Clean Technology for Landfill Gas Recovery

The Energy and Resources Institute and Jamia Milia Islamia

Methane is produced through the natural process of the bacterial decomposition of organic waste under anaerobic conditions in sanitary landfills and open dumps. After carbon dioxide, methane is considered the most harmful of greenhouse gases released into the atmosphere. Methane makes up approximately 50% of landfill gas, the rest is CO_2 mixed with small quantities of other gases. If Landfill Gas (LFG) is not collected, it escapes into the atmosphere.

It is a common practise in developed countries to capture the methane so released from landfills, as a strategy to *improve landfill safety, reduce odours, reduce greenhouse gas emissions, and to earn carbon credits.*

By virtue of its population, India is one of the largest emitters of methane from solid waste disposal, currently producing approximately 16 Mt CO_2 eq per year and is predicted to increase to almost 20 Mt CO_2 eq per year by 2020. A study using the Integrated Assessment Model for developing countries gives a much higher estimate of 48 Mt CO_2 eq per year by 2020 and 76 Mt CO_2 eq per year by 2030. With nearly 5100 cities, and mostly all having one or more landfill sites, efforts to control, capture and utilize this second largest source of methane emissions are yet to be made.

The *Municipal Solid Waste (Management and Handling) Rules, 2000* stipulates that LFG control system be installed, including a gas collection system at the landfill sites in order to minimize odour, prevent off site migration of harmful gases and to protect flora on the rehabilitated landfill site.

The project to demonstrate the feasibility of using LFG in a productive manner from deep waste disposal sites using indigenously developed LFG recovery, extraction and cleaning technology, was jointly awarded to The Energy and Resources Institute (TERI) and Jamia Milia Islamia, by the Ministry of Environment and Forests.

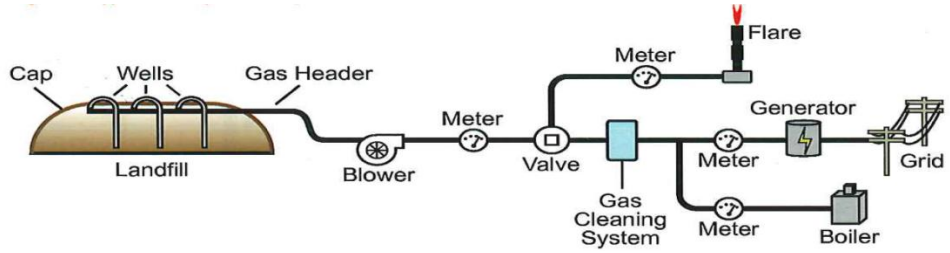
Methodology

The amount of LFG generated depends upon the type of waste disposal site. From international experience it is concluded that a sanitary landfill which uses waste management practices such as mechanical waste compacting and the use of liners, daily cover and a final cap and produces more LFG than open dumps because of the anaerobic conditions they facilitate, is most suited for LFG extraction.

A seasonal pump test was conducted at the Okhla landfill site, which is an open waste disposal site. The test has provided information regarding the availability of LFG. The objectives of the pump test were:

- To measure the LFG flow while extracting LFG from the landfill.
- To measure the methane levels of the extracted LFG during the pump test.
- To measure the pressure in probes to estimate the lateral influence of active pump test.
- To measure the oxygen levels of the extracted LFG during the pump test to check for air infiltration through the landfill surface during the pump test.

Figure 1: Typical LFG Components



Source: Demonstration of Clean Technology for Landfill Gas Recovery at Okhla Waste Disposal site, New Delhi, India. TERI Press. 2013

Table 1: Characteristics of Okhla landfill site

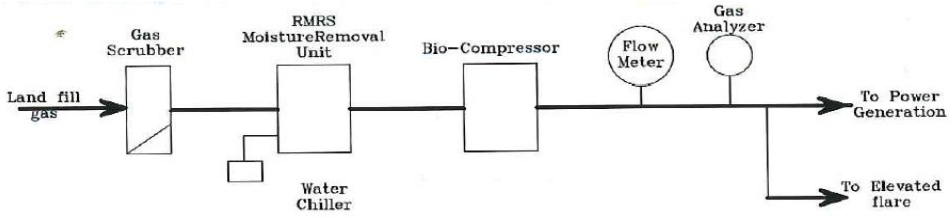
S. No.	Description	Site Characteristics
1	Starting Year	1994
2	Area for disposal	15.5 ha
3	Existing status of landfill	Operating
4	Accumulated waste (million cum)	3.0
5	Current Disposal Rate (TPD)	MSW-1600; C&D- 400
6	Type of Waste	Biodegradable & Non-Biodegradable Waste, Recyclables, Silt, Construction & Demolition Waste, Biomedical Waste
7	Average Age of Waste	15-17 years
8	Maximum height above ground level	40 m
9	Existing LFG collection system	No
10	Existing leachate treatment system	No
11	Side Slope	2H:1V
12	Base Elevation	183-201 m
13	Maximum elevation	240 m

