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LANDFILL METHANE OUTREACH PROGRAM

Powering Microturbines with Landfill Gas

Microturbines are an emerging landfill gas (LFG) energy recovery technology option, especially at smaller landfills where larger electric generation plants are not generally feasible due to economic factors and lower amounts of LFG. Several LFG microturbine projects have come on line recently, demonstrating both the risks and benefits of these small-scale applications. Microturbines may play an important role in future LFG project development, if the technical and economic hurdles facing them can be overcome.

This fact sheet provides an overview of microturbine technology and its applications, as well as the economic considerations and benefits of powering microturbines with LFG.

Overview

Microturbines are a recently commercialized distributed generation (DG) technology. Like other DG technologies, such as fuel cells, wind turbines, and photovoltaic cells, microturbines are generally best suited to relatively small applications (i.e., less than 1 megawatt [MW]) and are designed to produce electricity for onsite energy needs and for end users in close proximity to the generation site. As a point of reference, the output of a 30 kilowatt (kW) microturbine can power a 40 horsepower motor or satisfy the electricity needs of about 20 homes.

Internal combustion engines have traditionally been the choice for LFG projects 800 kW and larger, and conventional turbines are generally considered only for projects 3 MW and larger. However, with individual unit sizes in the 30 to 100 kW range and the ability to group these units into larger sets, microturbines can fill an important niche. They can be used at landfills where the gas output is too low for larger engines and conventional turbines or where excess gas or onsite energy needs exist. (As an example, microturbines could be used to power blowers in a gas collection system.)

To date, most microturbines on the market are powered using natural gas. However, they can also be operated using LFG or other waste fuels, such as oilfield flare gas and wastewater treatment plant digester gas. At the time of publication of this fact sheet, several companies are manufacturing and distributing microturbines or are expected to do so in the near future. These include: Bowman Power (Southampton, England); Capstone Turbine Company (Chatsworth, California); Elliott Energy Systems (Jennette, Pennsylvania); Ingersoll-Rand (Portsmouth, New Hampshire); and Turbec (Malmo, Sweden).

> Several LFG microturbine projects have come on line recently, demonstrating both the risks and benefits of these small-scale applications. Microturbines offer another option to generate electricity at sites ranging from older closed landfills with low-methane gas and low flow, to smaller, more rural landfills where larger generation technology is not usually feasible.

Nearly 100 microturbine projects operating on waste fuels are already operational, and additional projects are expected to be operational soon. In the past two years, microturbines operating on LFG have come on line at at least three landfills in the United States, and additional LFG projects are in the planning or construction stages.

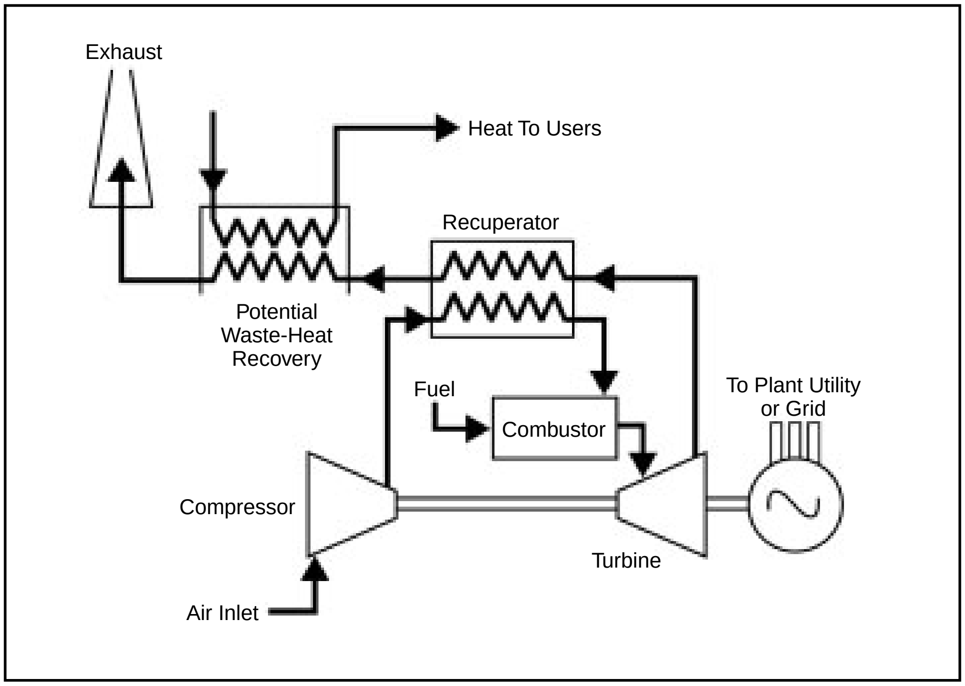
Microturbine Technology

Microturbine technology is based on the design of much larger combustion turbines employed in the electric power and aviation industries. Microturbines generally work as follows:

