

GUIDANCE FACT SHEET: LANDFILL GAS COLLECTION, FLARING, AND ENERGY RECOVERY DESIGN

Landfill gas (LFG) is produced by the anaerobic decomposition of organic waste in a landfill and is comprised primarily of methane and carbon dioxide. Other constituents such as sulfur compounds and volatile organic compounds are present in trace amounts typically in parts per million concentrations. Air can be present at various levels in extracted LFG due to the infiltration or air caused by vacuum applied by the extraction system.

LFG generation depends on waste quantity and composition as well as moisture content. Other factors impact generation to a lesser extent. The percentage of LFG generation that is actually collected is referred to as the collection efficiency, and varies significantly depending on the design and operation of a disposal site. While collection efficiencies at engineered and well operated landfills may reach 70 % or greater, most landfills in developing countries will have lesser rates in the range of 40 % to 60%.

The design factors that can lead to improved LFG collection for both flaring and energy recovery purposes are addressed below.

LFG management is an important part of sanitary landfill operations for many reasons, including:

- Control of off-site migration of methane through surrounding soils. Methane forms an explosive mixture with air at concentrations between 5 and 15 percent by volume. LFG infiltration and accumulation in structures can create an explosion hazard is not controlled properly.
- Odor control. LFG, particularly sulfur compounds in the mixture, can create significant odor problems around the landfill. Collection and combustion of LFG effectively destroys odorous compounds.
- Control of hazardous volatilized components in the gas,
- Greenhouse gas emissions control.
- Energy Recovery.

The first four objectives can be accomplished with LFG collection and flaring. The design of LFG collection and flaring systems must address site specific conditions. The primary components of LFG collection systems are briefly discussed below.

Vertical Extraction Wells

Vertical extraction wells are the primary means of collecting LFG from landfills. Wells are drilled into the waste using a drill rig capable of achieving a bore hole diameter of 30 to 100 cm in diameter. Bore hole diameters greater than 60 cm are preferred as larger wells increase gas collection potential. Well depths normally are extended to three-fourths of the waste thickness,

taking care not to get within 5 meters of the landfill liner system, if one is present. Surveyed information regarding existing landfill surface and liner elevations is critical to avoid drilling into the liner.

Well piping is typically Sch 80 PVC or SDR 11 HDPE to provide a strong material for resisting pipe failure from landfill settlement. Pipe perforations or slots should begin approximately 6 to 7 meters below the landfill surface to inhibit air infiltration. Drilling normally is stopped when standing liquid (leachate) is encountered in the waste mass. LFG can not be collected from flooded wells (when liquid fills the aggregate placed around the slotted pipe).

Horizontal Collectors

Horizontal Collectors (HC) are trenched into the waste in active waste filling areas of the landfill. The objective of HCs is to collect LFG earlier than is feasible when drilling vertical wells from the final grade (elevation) of the landfill. HCs consist of perforated piping (usually HDPE) installed in a stone filled trench. The top of the stone layer has a geotextile or membrane strip to prevent soil backfill from infiltrating the aggregate. HCs are not activated until at least 5 meters of waste are placed over top to inhibit air infiltration.

HCs installed at final grade (referred to as surface collectors) are sometimes employed to collect LFG from very wet landfills where the leachate level makes vertical wells ineffective. Surface collectors are constructed in the same way as HCs except that the trench is deeper (3 to 4 m) to inhibit air infiltration. If feasible, membrane capping over top of surface collectors (either a comprehensive cap or in strips at least 20 m wide centered over the trench) greatly enhances LFG collection.

For active landfills, a combination of vertical wells and horizontal collectors is often needed to maximize LFG collection.

Condensate Management

Wells and HCs are interconnected by header piping to the blower station, which exerts a vacuum on the system to extract LFG. LFG is typically warm and saturated with water vapor. As it passes through the piping, the gas cools and liquids condense. This condensate will drain via gravity in the direction of the pipe slope and accumulate in low points. Therefore, all piping must be sloped to drain to condensate management components located at low points. Condensate management components normally consist of one or more of the following:

- Self-draining condensate trap that allows liquids to flow back into the waste mass by via a vacuum break (U-trap) set up.
- Sump (manhole or tank) that is manually pumped or equipped with an automatic pump to remove condensate (normally by injection into the leachate collection system).

The self draining trap is cheaper to install, but requires relatively dry waste to function. The header system should be designed to minimize low points to reduce system costs. The header slope should be at least 3 percent to assure that the liquids will drain. As the landfill settles, new low points may form and the pipe re-sloped. For above grade piping systems, this situation is

readily identified and repaired. Belowgrade piping, however, is less prone to damage from landfill operations and is protected from freezing conditions in colder climates.

