

Integrated Combined Heat and Power/Advanced Reciprocating Internal Combustion Engine System for Landfill Gas to Power Applications

Development of an Improved Modular Landfill Gas Cleanup and Removal System

Introduction

Landfill gas (LFG), composed largely of methane and carbon dioxide, is used in over 450 operational projects in 43 states. These projects convert a large source of greenhouse gases into a fuel that currently provides 38 trillion Btu of electricity and 77 billion cubic feet of LFG annually to direct-use applications. However, there is still a significant resource base for new projects, with over 540 untapped candidate landfills across the country. Landfill gas and other opportunity fuels, such as digester gas from wastewater plants and coal-mine methane, need improved gas-utilization technology in order to lower costs, increase system efficiencies, and provide more effective and environmentally friendly gas cleanup.

To achieve these goals, this project will bring several technologies together in a combined effort to address gas quality and cleanup issues. The project team will work to increase system efficiency by incorporating waste heat recovery (instead of electric power) to drive the cooling system employed in the total contaminant removal (TCR) gas cleanup technology. The Pioneer TCR System provides extremely dry gas and removes siloxanes (silicon compounds), sulfur and halide compounds, and other difficult-to-remove contaminants (including up to 98%–99% of water moisture). In addition, advanced sensor technologies for monitoring fuel gas heating value will be integrated into engine controls to improve the performance and reliability of the reciprocating internal combustion engines that use LFG and other opportunity fuels available from wastewater plants.

Benefits for Our Industry and Our Nation

The project will allow for wider use of LFG, turning a significant source of greenhouse gas into a fuel that displaces electric power generation. If the project technology was installed at one-fourth of the 540 untapped U.S. candidate landfills, the estimated energy savings is expected to be approximately 155 trillion Btu (equivalent to the annual greenhouse gas emissions from approximately 2.5 million passenger vehicles). The project technology will improve the system power output capacity (and

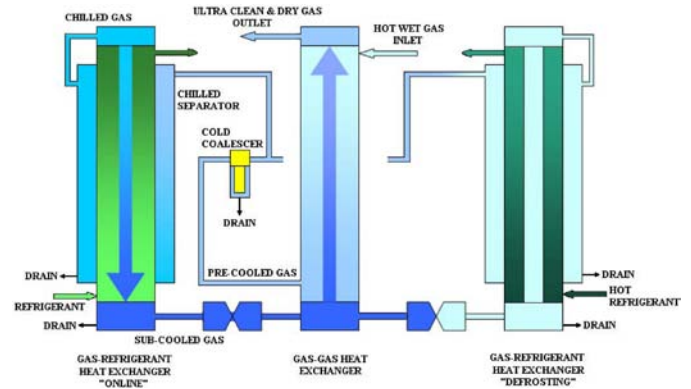


Figure 1. Flow diagram of the total contaminant removal (TCR) patented technology (U.S. Patent No. 6,712,885). Alternating heat exchangers provide frosting and defrosting action. Most of the contaminants either condense or dissolve in condensed fluids. If required, media adsorption can be added for additional gas cleaning.

Illustration courtesy of Pioneer Air Systems Inc.

thus provide direct energy savings) in excess of 5%. Further, the lower system-refrigeration temperature will lead to reduced contamination of the carbon media, resulting in reduced disposal and energy costs. The technology is also designed with increased productivity and easier system implementation in mind, as it will be available as an integrated prefabricated modular product, reducing time and money spent on custom engineering for future applications.

Applications in Our Nation's Industry

This technology will have extensive applications in LFG industries. Applications will also be found in other industries that include wastewater treatment (digester gas) and coal-mine methane, as well as in a growing market for digesters that use agricultural waste.

Project Description

One goal of this project is to improve cleanup-equipment performance for higher fuel utilization and reduced maintenance costs. The second goal of this project is to develop and demonstrate an improved control system for stoichiometric engines that employs the most advanced sensor technology available for monitoring fuel heating value, engine exhaust nitrogen oxide (NO_x)/oxygen (O₂) levels, and changes in exhaust-gas temperature. The third goal of the project is to produce a packaged and modular system for reduced installation costs. Further, this project aims to reduce emissions in comparison to conventional technologies to meet local air quality authority emissions restrictions.

Barriers

- Development of an absorption chiller-based gas dryer, driven by waste thermal energy from the engine
- Development of a new engine monitoring and control system capable of detecting fuel heating value and composition variability, while also maintaining reliable engine operation at optimum conditions
- Development of an exhaust-gas recirculation system that reduces engine exhaust (NO_x) levels and permits engine operation closer to the maximum efficiency point

Pathways

The proposed project will modify an existing design for LFG, digester gas, and other opportunity gaseous fuels to utilize waste heat instead of electricity to drive the cooling process within the system. This will increase output of electric power from the system, increase system reliability, reduce net emissions, improve engine efficiency, and reduce maintenance costs by improving gas quality.

Milestones

This project started in 2009.

- Year 1: Development of a fuel gas cleanup system with heat recovery
- Year 1: Development of a gas-quality sensor for real-time detection of opportunity fuel composition and heating value to provide the air/fuel ratio controller with a necessary feed-forward input
- Years 1–2: Development of software and a control system for the air-fuel ratio controller for opportunity fuels
- Year 2: Development and testing of the cooled exhaust-gas recirculation system required for maintaining stoichiometric operation of the opportunity fuel-powered field-test engine with three-way catalyst to control emissions
- Year 2: Combination of the gas quality sensor, advanced engine controller, and exhaust-gas recirculation into an integrated prototype system on a multicylinder test engine for operation on simulated opportunity-fuel composition
- Year 3: Field evaluation of the integrated gas-cleanup system on a 1 megawatt (MW) engine with a cooled exhaust-gas recirculation and an advanced engine monitoring and control system

Commercialization

The project partners offer a unique coordination of technologies that is necessary to improve upon available technologies and successfully commercialize two project products. First, a TCR system with waste heat recovery will be offered as a product by Pioneer Air Systems, whose existing market position will facilitate commercial sales in this area. Second, an advanced engine-combustion control system, including key sensor and control system elements, will also be commercialized for use with other opportunity fuels.

Project Partners

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