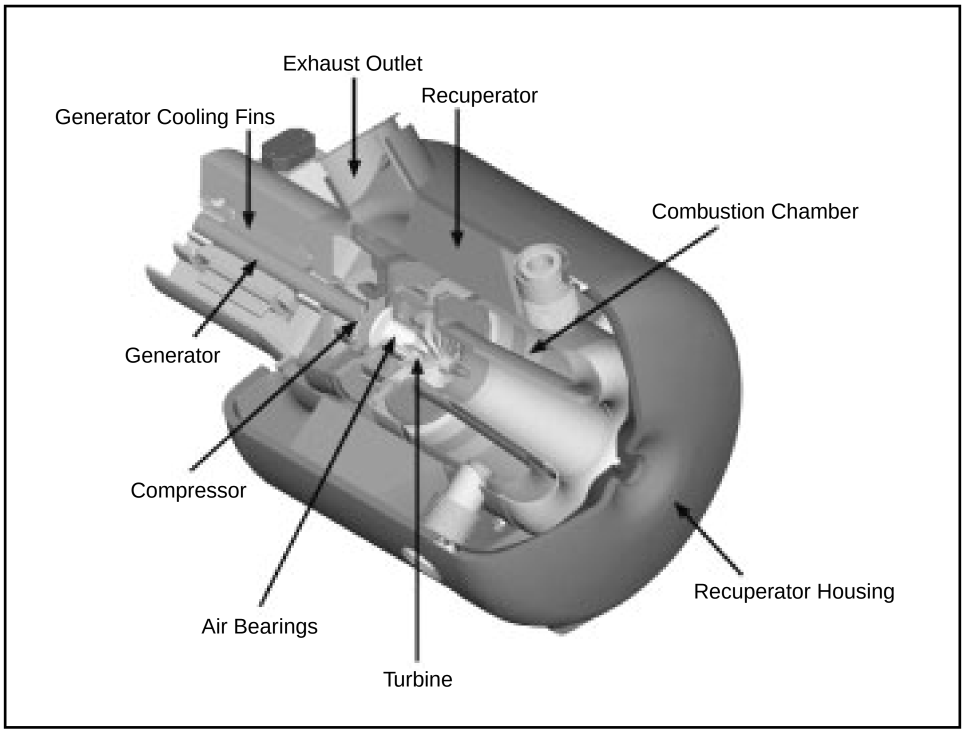
- Fuel is supplied to the combustor section of the microturbine under 70 to 80 pounds per square inch gauge (psig) of pressure.
- Air and fuel are burned in the combustor, releasing heat that causes the combustion gas to expand.
- The expanding gas powers the gas turbine that in turn operates the generator; the generator then produces electricity.
- To increase overall efficiency, microturbines are typically equipped with a recuperator that preheats the combustion air using turbine exhaust gas. A microturbine can also be fitted with a waste heat recovery unit to heat water.

A general schematic of the microturbine process (illustration at upper right) as well as a cross-section of one microturbine that is currently available for LFG application (lower illustration) are shown to illustrate how a microturbine operates.

Microturbines differ from traditional combustion turbines in that they spin at much faster speeds. Those currently on the market are equipped with air bearings rather than traditional mechanical bearings in order to reduce wear. A typical LFG-fired microturbine installation has the following components:



Microturbine process schematic.



Cross-section of a microturbine. *Courtesy of Capstone Microturbines*

- LFG compressor(s)
- LFG pretreatment equipment (for moisture, siloxanes, and particulates removal)
- Microturbine(s)
- Motor control center
- Switchgear
- Step-up transformer

The extent of fuel pretreatment steps required depends on the characteristics of the LFG and varies by microturbine manufacturer. In some instances, the gas is chilled to remove moisture and condensable impurities and is then reheated to supply fuel above dew point temperature to the microturbine. In addition to moisture removal, some manufacturers recommend an adsorption step using activated carbon to remove virtually all impurities.

Applicability

Microturbines provide unique advantages over other electrical generation technologies for landfills in cases where:

- LFG flow is low (or excess flow from an existing project is available).
- LFG has low methane content.
- Air emissions, especially nitrogen oxide (NO_X), are of concern (e.g., in NO_X nonattainment areas where the use of reciprocating engines might be precluded).
- Electricity produced will be used for onsite facilities rather than for exporting power.
- Electricity supply is unreliable and electricity prices are high.
- Hot water is needed on site or nearby.

Economic Considerations

Microturbine heat rates are generally 14,000 to 16,000 Btu/kWh. The total installed cost for a LFG microturbine project is estimated to be $4,000 to $5,000 per kW for smaller systems (30 kW), decreasing to $2,000 to $2,500 per kW for larger systems (200 kW and above). Non-fuel operation and maintenance costs are about 1.5 to 2 cents per kWh.

LFG microturbine projects are most economical under a retail deferral scenario. (Retail deferral is the replacement of purchased electric power by self-generated power.) In many cases, the cost to generate electricity with microturbines will be higher than the price for which it can be sold to utilities.

