4.1.2 CONVERSION OF LANDFILL GAS TO ALTERNATIVE USES

Technology Description

Landfill gas to compressed natural gas vehicle refueling station, Los Angeles, California

Conversion to compressed natural gas (CNG) and liquefied natural gas (LNG): Use of landfill gas to produce CNG and LNG for vehicle use has gained interest because: (1) it provides an alternative use for landfill gas projects that cannot use all of the gas recovered; and (2) increasingly stringent diesel emission regulations require use of alternative fuel vehicles. Use of CNG and LNG has been recognized for its environmental benefits because it is a cleaner-burning fuel relative to gasoline and diesel fuel, especially for NO_x and particulate matter (PM) emissions.

Pipeline quality gas and CO_2 production: Since landfill gas is about half CO_2 and half methane, separation of these two gases can generate two separate sources of revenue – commercial CO_2 and pipeline-quality (high-Btu) methane. Since methane is the chief constituent of natural gas, the methane from landfills, once cleaned and processed, can be fed into existing natural gas distribution networks. CO_2 separated from landfill gas can be processed to high-purity (food grade) liquid CO_2, coalbed, oil and gas enhancement; wastewater treatment; dry cleaning; or for the production of dry ice; or to promote plant growth in greenhouses.

Conversion to methanol and ethanol: Landfill methane has been successfully converted to methanol and ethanol, both renewable fuels that produce fewer emissions than gasoline. Landfill gas can be converted to methanol and ethanol for use as a chemical feedstock, hydrogen production, or as a vehicle fuel or fuel additive.

System Concepts

- *Conversion to CNG/LNG:* In general, to produce LNG from landfill gas, the removal of corrosive trace impurities is accomplished through the use of phase separators, coalescing filters, and impregnated\non-impregnated activated carbon adsorbents. Next, a zeolite adsorbent removes remaining polar molecules (specifically water) to a concentration of a few parts per million. Oxygen also must be removed at this point, if present in more than trace quantities. The resultant gas then enters a cryogenic purifier where the carbon dioxide is separated out, leaving a high-grade LNG product consisting of 90%-97% methane. The remainder of the LNG is dissolved nitrogen. Conversion to CNG is a similar process and therefore not addressed here.
- *Pipeline quality gas production:* Landfill gas must be processed to increase its energy content and to meet strict standards for oxygen, hydrogen sulfide, moisture, carbon dioxide, and non-methane organic compounds. The landfill gas also must be free of environmentally unacceptable substances and must be pressurized to the pressure of the pipeline to which the gas production facility is interconnected.
- *Conversion to methanol and ethanol:* Nearly all methanol produced today is made from natural gas. Ethanol is produced primarily from biomass feedstocks. Landfill gas is an alternative, renewable feedstock.

Representative Technologies

- *Conversion to CNG/LNG:* Thermal regenerative purification system.
- *Pipeline quality gas production:* At least three processes are employed to upgrade landfill gas to pipeline quality – membrane separation process, molecular sieve (pressure swing adsorption), and absorption process using a liquid solvent.
- *CO_2 production:* Triple-point crystallization and the use of cold liquid carbon dioxide.
- A CO_2 wash technology removes contaminants from landfill gas. The resultant clean stream of methane and CO_2 can be used as medium Btu gas or can be further refined into products such as CNG/LNG production, pipeline quality gas, and methanol.

Technology Status/Applications

- *Conversion to CNG/LNG:* To date, three landfill-gas-to-CNG projects have been successfully demonstrated worldwide. Los Angeles County, California, has operated a CNG project at Puente Hills Landfill for more

than five years. The CNG plant produces 3,500 psi natural gas equivalent as fuel for several pieces of landfill equipment (e.g., water truck). The first landfill-gas-to-LNG pilot plant recently completed initial performance testing at the Hartland Landfill in Victoria, British Columbia (Canada). By 2004, the first four commercial landfill-gas-to-LNG production and fueling facilities are planned for landfills in California (2), Pennsylvania (1), and Texas (1).

