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‘Start-of-pipe’ solutions: The conversion of landfill gas into pipeline gas

Technologies for purifying landfill gas are gradually gaining acceptance. This, combined with the rising price of natural gas, is driving the development of landfill gas to pipeline plants across the US

by Martin Pomerantz

Western Pennsylvania, USA has a history of new fuel discoveries and initiatives. The first commercial oil well in the USA was drilled in 1859 near the town of Titusville and ushered in the modern oil industry. In 1878 the first commercial natural gas well was drilled in Murrysville, which led to the development of the Equitable Gas Company.

More recently, the first commercial nuclear power plant in the USA was commissioned in 1957 near Shippingport, and the first large-scale landfill gas (LFG) to pipeline project using membrane technology became operational in 1998 in Murrysville, Pennsylvania.

It is within this context that we explore the evolution of LFG to pipeline projects in the USA. Naturally the focus is drawn toward western Pennsylvania, though _ as will be seen later in this article _ the first large-scale, commercial project worldwide took place further east in New York City.

Conversion explained

The conversion of LFG to pipeline quality gas requires five basic steps. First the landfill must modify the LFG collection system so that entry of air into the LFG is limited. For most LFG purification technologies this requires that the nitrogen content must be limited (unless the project can obtain a waiver from the pipeline). The next steps are: remove moisture; remove hydrogen sulphide and non-methane organic compounds; remove carbon dioxide; and then compress the gas to pipeline pressure. The process choices differ in the method of carbon dioxide removal. They are as follows (with current technology suppliers listed in parentheses):

- solvent absorption (Selexol and Kryosol)
- pressure swing adsorption, or PSA (QuestAir Technologies and others)
- membrane separation (UOP and Air Liquide)
- carbon dioxide wash (Acrion Technologies).

A response to rising oil prices

Looking at the historical development of this technology, in 1978 the US Congress passed the Public Utility Regulatory Policies Act (PURPA), which led to the rapid development of LFG to electricity projects and direct-use projects. (A direct-use project is one where the LFG is only dried and compressed and sent through a dedicated pipeline to a single user.) At this time forecasts were made that oil would reach the unheard-of price of US $100 per barrel and natural gas would reach US $6/MMBtu (three times its normal price).

In response to this forecast Getty Synthetic Fuels and the Brooklyn Union Gas Company installed an LFG to pipeline project at the Fresh Kills landfill on Staten Island, New York City, in 1982. It was a US $20 million Selexol project with significant processing capacity and represented the first large-scale commercial application of LFG to pipeline technology worldwide.

Over the next five years Getty installed LFG to pipeline projects at two other US landfills, namely the Rumpke landfill in Cincinnati, Ohio and the McCarty Road landfill in Houston, Texas. But, in parallel, and against earlier expectations, natural gas prices declined.

During the 1993 to 1999 period the price of natural gas was in the US $2–$3 range. Naturally, this prompted stakeholders to examine the economics of different technologies when deciding how best to proceed. An excellent summary of the comparative economics of LFG to pipeline gas, LFG to electric generation and LFG direct use was published in 1991.

Moving forward, natural gas prices started to increase in 2002 and reached the US$6–$8 range in 2006. By this time, 290 electric generation projects and 80 direct-use projects had been developed across North America. In contrast, the continent had seen only nine LFG to pipeline projects develop (eight in the USA and one in Québec). Four used solvent (Selexol or Kryosol) technology, three used UOP membranes and two used pressure swing adsorption (PSA).

What was the reason for relatively slow uptake of this technology? One key aspect was that whilst PURPA, and the resulting state regulations, required electric utilities to accept electricity generated from landfill gas, there were no Federal or State rules that required pipelines to accept, purchase, or transport purified LFG, and there were no uniform Federal or State specifications for gas acceptance. Thus landfill gas developers had to negotiate an acceptance specification with the natural gas pipeline. In addition, refined LFG will always have a lower heating value than natural gas in the pipeline since LFG contains only methane and does not contain the higher hydrocarbons usually found in natural gas.

A new entrant in the market: the case study of Air Liquide

Undeterred by the apparent hurdles to development, in 2000 Charles L. Anderson of Air Liquide became aware of a market opportunity for Air Liquide membranes and he asked landfill gas developers to consider using Air Liquide membranes. The technology his company developed for application in this sector is depicted in Figure 1.