Benefits

LFG microturbines offer the following advantages when compared to other types of LFG utilization technologies:

- *Portable and easily sized.* Microturbines are modular and available in incremental capacities for multiple-unit stacks, so that single or multiple microturbines can be configured to adapt to gas flow and satisfy onsite power requirements. They can then be moved to another project site when gas production ceases.
- *Flexibility.* Microturbines may be a more viable option at smaller and older landfills where LFG quality and quantity would not support more traditional LFG electric power generation technologies. They may also be feasible at larger LFG projects that have excess unutilized gas.
- *Compact and fewer moving parts.* Microturbines are approximately the size of a large refrigerator and require minimal operation and maintenance. The use of air bearings coupled with an air-cooled generator eliminates the need for lubrication and liquid cooling systems.
- *Lower pollutant emissions.* Microturbines burn cleaner than comparable reciprocating engines. For example, NO_X emissions levels from microturbines are typically less than one-tenth those of the best performing reciprocating engines and lower than those from a LFG flare.
- *Capable of combusting lower-methane-content LFG.* Microturbines can operate on LFG with 35 percent methane content and perhaps as low as 30 percent.
- *Ability to generate heat and hot water.* Most microturbine manufacturers offer a hot water generator as a standard option to produce hot water (up to 200°F) from waste heat in the exhaust. This option can replace relatively expensive fuel, such as propane, needed to heat water in colder climates to meet space-heating requirements. The sale or use of microturbine waste heat can significantly enhance project economics.

Concerns with LFG Microturbines

Reciprocating engines are a widely proven, mature technology in the LFG power generation industry, especially for 800 kW and larger units. In contrast, the long-term reliability and operating costs of microturbines have yet to be confirmed. Disadvantages of microturbines as a LFG utilization option include:

- Microturbines have a lower efficiency than reciprocating engines and other types of turbines, and they consume about 35 percent more fuel per kWh produced.
- Microturbines are sensitive to siloxane contamination, and LFG supplied to microturbines is generally expected to require more pretreatment than LFG used to power conventional turbines or other electric generation sources.
- Currently, few low-flow, high-pressure compressors are available that meet the needs of microturbines without high equipment modification costs; a suitable solution would need to be identified to permit cost-effective delivery of LFG to microturbines without significantly increasing the parasitic load.
- Information needs to be gathered about the long-term reliability and operation and maintenance costs of LFG microturbines.

To learn more about the potential concerns of running microturbines on LFG, a pilot test of a 30 kW unit was conducted at the Puente Hills Landfill in Los Angeles County, California. Microturbines that were operated for over 2,000 hours on LFG developed some wear and tear, potentially from abrasives (such as siloxanes) in the LFG. A second pilot project was launched in June 2001 to learn more about and eliminate these problems.

Development Potential

At present, principal hurdles in the development of LFG microturbine technology are the lack of information on long-term reliability, unclear estimates of operation and maintenance costs arising from extensive LFG cleanup requirements, and high capital costs. The microturbine projects that are currently in operation or under development are attempting to address these concerns by:

- Obtaining extended-term operation and maintenance cost guarantees from equipment manufacturers, based on agreed upon fuel specifications.
- Applying aggressive LFG pretreatment (e.g., refrigeration, activated carbon treatment).
- Emphasizing projects with relatively rapid projected paybacks.

Microturbines offer another option to generate electricity at sites ranging from older closed landfills with low-methane gas and low flow, to smaller, more rural landfills where larger generation technology is not usually feasible. While the future of microturbines that run on LFG is uncertain, additional research is essential to gain a better understanding of the long-term viability of this technology.

Sources of Additional Information

While limited research has been conducted to date on powering microturbines with LFG, some sources of information include:

1) "Landfill Gas Fueled Microturbines Are Here," George Wiltsee, Capstone Turbine Corporation, and Paul Wintheiser, EMCON-IT Group, 5th Annual LMOP Conference and Project Expo, December 13-14, 2001, Washington, DC. (Contact LMOP at 888-STAR-YES or visit www.epa.gov/lmop.)

2) "Demonstration Test of the Capstone Microturbine on Landfill Gas," Ed Wheeless, Sanitation Districts of Los Angeles County, California, and George Wiltsee, Capstone Turbine Corporation, 24th Annual Landfill Gas Symposium, March 19-22, 2001, Dallas, TX. (Contact SWANA at 800-GO-SWANA.)

3) "Microturbine Distributed Generation Using Conventional and Waste Fuel," Jeff Pierce, SCS Engineers, The National Defense Industrial Association's 28th Environmental and Energy Symposium and Exhibition, Charleston, South Carolina, March 25-28, 2002. (Contact Mr. Pierce at 562-427-0805.)

4) U.S. Department of Energy, Office of Distributed Energy Resources, Microturbines Program. (Visit www.eren.doe.gov/der/microturbines/microturbines.html.)

The **Landfill Methane Outreach Program (LMOP)** is a voluntary program that assists project developers, utilities, landfill owner/operators, energy users, and communities to encourage new landfill gas use projects. The U.S. Environmental Protection Agency has developed a variety of tools (e.g., profiles, fact sheets, project development manuals, and software) to facilitate the development of LFG use projects. For more information, please contact LMOP at:

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