Condensate blockages in the header piping are the most common problem in LFG collection systems. Therefore, careful attention should be paid during design to have sufficient condensate collection points and provisions for condensate pumping if needed. Such provisions include sufficiently sized piping in self draining traps to accommodate a submersible pump if needed.

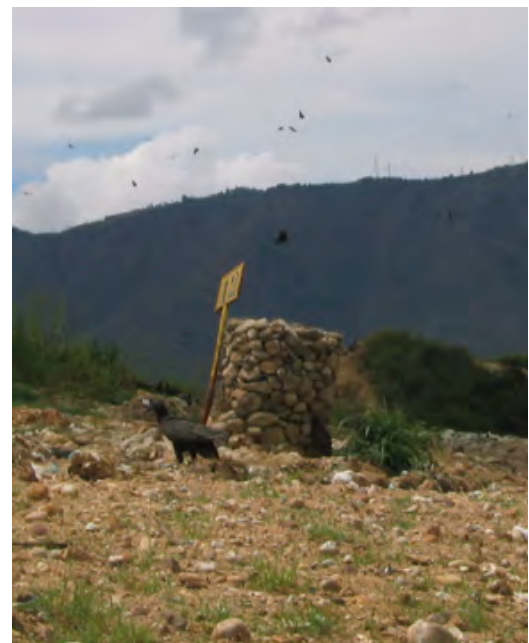


Passive Vents

The Clean Development Mechanism (CDM) has promoted the implementation of LFG collection systems at many landfills in developing countries where LFG management at landfills is not yet standard practice. Many such landfills construct gas vents at the beginning of waste filling and extend them vertically as the waste depth increases. These vents typically consist of large stone placed in perforated concrete manhole sections, large diameter corrugated metal pipe, or wire mesh baskets. Piping is sometimes installed in the center to convey gas to the top. More often than not, stone backfill is placed up to the final vent opening at finished grade. Photos of typical installations are shown below.

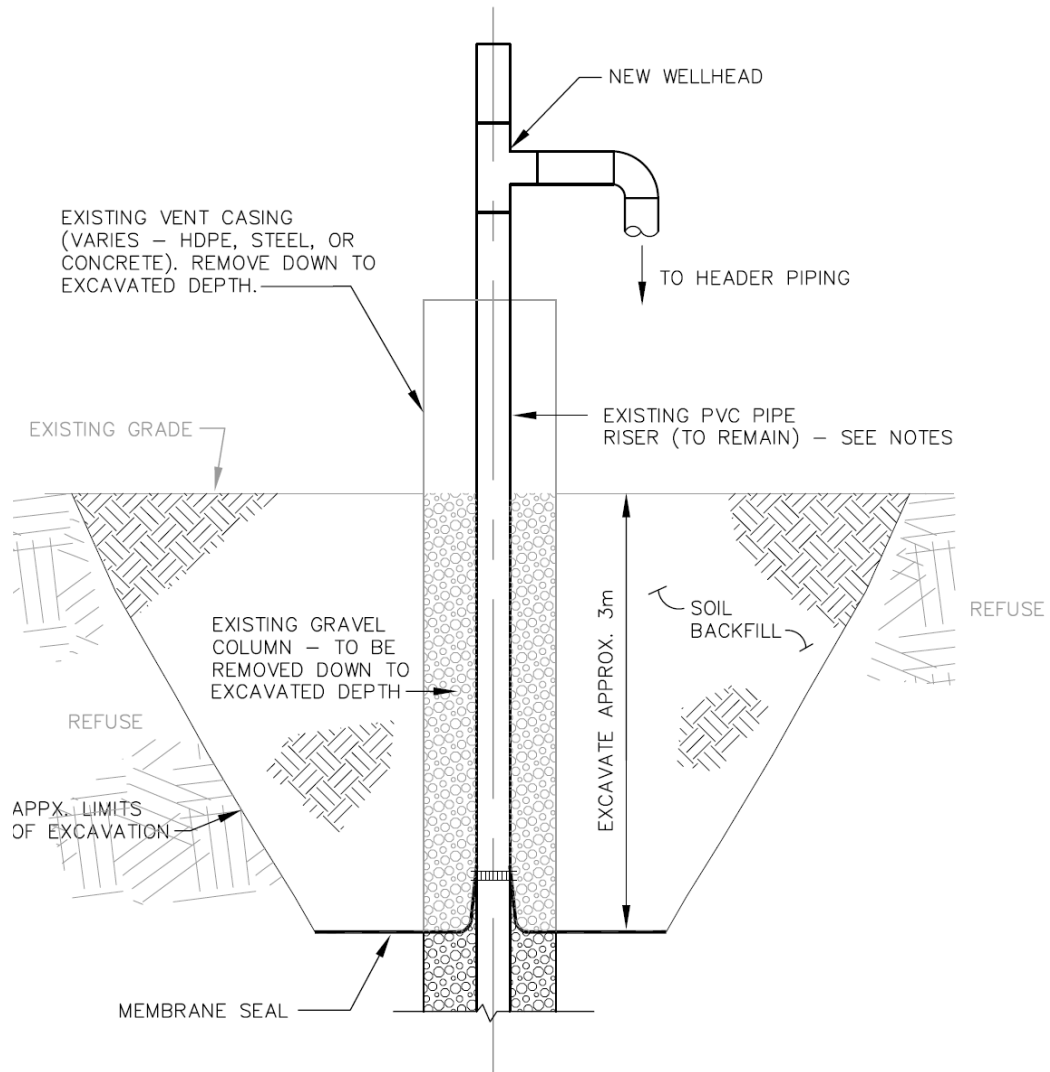
For practical purposes, these vents provide some gas pressure relief and odor control if flared. They also can be an effective way to construct gas extraction components as the landfill grows without relying on drilling equipment that is sometimes difficult to contract. The typical vent installation, however, provides several design and operational challenges, including the following:

