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LANDFILL GAS CONVERSION TO LNG and LCO_2

PHASE II
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PHASE II FINAL REPORT

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prepared for

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EXECUTIVE SUMMARY

This report summarizes work on the development of a process to produce LNG (liquefied methane) for heavy vehicle use from landfill gas (LFG) using Acrion's CO_2 wash process for contaminant removal and CO_2 recovery. Work was done in the following areas: 1) production of natural gas pipeline methane for liquefaction at an existing LNG facility, 2) production of LNG from sewage digester gas, 3) the use of mixed refrigerants for process cooling in the production of LNG, liquid CO_2 and pipeline methane, 4) cost estimates for an LNG production facility at the Arden Landfill in Washington PA.

Process designs and economics were developed to produce pipeline gas and liquid carbon dioxide (CO_2) from landfill gas (LFG) using the Acrion CO_2 wash process. The patented Acrion CO_2 wash process uses liquid CO_2 to absorb contaminants from the LFG. The process steps are compression, drying, CO_2 wash contaminant removal and CO_2 recovery, physical solvent residual CO_2 removal to pipeline specifications. Installed capital cost is $5.3 million, annual operating costs $1.0 million, and project payback is 3.1 years with methane at $2.00 per MMBtu and liquid CO_2 at $40/ton. This design is the basis for determining the economic feasibility of liquefying natural gas at large LNG peak shaving facilities, swapping lower cost landfill methane injected into the distribution system near the landfill for natural gas removed from the supply pipe at the peak shaving plant.

Pipeline natural gas specifications have been compiled and are reported. Two pipeline gas characteristics crucial to conversion of landfill gas to pipeline methane are heating value (Btu/SCF) and total inerts. These characteristics are not independent and are the most difficult to achieve in the upgrade of landfill methane to pipeline specifications. Heating value can be increased by propane injection, and may prove economic if the amount required is less than about 1 to 2 vol%. Injection of processed landfill methane into distribution and transmission pipelines must be examined carefully on a case-by-case basis. and lengthy negotiations with the pipeline owner can be anticipated.

Vandor + Vandor, an independent subcontractor, studied "Wheeling" landfill methane for LNG. Vandor's work examined the feasibility of utilizing excess liquefaction capacity at large peak shaving plants to produce LNG, and distribution of LNG from the peak shaving plant(s) with Maryland. The concept appears feasible.

Sewage digester gas as a methane source for production of liquid methane has been investigated. AplusB, Inc., an independent subcontractor, studied sewage digester gas and reviewed commercial or near-commercial bio-digester technologies. Process designs were developed to convert digester gas to LNG at two levels of H_2S in the raw gas, 100 ppm and 600 ppm. Economics appear favorable for a 21,500 gal/day production facility with simple paybacks of 3 and 3.3 years. However Acrion does not intend to actively pursue sewage digester gas as a methane source for LNG heavy duty truck fuel for several reasons: 1) digester gas is tightly integrated into the energy balance of most waste water treatment plants and conversion of digester methane to LNG for offsite use would require procurement of an alternative less expensive energy source to replace it; and 2) high H_2S levels at some wastewater treatment plants increase costs and 3) there is much greater opportunity to develop LNG projects at municipal landfills.

Mixed refrigerant systems have been compared with a conventional cascade refrigeration system for the LNG and liquid CO2 designs developed in Phase I and the pipeline gas and liquid CO2 design developed in Phase II. For the low temperature LNG and liquid CO2 design the power requirement for the mixed refrigerant and cascade refrigeration systems were the same but the capital cost of the mixed refrigerant system was about 5% lower due to the presence of a single compression unit. For the warmer refrigeration requirements of the pipeline gas and CO2 refrigeration system (-70°F), the mixed refrigerant system had a 19% lower power requirement than the cascade system and a 9% lower capital cost.

A cost estimate for gas compression and cleanup to supply a small LNG production facility to fuel refuse vehicles at the Arden Landfill in Washington PA was developed. Vendor quotes for a 1200 gal/day facility were acquired. The estimated plant cost is $860,000.

The next step in the development process is to define the size and scope of a project at the Arden landfill. Acrion would pursue the task of firming the cost estimate and identifying lower cost technologies and sources for trace CO2 removal. We would also identify the market for co-produced CO2 in the area. Acrion's pilot LFG to liquid CO2 pilot unit, currently under construction for placement at the NJ Ecocomplex, can supply high pressure contaminant free methane enriched gas which can be further processed to approximately 800 gal/day of LNG.