Presentation On Landfill Gas Pilot Project

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LFG & Global Warming

- LFG is generated by Anaerobic digestion of Municipal Solid Waste (MSW)
- The LFG principally contains Methane (~45%) and CO2 (~50%) and other minor constituents like H2S in ppm level apart from few micro constituents.
- Methane is 25 times more potent than CO2 in causing Global Warming.
- Landfill is the 2nd Largest source of CH4 emission after coal mining.
- Current level of Methane in Earth’s atmosphere is > 150% as compare to the base year 1750.
- Therefore capturing of LFG shall help in efforts towards mitigation of Global Warming.
LFG – Generation Process

- LFG Generation Process consists of few complex biological and chemical reactions:
  - **Hydrolytic and fermentative** bacteria hydrolyze polymers and ferment the resulting monosaccharides to carboxylic acids and alcohols.
  - **Acetogenic** bacteria converts these carboxylic acids and alcohols to acetate, hydrogen and carbon dioxide; and
  - **Methanogenic** bacteria converts the end products of the acetogenic reactions to methane and carbon dioxide.

- These reactions are influenced by the field conditions like composition of organic waste, moisture, compaction level, ambient temperature etc.

- Various theoretical & experimental studies report generation of around ~ 150 M3 of LFG per Tonne of MSW with 60% of bio-mass content.
## MSW Management Scenario In India

- Nearly 210 Million Tons of MSW is generated in India per annum.
- The biodegradable waste in MSW is contributed by food & yard waste.
- The per capita waste generation in India is 0.1kg, 0.3kg & 0.5 kg for Small, Medium and Big cities respectively and is growing at 1.3% per annum.
- Over 90% of MSW is not processed and is disposed off in landfills.
- The landfill sites are growing vertically as new sites are not available in major cities.

### Typical Composition of Indian MSW (in wt%)

- Organic: 50%
- Recyclable: 22%
- Inerts: 20%
- Others: 8%
Methane emissions from Indian Landfill sites is around 16 Million Tonnes of Carbon Dioxide equivalent (CO2e) per annum and is predicted to rise to 20 MMT of CO2e by 2020 (IEA study Report).

The combined emissions reduction potential of Delhi, Hyderabad, Mumbai, Ahmedabad & Pune landfills alone estimated at 3,00,000MT of CO2e per annum.(USEPA-2009)

The total estimated LFG generation potential~ 87 MMSCMD (considering the current MSW generation rate of 0.575MMT/day with 60% organic content)

Thus Indian landfills provide huge opportunities for the extraction & utilisation of methane from LFG. However, there are lot of challenges that need to be overcome for achieving this.
GAIL (India) Ltd, a Maharatna company, & erstwhile MCD (Now EDMC) took an initiative to implement a Pilot project to ascertain the potential of LFG recovery from an un-scientifically managed active MSW dumping site.

GAIL entered into an MoU with MCD for implementation of LFG Project. MCD earmarked 4 Hectares of Landfill site out of 29.6 Hectares at the Ghazipur landfill site for the Pilot Project.

**Objective of Pilot project:**

Phase-1 - To scientifically close the earmarked landfill site, construction of LFG collection wells, LFG extraction and Flaring

Phase-2 - To implement LFG purification system to enrich LFG to Natural gas quality for utilization as CNG and establish the techno-economic feasibility
Ghazipur Landfill Site

- Ghazipur landfill site is in operation since 1984 and spreads over an area of 29.62 Hectares
- MSW height has reached ~ 30m with average side slope of >70°
- The total accumulated waste is estimated at 4.7 Million Tonnes & nearly 2100 MT of MSW is being received daily.
- Animal waste from near by fish & poultry market also finds it way to the landfill.
- The site & is close to habitation.
The Pilot Project Area comprises of 4 Hectares (10 Acres) in the North-Eastern part of the Ghazipur Landfill site.

- The Area can be sub-divided into three parts:
  - Slice-A : Plateau area;
  - Slice-B & C : Sloped area

- The accumulated waste in the Pilot Project Area is ~ 0.45 Million Metric Tonnes.
Pre-Project Activities

- Waste Characterization of Fresh waste and Accumulated waste was carried out.
- Three LFG extraction wells of 500mm bore dia.& 15 m depth were installed for carrying out Pump tests to estimate the potential for LFG recovery under static & dynamic conditions.
- Estimated LFG production was ~ 900 M³/Hr. Assuming a gas collection efficiency of 60%, the LFG Flow was expected at 550 M³/Hr in the Pilot Project area.
- Radius of influence of each well was estimated to be 25m
- IPCC First Order Decay Model was used to estimate the LFG potential over the next few years.
- Pre-Project Activities Completed in 2011
LFG Phase-1 Implementation

Activity-1: Scientific closure as per MSW rules:

i) **Protective layer**: A protective layer of 200 mm thick soil was provided along the reformed Slope & Top portion.