- If flared, the flame is difficult to maintain due to low gas velocities and the lack of a wind shroud and automatic ignition device.
- If the vent opening is close to the ground surface, safety hazards can be created by open flames or concentrated gas emissions.
- When converting to an active system, such vents are difficult to utilize in the final system without significant modification to reduce the likelihood of air intrusion created by the stone backfill extending to the surface.



- If new vertical wells are drilled near existing vents, the vents can act as air intrusion points if vacuum from the new wells overlaps the vent location. Thus, unused vents may need to be sealed, which is difficult when the vent riser is a large diameter concrete ring or corrugated metal pipe.

In order to address these issues, two design approaches are recommended. The first approach is illustrated in the following detail for modifying existing vents to transform them into active extraction wells. The intent is to excavate to a sufficient depth around the vent to modify the top portion so that a vacuum can be applied with less potential for air intrusion.



TYPICAL LFG VENT MODIFICATION
NO SCALE

The second approach is to modify the vent construction so that the final 5 to 7 meters is constructed in a manner that can easily be converted to an active extraction well.

LFG Combustion

Collected LFG can be conveyed to a flare or an energy conversion device such as a boiler, internal combustion engine, or gas turbine. The methane component in LFG is readily combusted and destruction efficiency levels in the high 90 percent range are normal. Due to an

inability to measure actual destruction efficiency in an open flare, however, these types of control devices are not recommended for CDM projects (for which the approved methodology requires a steep discount on verified emission reductions).

Energy recovery is a natural second phase for projects that already collect and flare LFG because the same collection system is used and the collection quantities are well established at the flare. Many hundreds of LFG to energy projects have been developed around the world and the technology for these types of projects are well established. The criteria that determine the economic feasibility of LFG energy projects include:

- The distance to the nearest industrial user if a direct use project is considered. Typical distances for transmitting LFG via pipeline are less than 10 km; however, a few large projects have been developed with pipeline lengths exceeding 30 km. The type of terrain between the landfill and the end user (city, mountains, rivers, etc) also has a big impact on cost.
- The value of electricity (the amount the project owner would get paid by the utility or direct purchaser of power). This price values tremendously based on supply and demand and will determine if the investment costs of a power plant are economically attractive. Another important consideration for power projects is the treatment requirements of the collected LFG. High sulfur or siloxane concentrations require expensive treatment costs that may impede an otherwise attractive project. An additional consideration is the cost of connecting a power generation system to the electrical grid.
- The value of natural gas or similar fuel. The natural gas price will dictate how far a pipeline can be built for either a direct use project or a gas processing plant that treats LFG to natural gas quality for injection into a pipeline. As with electricity pricing, natural gas pricing varies significantly in different locations.

An added benefit to energy recovery over simple flaring of LFG is that it further reduces carbon emissions if it displaces another fuel source that requires combustion.

Sources of Additional Information

The World Bank. Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean. http://www.bancomundial.org.ar/lfg/gas_access_008.htm

The World Bank. www.worldbank.org/solidwaste