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An ONSI PC25™, 200 kW (nominal capacity) phosphoric acid fuel cell operating on landfill gas (LFG) is installed at the Town of Groton Flanders Road landfill in Groton, Connecticut. This joint project by the Connecticut Light & Power Company (CL&P) which is an operating company of Northeast Utilities, the Town of Groton, International Fuel Cells (IFC), and the United States Environmental Protection Agency (EPA) is intended to demonstrate the viability of installing, operating, and maintaining a fuel cell operating on LFG at a landfill site. The goals of the project are to evaluate the fuel cell and gas pretreatment unit (GPU) operation, test modifications to simplify the design, and demonstrate the reliability of the entire system.

In 1990, the EPA contracted with IFC to design and build a landfill GPU that would allow LFG to be used by a fuel cell. Upon successful demonstration of the GPU, the fuel cell was installed at the Penrose Landfill in Los Angeles to demonstrate the system operation. The energy recovery system operated for approximately 3 months, concluding operations in February 1995. In order to verify operation on a different composition LFG and in different climatic conditions, the energy recovery system was shipped to the East Coast. Discussions between all parties resulted in the Town of Groton landfill being chosen as a site to continue operation of the fuel cell and GPU system. The EPA is the current owner of the fuel cell and the GPU and is providing technical expertise for the project. CL&P is the funding source for the project and is providing the engineering, design, and construction for the installation as well as the operation and maintenance for the 12-18 month demonstration period. IFC is providing technical expertise for the operation of the fuel cell and GPU system. The Town of Groton is providing the site as well as the collected LFG and operation of an existing LFG flare at no cost to CL&P.

The LFG is collected from an 18.2 ha (45 acre) closed landfill. Based on the estimated volume of solid waste in the Groton landfill, a calculated 5.8 million m^3 (204 million ft^3) of LFG would be produced annually. Prior to the installation of the fuel cell system at Groton, the LFG was collected and burned in a flare at a rate of approximately 0.189 m^3/s (400 cfm). The fuel cell system uses a maximum of 0.0378 m^3/s (80 scfm) of landfill gas while the remaining gas continues to be burned by the flare. Where LFG is emitted into the atmosphere without recovery and use, methane has a global warming potential much greater than that of carbon dioxide (CO_2). Some of the non-methane constituents of LFG, such as hydrogen sulfide (H_2S), are odoriferous and potentially harmful to the environment.

The fuel cell emissions are primarily water vapor and CO_2. Emissions of nitrogen oxides (NO_x) and sulfur dioxide (SO_2), which result from the combustion of LFG, are virtually eliminated. Due to its higher efficiency, the quantity of CO_2 emitted from the fuel cell is less than the amount created through combustion conversion electrical generators such as the combustion turbine and internal combustion engine. A comparison of typical emission rates is:

	Typical Emission Rates (g/kWh)		
	Combustion Turbine	Internal Combustion Engine	Fuel Cell
NO_x	0.694	0.417	0.004
SO_2	0.077	0.054	0
CO_2	889.041	621.421	435.449

System Description at the Groton Landfill

The LFG is collected from the closed and capped landfill through a series of wells and is drawn out of the landfill by the flare blower. This maintains an absolute pressure of 99.8 kPa (14.5 psia) on the collection system. An LFG compressor draws LFG from a collection header and compresses the gas to 276 kPa (40 psig) for use in the GPU. Two H_2S absorbers, using activated carbon as the absorbing medium, are installed on the suction side of the compressor to remove the H_2S from the gas stream prior to compression. A moisture separator prior to the H_2S absorbers removes any bulk moisture present in the gas. The H_2S absorbers are installed in a parallel/series arrangement where normal operation is in series but either absorber can be removed from service while the other is in service. This is useful for carbon changeout during operation or testing the removal effectiveness of an individual absorber.