- *CO_2 production:* Triple-point crystallization has been demonstrated. Use of cold liquid carbon dioxide is under development.
- *Pipeline quality gas production:* At least eight projects that convert landfill gas to high-Btu (pipeline-quality) gas are currently in operation throughout the United States. An additional three projects are currently under construction and planned.
- Conversion of landfill gas to methanol and ethanol for use as a vehicle fuel or as a chemical feedstock has been investigated in the United States since the early 1980s.

Current Research, Development, and Demonstration

R&D Goals

- *Conversion to CNG/LNG:* Monitor performance of LNG conversion technology application on landfill gas and converted vehicle performance; development of distribution/fueling infrastructure.
- *Pipeline quality gas production*: Develop cost-effective separation technology applications.
- *CO_2 production*: Evaluate and demonstrate technologies for producing commercial carbon dioxide.
- When technologically feasible and cost competitive, LFG could offset natural gas consumption for the production of methanol and hydrogen.

RD&D Challenges

- *Conversion to CNG/LNG*: No commercial-scale, landfill-gas-to-LNG facility is currently operational. Major drawbacks to using CNG in motor vehicles include the limited driving range of vehicles because of fuel storage capacity constraints. For both CNG and LNG, another limitation has been the availability of fuel dispensing facilities. In addition, the cost to convert vehicles from diesel to CNG/LNG is prohibitive.
- *Pipeline quality gas production*: The cost of the landfill gas clean-up technologies is such that this application is only feasible at the largest landfills (which produce greater quantities of landfill gas), where economies of scale can make projects cost-effective.
- *CO_2 production*: Costs to recompress the CO_2; the need to remove trace contaminants to meet purity requirements for food-grade use; and nontechnical hurdles, such as public perception of a food product developed from landfill gas.
- The major obstacle facing methanol and ethanol production from landfill gas has been the overall economics of the conversion technology and lack of suitable markets for the end product.

RD&D Activities

- *Pipeline quality gas production*: As of July 2003, two studies are currently under development to investigate pipeline gas production at a small landfill in West Virginia, and the production of hydrogen from a landfill in Florida for NASA's Kennedy Space Flight Center (i.e. Space Shuttle fuel).
- *CO_2 production*: Field tests were conducted on producing commercial CO_2 from landfill gas at the Al Turi Landfill in Goshen, New York, with a grant from DOE's Federal Energy Technology Center. A DOE Small Business Innovation Research grant helped fund a demonstration project to convert landfill gas into methane for fuel cell electric generation and pure carbon dioxide to stimulate greenhouse crop growth. Brookhaven National Laboratory is supporting a study that will remove landfill gas contaminants and produce approximately 24,000 gal/day of LNG and 85 ton/day of liquid CO_2 from 4 million scfd of raw LFG.

Recent Progress

- *Pipeline quality gas production:* At least eight projects that convert landfill gas to high-Btu (pipeline-quality) gas are operating in the United States.
- *CO_2 production:* Klickitat Public Utility District in Oregon will generate carbon offsets by use of landfill gas to produce green electricity. The project is expected to produce 2.1 MW of electricity and 13 ton/day of CO_2

while removing contaminants such as sulfur compounds, volatile organic compounds, and siloxanes.

- Under a recently completed Small Business Innovation Research Phase II grant from DOE, Acrion Technologies, Inc., successfully demonstrated the Liquid CO_2 Wash Process with a pilot-scale system at the Al Turi Landfill in Goshen, New York.
- The first commercial-scale application of the Liquid CO_2 Wash Process is under development at a landfill in Ohio.

Commercialization and Deployment Activities

- Currently, few companies manufacture the landfill-gas-to-LNG conversion technology.
- Commercial technologies exist for upgrading LFG to high Btu gas production; however this application is only feasible at the largest landfills.
- Available methanol and ethanol conversion technology is limited.

Market Context

- Conversion of landfill gas to LNG or CNG may be ideally suited for small- to medium-scale landfills, especially with existing gas collection systems. Municipalities and private-sector companies that maintain medium- and heavy-duty vehicles (buses, trash collection, postal service, etc.) – especially in metropolitan areas – represent important markets.
- Commercial CO_2 markets include food and beverage and other industrial applications.
- Pipeline gas and hydrogen production from large landfills.