ii) **Impervious Layer**: An impervious layer of 1.5 mm thick HDPE liner (Geo-membrane) was provided as a waterproof layer and to prevent the escape of LFG into the atmosphere. Further, a 1.5 mm thick Geo-composite layer was provided to act as a drainage layer.

iii) **Top Liner**: The top layer was formed by 450 mm thick soil & vegetative cover was provided

iv) **Top liner in steep slopes**: The top layer in steep slopes was provided by paver block in the area adjoining to the active landfill & in other areas grass paver block & GeoCell with grass cover was provided to provide stability to the steep slopes.
Activity–2: Construction of LFG collection wells & Leachate Recirculation system:

i) 20 No’s of LFG wells were constructed in the earmarked area with maximum no. of wells in Slice-A

ii) The bore diameter of wells is 500mm and drilled up to 75% of depth of waste.

iii) HDPE pipe of 160mm with bottom 2/3 slotted is inserted in each well.

iv) The annular core between the HDPE pipe and extraction well are filled with gravels of 25-40 mm size.

v) The top of the LFG well is sealed with Bentonite seal (1500mm in Length) and capped. Out of the 20 wells, 11 wells are dual wells and provided with Leachate pumps.
Cross Sectional view of LFG Well
Activity- 3 : Installation of LFG collection network:

A Feeder pipe (110mm dia.) and Header pipe (200/160 mm dia.) was laid at a depth of 30 cm to collect & transfer LFG.

Activity- 4 : Installation of Enclosed Flare System:

i) An enclosed Flare System was designed with a residence time of greater than 0.3 seconds and destruction efficiency of 99%.

ii) The flare system is designed for lean burning of LFG with CH$_4$ concentration as low as 20%.

iii) The flare stack height is 10 m.

iv) Controlled Automatic/Motorized air dampeners provide ambient air to the flare for combustion and for controlling exit gas temperature.

v) LFG blower (1000m3/hr) along with associated flow control system are part of the flare system.
LFG Pilot Project – Some Moments Through Photo
Slope Reformation

Reformation activities at Slice B and C
LFG Well Construction
Geo Membrane & HDPE Layer Laying
Paver Block Laying
Geo-Grid Laying
Enclosed Flare Erection
Enclosed Flare System
Visible Change of Landscape

THEN

PRESENT
Greenery in Side Slopes
LFG Operation Phase

- **Objective:**
  - To monitor LFG Quality and Quantity
  - To firm-up operational parameters
  - To obtain carbon credits.
  - To finalize design parameters for Phase-2

- **Methodology:**
  - Gas quality (CH$_4$, CO$_2$, H$_2$S) monitoring using online Gas analyzer
  - Physical sampling at collective outlet & at individual loops
  - Individual well analysis using handheld LFG monitors
  - Online Controlling & monitoring of quantity
  - Monitoring of other process parameters like flare temperature etc.
  - Registering of Project under UNFCCC
LFG Well Distribution
Operational Results (July-2014)

Average Flow Rate (cum/hr)

Methane (%)

Average Methane Yield (cum/hr)
## Consolidated Results

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Volume of LFG (m³/hr)</th>
<th>Average CH₄ (Vol %)</th>
<th>Cumulative LFG Captured &amp; Combusted (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May -2013-14</td>
<td>150.0</td>
<td>27.0</td>
<td>960000</td>
</tr>
<tr>
<td>May-2014-15</td>
<td>127.0</td>
<td>23.0</td>
<td>812800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>25.0</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>1772800</strong></td>
</tr>
</tbody>
</table>

Amount of CH₄ Destroyed ~10,000MT of CO₂ equivalent

The Project was successfully validated & registered with UNFCCC for availing carbon credits
Trail Run Analysis

- Out of total 20 Gas wells (GW), 12 GWs are working as expected with Gas Well nos. 10, 11, 14 & 15 have consistently shown good results (Slice-A).
- Yield is lower than expected in 3 GWs (Slice B & C).
- Air intrusion is observed in 5 GWs, which are at the edges of Slice A & B in continuation with the active landfill site.
- After one Month of trial run, a Considerable drop in the quality & quantity of LFG is observed.
- Methane concentration range is fluctuating between 23-28% with an average of 25vol% (with O2 content less than 2%).
- LFG Flare & LFG flow rate is stabilized at 150 m^3/ hr
- Average Calorific Value-2000-2500 Kcal/m^3
Typical LFG Operation Range

<table>
<thead>
<tr>
<th>Calorific value</th>
<th>0</th>
<th>0.22</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3.5</th>
<th>4.5 kWh/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane content</td>
<td>0</td>
<td>2.2</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>35</td>
<td>45 Vol % CH₄</td>
</tr>
</tbody>
</table>

- Poor gas
- Middle gas
- Normal gas

Gas Plants

Gas engines

Muffle / steam engine

Flares

Technical limit of flare operation

Higher Explosion Limit (100 % HEL)

Lower Explosion Limit (100 % LEL), 4.4 Vol % according to IEC 60079-20

Biofilters / flameless oxidation systems < 2.2 vol %
# LFG To CNG Technology Options