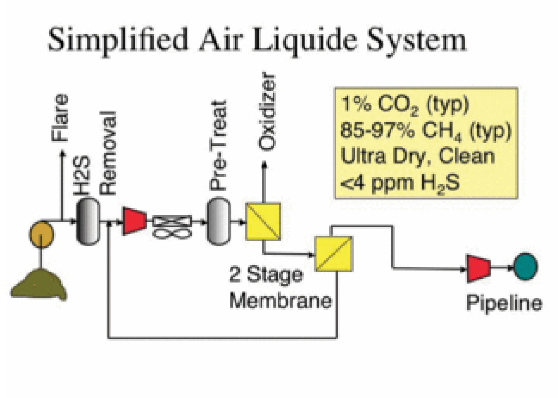

Figure 1. A process flow diagram for a simplified Air Liquide system

Starting with the left side of the diagram the landfill blower removes the LFG from the landfill. The LFG is then sent to an existing flare or to the processing plant. In the processing plant the hydrogen sulphide is removed, and the gas then goes to a compressor that increases the pressure from atmospheric to 200 psig (13.7 bar g). The gas is cooled and then proceeds to the pre-treat section for removal of non-methane organic compounds. The clean gas then goes to the membrane section where the carbon dioxide and some of the oxygen are removed. Thereafter the gas is compressed to pipeline pressure. Waste gas containing the non-methane organic compounds is sent to the thermal oxidizer for destruction.

The Laurel Highlands landfill in Pennsylvania, USA installed a skid supplied by Air Liquide

Liquide membranes should be evaluated for landfill gas projects because they remove carbon dioxide from the methane at 200 psig (13.7 bar g) rather than at the 600 psig (41.2 bar g) used with the UOP membranes. The benefit of this lower pressure for gas separation is that the required compressor power is reduced, which in turn reduces the capital and operating costs of the LFG processing plant. Two months later, at the SWANA LFG Symposium, the idea gained momentum when a paper was presented describing the performance and economics that could be obtained if a landfill gas to pipeline project were to use Air Liquide membranes4.

Four Vilter compressors installed at the Shade Landfill in Somerset County. They increase the gas pressure to 200 psig (13.7 bar g) for processing by the Air Liquide system. Vilter has become an important supplier of LFG compressor equipment over the past two years

Based on this information and further evaluations, Harry L. Crouse, Chairman, Keystone Renewable Energy, LLC, who was familiar with the use of UOP membranes for gas separation, realized that there was an economic opportunity now that natural gas prices were projected to be above US $6/MMBtu. He contacted Air Liquide and purchased the first Air Liquide membrane skid designed for LFG purification. Air Liquide had designed a modular skid that contained all the essential systems to remove the non-methane organic compounds, carbon dioxide and oxygen, plus all the necessary control systems. This simplified the design and operation of a membrane processing plant. The skid, with its capacity to process raw LFG feed, became the first commercial use of Air Liquide membrane technology in the LFG market. It was first installed in June 2006 at the Laurel Highlands Landfill in Cambria County, Pennsylvania, USA and is shown in the photograph. The plant delivers 96% methane gas through a 1.8 mile (2.9 km) pipeline to a natural gas distribution system.

In August 2007 two more Air Liquide membrane plants were installed by Keystone Renewable Energy – one at the Shade Landfill in Somerset County and one at the Southern Alleghenies Landfill in Somerset County. All three of these plants are located in western Pennsylvania. The Shade Plant delivers 96% methane gas through a 12 mile (19.3 km) pipeline to a natural gas distribution system. The simplicity of these systems is depicted in the photographs.

Summary

There are now over 20 LFG to pipeline plants operating in the USA and six of the eight membrane plants are using Air Liquide membranes. And these are not the only examples. One project using an Air Liquide skid is being developed by the Renewable Solutions Group in Atlanta, Georgia; and there are at least three other Air Liquide membrane projects under construction elsewhere in the USA.

The Air Liquide skid is a compact machine, shown in *situ at the Shade Landfill*

In addition, there are three more operating Selexol plants (SouthTex Treaters), a new large Pressure Swing Adsorption (PSA) plant (QuestAir Technologies) and a first-time combined nitrogen/carbon dioxide removal system (Guild Associates) is under construction. If the Guild technology is proven to be economically viable it will reduce the need to control the entry of air into the LFG.

The development of LFG to pipeline projects is growing rapidly in the USA because it utilizes established technology, the higher natural gas prices can support these projects and the plants have a relatively small footprint. A basic plant can be housed in a building 60 feet (18.3 metres) wide and 80 feet (24.4 metres) long. Furthermore there are other environmental benefits from pursuing this approach.

The thermal oxidizer used to destroy the non-methane organic compounds that are removed from the LFG

A plant processing raw LFG will significantly reduce NOx and CO_2 emissions. Production of pipeline gas is eligible for Clean Development Mechanism (CDM) credits because of the reduction of carbon dioxide produced by the displacement of natural gas. NOx emissions are also reduced at the landfill because of the reduced methane flow to the flare. Work is now under way to develop the ability to use purified LFG for vehicle fuelling as compressed biogas (CBG) or liquid methane gas (LMG). Use of these fuels will reduce NOx emissions by 50%, particulates by 80% and carbon monoxide by 90% when compared with diesel fuel. At least two vehicle fuel projects are expected to be in commercial operation within the next two years.

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