissions – again, this is in keeping with the 'closed-loop' concept.

Mariannhill leachate treatment plant

The disposal of leachate prior to the construction of the treatment plant was to the municipal sewer, an approximate distance of one kilometre away. The disposal of leachate to sewer is not a treatment method, but rather one of dilution. Raw (untreated) leachate does potentially pose a risk of corrosion and elevated methane gas levels to the municipal sewer systems.

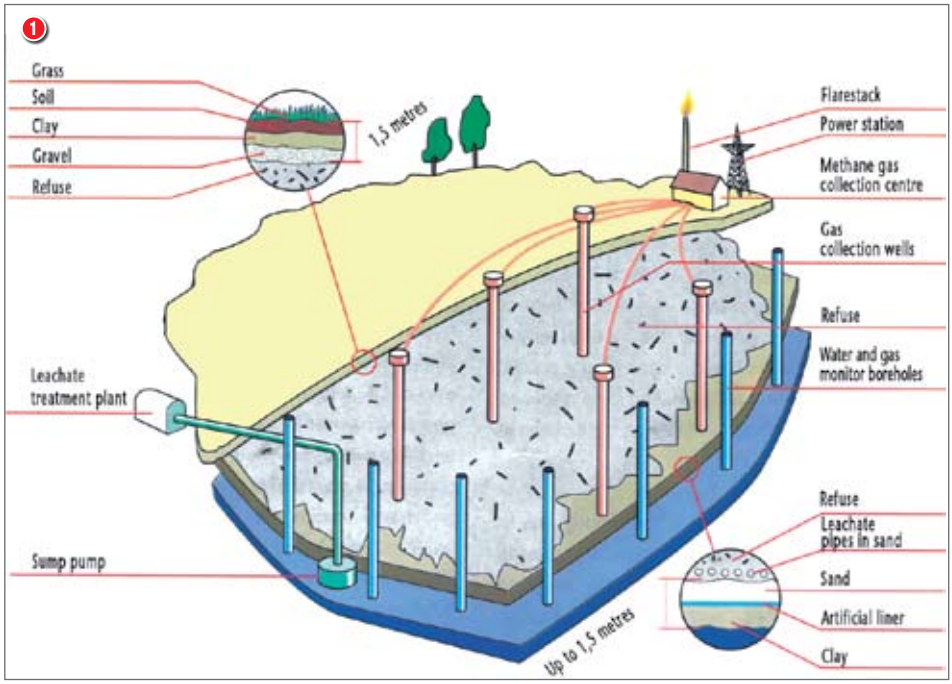
Leachate treatability trials began in 1998 by DSW, in collaboration with Enviros UK (previously Enviros Aspinwall). The trials demonstrated that the Mariannhill landfill leachate can be treated to high standards, within the limits of the discharge standards required by the Department of Water Affairs and Forestry for discharge of wastewater by irrigation. The findings of the treatability trials thus allowed DSW, in association with Enviros (UK), to design a full-scale treatment plant.

The overall treatment philosophy of the treatment plant is the use of 'natural, low-cost and robust' treatment processes. This plant therefore adopts biological primary treatment processes (aligned to the activated sludge process) and secondary 'polishing treatment' by reedbed.

The treatment plant comprises one sequencing batch reactor (SBR) unit constructed of reinforced concrete 10 m in diameter and 6 m deep. This capacity allows for the treatment of up to 50 m^3 of leachate daily. The plant also comprises a lined reedbed of some 280 m^2 which provides 'polishing treatment' for the removal of specifically residual BOD, COD and solids.

All treated effluent from the SBR is fed into a

1 *Diagram of typical site layout*



Overview

CDM project type

This is the first clean development mechanism (CDM)-registered landfill gas project in Africa.

Project owner

The project owner is the eThekwini Municipality. The project is operated within the Department of Cleansing and Solid Waste (DSW).

Brief description

The project comprises the extraction of landfill gas (comprising 40–60% methane) through gas wells and interlinking pipework installed into the Mariannhill and La Mercy landfill sites and the generation of electricity by purpose-built spark ignition engines of 1 000 kW and 500 kW capacity respectively.

Emission reductions

The project will bring about the reduction in the release of harmful greenhouse gas emissions of approximately 700 000 t of carbon dioxide equivalent over a period of some ten years. Reductions will be attributed to the destruction of methane gas and the displacement of coal-derived electrical power to the Durban municipal grid.