<table>
<thead>
<tr>
<th>Usage</th>
<th>Advantages</th>
<th>Dis advantages</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purification To NG quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. PSA system</td>
<td>Easy to operate &amp; less monitoring</td>
<td>High capital cost</td>
<td>High N2/O2 content – high purification cost</td>
</tr>
<tr>
<td>2. Membrane</td>
<td>Compact</td>
<td>High capital &amp; Maintenance cost</td>
<td>Lean gas problem &amp; Requirement of high pressure</td>
</tr>
<tr>
<td>3. Water Scrubbing</td>
<td>Low capital cost</td>
<td>High O&amp;M</td>
<td>Can’t remove N2</td>
</tr>
</tbody>
</table>
## LFG To CNG: Pre Feasibility

<table>
<thead>
<tr>
<th>S.N</th>
<th>Particulars</th>
<th>Parameters</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Current LFG flow rate</td>
<td>150 m³/hr</td>
<td>From Pilot plant Operation</td>
</tr>
<tr>
<td></td>
<td>Established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Average Methane Concentration</td>
<td>25-30% (Vol)</td>
<td>From Pilot plant Operation</td>
</tr>
<tr>
<td>3.</td>
<td>CNG Generation Potential</td>
<td>36 m³/hr (28 kgs/hr)</td>
<td>With 80% recovery</td>
</tr>
<tr>
<td>4.</td>
<td>CNG generation</td>
<td>560 kgs/day 205 MT/yr</td>
<td>With 20 hrs of operation in a day</td>
</tr>
<tr>
<td>5.</td>
<td>Cost of production of CNG from LFG (with 5 yrs. Depreciation)</td>
<td>Rs. 110-120 per kg of CNG</td>
<td>Current CNG price:  &lt;br&gt; • Rs. 43.3 / kg (Delhi)  &lt;br&gt; • Rs. 45.9 / Kg (UP)</td>
</tr>
</tbody>
</table>

LFG To CNG Purification Cost is High due to higher level of N2 & O2
# LFG To Power Technology Options

<table>
<thead>
<tr>
<th>Usage</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Power generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reciprocating IC engine</td>
<td>Easy to Install &amp; operate</td>
<td>High capital cost for small plant</td>
<td>Lean gas burning design required Pretreatment Suitable for medium landfill</td>
</tr>
<tr>
<td>2. Turbine (micro turbine)</td>
<td>Compact &amp; Easy to Operate, High Efficiency</td>
<td>High capital &amp; Maintenance cost</td>
<td>Requirement of high pressure Pretreatment</td>
</tr>
<tr>
<td>3. Organic Rankine Cycle/Stirling Cycle</td>
<td>Less moving parts</td>
<td>Low Efficiency</td>
<td>At Early stage of use in LFG</td>
</tr>
</tbody>
</table>
MT uses Recuperated Brayton Gas Turbine Cycle.

MT based small power plant of 30KW is planned

Low quality LFG shall be partially upgraded so that $\text{CH}_4 > 35\%$

High pressure Water Scrubbing system shall be used for LFG partial up gradation

Pre-Project works initiated & MT shall be installed by Sep-2015.
Achievements

- The Pilot LFG plant was installed on an active Landfill site: first of its kind in India.
- Average LFG Flow rate stabilised at 125-130 m³/hr & CH₄ concentration stabilised at -25%(Vol).
- Although the project boundary was contiguous with the active landfill, the O₂ ingress in the LFG was minimal due to good Design and work quality. (Average O₂ concentration in LFG is <2%(Vol.) & H₂S is <15 ppm.)
- Project was successfully Validated & Registered with UNFCCC for availing CDM benefits.
- So far, ~10000MT of CO₂ Equivalent of Methane is Captured and destroyed leading to accrual of ~10000 CERs.
Summary

- **Innovative Project**: LFG Extraction from part of active landfill-First Time in India.
- **Repeatability**: May be replicated in vertically growing landfill sites due to constrain in development of new landfills.
- **Environmental Benefit**: GHG Mitigation-So far Destroyed 10000Mt of Co2 Equit of GHG, Improvement in Air quality.
- **Sustainability Benefit**: LFG is a renewable fuel-Offset the use of non-renewable resources like Natural Gas.
- **Economic Benefit**: Gainful employment for local population & revenue to the organizations (CDM) and improvement of quality of Life in surrounding areas.
- **Safety**: Fire/Explosion hazard associated with Methane is prevented through enclosed flaring in a scientific manner.
- **Aesthetics**: The project improved the overall aesthetic of the landfill site & the surrounding area.
Temperatures at Full Power

- Inlet Air Filter: 15°C (59°F)
- Generator Cooling Air
- Dump Valve
- Tcin Sensor
- Generator
- Compressor
- Turbine
- Recuperator: 290°C (550°F)
- 205°C (400°F)
- Combustor: 950°C (1750°F)
- TET Sensors
- 510°C (950°F)
- 590°C (1100°F)