Source: MCD. 2009

The raw LFG extracted from the Okhla landfill using vertical well and piping arrangement needs to be treated and conditioned before being used as a source of energy or flared. The treatment process is required for the removal of contaminants and moisture present in the LFG, which can create problems of corrosion, scale deposition and wear and tear of the LFG utilization system components. The key contaminants that require treatment are:

1. Particulates
2. Hydrogen Sulphide (H_2S)
3. Free moisture/ Water Vapour

Figure 2: Flow diagram of LFG extraction, treatment, conditioning and flaring system



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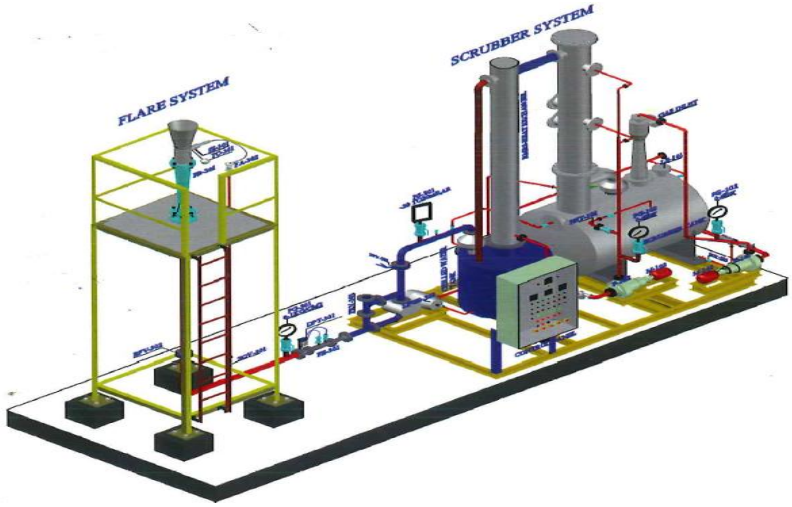
LFG Scrubbing System: The systems consists of water and scrubbing liquid (NaOH Solution) recirculation sections. The first is used for the removal of particulates, and the second for the removal of H_2S. Both the sections are connected to the PLC based control panel for monitoring and control of the scrubbing system. Once the scrubber system is ready, it will automatically start the scrubbing pump and the NaOH solution will start spraying in the venture and generate the appropriate suction so that the pressure drop in the venture is catered for. The LFG is scrubbed in the venture section and mixes thoroughly at the throat and the divergence section. The saturated LFG is then passed though the baffles for inter stage moisture separation. The scrubbed LFG is the allowed to pass though the packed bed columns where LFG passes though the ceramic section and the NaOH is sprayed through the custom designed spray nozzle. Here the remaining hydrogen sulphide is removed. Finally the LFG passes through the nylon demister bed.

Figure 3: Graphical representation and layout plan of LFG treatment, conditioning and flaring system for Okhla landfill site



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LFG Drying System: The LFG drying system removes the moisture content from the treated LFG. The moisture content should not exceed the dew point of 15 to 18^{o}C. The drying system consists of shell and tube heat exchanger and the plate type heat exchanger to cool the LFG.

LFG Suction and Compression/ Boosting System: A root blower fitted to the LFG blower motor is provided for suction/ boosting of LFG. A combination of venture flow element and differential pressure transmitter is provided at the blower discharge for monitoring and measuring the LFG flow.

LFG Flaring System: The pilot burner is an aspirating type and has high ignition reliability.

This is the pilot project; efforts are being made to implement this technology on a pan India basis.

Benefits

This demonstration was the pilot project for the clean technology extraction of LFG is a success. Through this extraction, not only do we are able to utilize an available source of energy which was otherwise wasted, but are in effect substituting fossil fuels by a clean renewable energy. The carbon credit potential of this extraction process is phenomenal. Methane being one of the harmful of GHG's is being efficiently controlled. Also, if this process is correctly incentivized, it will lead to an improvement in the operating conditions of existing waste disposal sites and their safe rehabilitation.

Table 2: Economic benefits due to conversion of LFG to electricity:

S. No.	Capacity of LFG Plant (m^3/hr)	Capital cost of LFG plant (INR)	Yearly O&M cost of plant (INR)	Payback period (years)	Per unit cost of electricity (INR)	Achievable thermal efficiency (%)
1	250	18,750,000	8,43,750	5-7	9.5	37
2	500	75,000,000	3,375,000	5-7	9.5	37
3	1,000	1,35,000,000	6,075,000	5-7	9.5	37
4	1,500	2,00,000,000	9,000,000	5-7	9.5	37
5	2,000	2,50,000,000	11,250,000	5-7	9.5	37

Source: Demonstration of Clean Technology for Landfill Gas Recovery at Okhla Waste Disposal site, New Delhi, India. TERI Press. 2013

The Capital Costs mentioned above include the cost of LFG recovery system, purification system, compression system, gas engine, measuring instrumentation and control system excluding civil works. The Operation and Maintenance (O&M) cost is assumed as 4.5% of the investment cost.

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