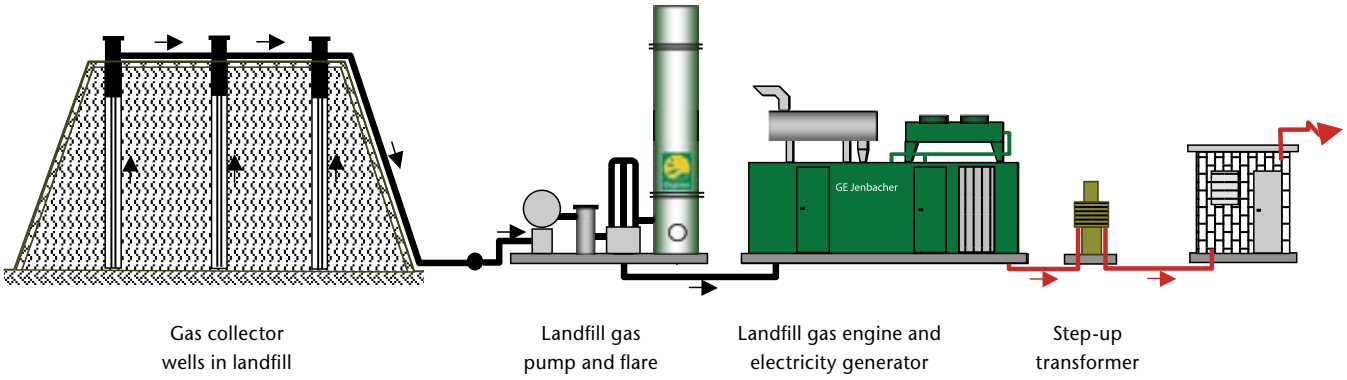
Project financials

Total project capital expenditure is some R19,5 million and operational costs will be some R1,2 million per annum. Total project income revenue will be some R33,9 million realised from the sale of carbon credits (some R20,7 million) and the sale of electricity (some R13,2 million).

The landfill conservancy

The Mariannhill landfill presents a landfill development where landfill-engineering methods have been successfully combined with the daily operation to realise South Africa's first landfill site conservancy. The Mariannhill landfill site is an exemplary example of an ecosystem restoration project which has become an increasingly important part of biodiversity conservation.

'Mariannhill and La Mercy serve as a pioneer for other CDM landfill gas capture and landfill gas to energy projects on the continent, and the project stands as an example of successful collaboration between the local municipality (eThekwini Municipality), Durban Solid Waste as the responsible municipal agency, the financing agency, Agence Française de Développement (AFD), South Africa's departments of Trade and Industry (DTI) and Minerals and Energy (DME), and the World Bank's energy, environment, and carbon finance teams', Noreen Beg, of the World Bank commented.



2 Schematic layout of landfill gas to electricity
3 The gas extraction and electricity-generating plant
4 Mariannhill is the first landfill gas CDM project on the continent of Africa. The gas that is extracted is used to drive a spark ignition gas engine to drive a turbine currently producing 900 kWh of electricity
5 Simple illustration of how the wells are installed
6 The sequential batch reactor leachate treatment plant, showing how it was constructed on the side of the hill to blend in with the surrounds. The function of the reedbed is to polish the leachate to standard for discharge into the environment
7 All plants and seeds are recovered in the plant recovery unit and brought to the nursery, where seeds are propagated. These are planted out into mini eco-systems and moved out into the natural environment

balance tank, which is level controlled to supply a portion of the effluent to a standpoint for the site water tanker (dust suppression) and a portion to the reedbed. The effluent from the reedbed is used for irrigation of the vegetated areas within the conservancy area. The treatment processes are controlled by computer systems which relay information via a visual display on a computer screen.

Landfill gas to electricity

It is widely known that landfill sites, with wastes undergoing a methanogenic stage of biodecomposition, produce large volumes of landfill gas. The recent availability of carbon finance – since South Africa's recent signing of a host country agreement in terms of the Kyoto Protocol – has made landfill gas-to-electricity generation financially viable.

A landfill gas extraction scheme comprising six gas wells linked to a 500 Nm^3/h flare unit has been operational for some three and a half years. The gas collection system for the flaring as installed at the Mariannhill landfill site has proved to be an adequate starting place as a pre-injection treatment system for the engine generators. As is typical with several other projects worldwide, landfill gas is drawn from the wells through pipe work systems by extraction equipment and fed to an electricity generation unit, with any surplus gas being flared. At present Mariannhill is generating 900 kWh of electricity, which is being fed into the local grid.

CLOSING COMMENT

The success of the project indicates that the methods utilised in running the landfill should be used as a blueprint for all landfills in the country. The project is sustainable – in fact running a landfill in this way realises reduced costs to the relevant municipality. □