The gas is discharged from the gas compressor and into the GPU where moisture and volatile organic compounds (VOCs) including sulfides and halogenated compounds are removed. The GPU has dual cleanup trains so when one train is in service cleaning the gas the other is being regenerated with a portion of the cleaned gas. The regeneration gas, in the quantity of 0.0118 m^3/s (25 scfm), is combusted in an enclosed flare. The cleanup train consists of an alumina plus mole sieve dryer vessel which removes the moisture from the gas, a carbon vessel which absorbs hydrocarbons and VOCs, and a refrigeration unit and heat exchanger which are used to cool the gas to 274.3 K (34°F) prior to entering the cleanup train. The gas leaves the GPU consisting of methane, CO_2, and trace amounts of nitrogen and oxygen. The dew point of the gas is 244.3 K (-20°F). The specific composition of the Groton LFG leaving the GPU is:

Methane - 57.1%
Carbon dioxide - 41.0%
Nitrogen - 1.5%
Oxygen - 0.4%

The fuel cell has been modified for operation on LFG to accept the higher flow rate required because of the reduced methane content in the LFG. These modifications include a larger fuel control valve and fuel control venturi plus resizing of two fixed orifices. Minor modifications were also made to the control settings.

Site Layout

Figure 1 is a site layout plan that shows the equipment configuration. The total site encompasses an area 13.12 m (43 ft) wide by 41.15 m (135 ft) long and is enclosed by a chain link fence. Located at the south end of the site are the existing LFG flare and a newly installed underground storage tank to collect condensate that comes from the landfill with the gas as well as from the GPU. The GPU control room houses the GPU control panel, refrigeration unit purge air compressor, nitrogen bottles for actuating the GPU pneumatic valves, and project documentation. The GPU flare is used to combust the regeneration gas. The gas pretreatment unit building is a pre-engineered building with aluminum sided and insulated walls and roof. The space inside the building is considered a Class 1, Division 2 location, and all electrical equipment and fixtures are explosion proof. Enclosed in the gas pretreatment unit building is the LFG moisture separator, H_2S absorber vessels, gas compressor, GPU, and refrigeration unit. A combustible gas detector is used to monitor the interior atmosphere and ultimately shut down the

gas compressor if gas is detected. A compressed natural gas (CNG) bottle rack is required to supply start up burner fuel for the fuel cell and for the GPU flare. The fuel cell and cooling module are in the standard configuration for a typical installation. A nitrogen bottle rack external to the fuel cell is used to increase bottle capacity and facilitate bottle changeout. The switchgear contains the distribution bus and breakers for the fuel cell and all other site equipment. The step-up transformer takes the 480 V power from the fuel cell output and increases it to 13,800 V for use on the utility grid. The equipment and site layout are designed for unmanned operation. Remote data monitoring of the fuel cell and GPU controller will be utilized.

Project Status

Construction was completed in mid-June 1996, and system start-up and testing was in progress at the time of the submittal of this paper in late August 1996. Prior to start-up of the fuel cell, the GPU was started and operated for 200 hours, and gas quality suitable for fuel cell operation was verified. Operation of the fuel cell at the Groton site on landfill gas has been achieved with an output of 165 kW obtained to date. The power generated is enough to supply over 100 homes and is fed into the local utility grid. Continued testing and refinement of the system is expected to achieve a continuous net fuel cell output of 140 kW.

Conclusion

The operation of fuel cells on landfill gas presents an opportunity to use a waste gas that is harmful to the environment to generate electricity more cleanly and efficiently than other methods currently used. The use of other bio gases, such as from waste water treatment plants and livestock wastes, in fuel cells is possible as a result of the work performed using LFG as a fuel. This project brings bio gas conversion using fuel cells one step closer to commercial application.

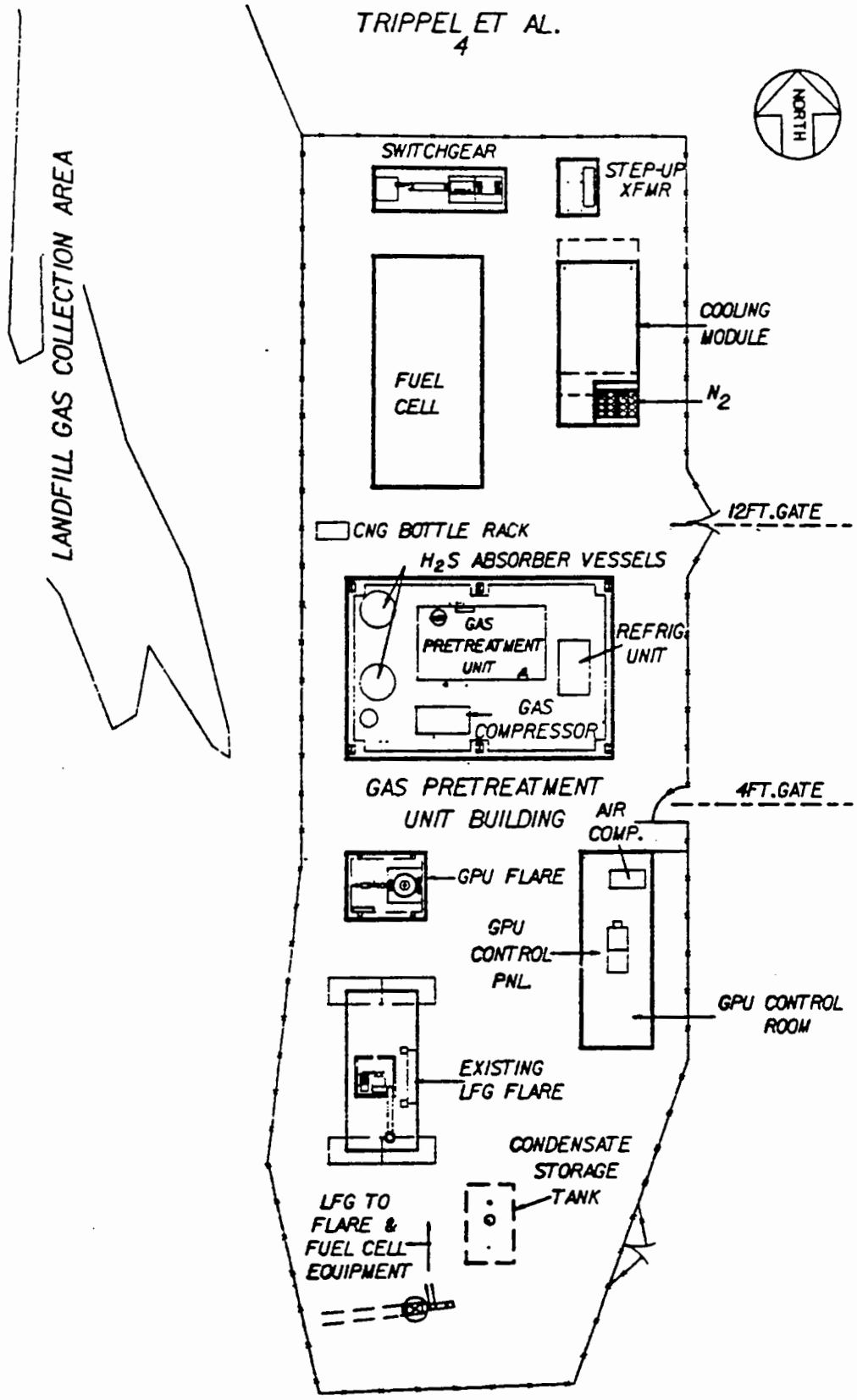

Figure 1

Groton Fuel Cell Site Layout

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16. ABSTRACT The paper discusses operating a 200-kW phosphoric acid fuel cell using landfill gas (LFG) in Groton, Connecticut. The project is intended to demonstrate the viability of installing, operating, and maintaining a fuel cell operating on LFG at a landfill site. The goals of the project are to evaluate the fuel cell and gas pretreatment unit (GPU) operation, test modifications to simplify the design, and demonstrate the reliability of the system. The operation of the fuel cell on LFG presents an opportunity to use a waste gas that is harmful to the environment to generate electricity more cleanly and efficiently than other methods currently used. The use of other bio gases, such as from waste water treatment plants and livestock wastes, in fuel cells is possible as a result of the work performed using LFG as a fuel.

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