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With the public spotlight on the environment and climate change, reducing emissions from power plants is a task that many countries are taking seriously. Microturbines could help tackle some of the problems.

Macro problem – Micro solution?

In the face of continued population growth, increasingly taxed ecosystems and more stringent environmental regulations, advanced technology solutions are critical for waste treatment industries. The conversion of organic wastes into biogas (methane and carbon dioxide) using controlled biological systems is an increasingly important waste management technology – whether it occurs deep inside a landfill, in anaerobic digester vessels at industrial or wastewater treatment plants, or in covered lagoons at livestock farms.

Finding cleaner ways to turn biogas into electricity and heat using equipment with higher reliability – and at the same time reducing maintenance costs – is the challenge being met by microturbines.

Biogas-fuelled microturbines are dotting up around the world in Germany, Italy, the UK, Brazil, Malaysia and Japan, matching a trend that began two years ago in the US. Microturbines are a relatively new but now proven technology to convert sources of pollution and greenhouse gases into onsite power: fuel-flexible and small – commercially available units from Capstone Turbine, Ingersoll-Rand, Turbec and Bowman are less than 100 kW per unit, but most installations involve arraying several units. Los Angeles based Capstone Turbine has sold and shipped more than 2400 microturbines worldwide. The other companies have sold about 150 more. Most of these super-low-emission marvels run on natural gas, diesel or kerosene. But more than 200 are currently running on an exclusive diet of biogas from digesters and landfills, and many more are coming online.

Figure 1. A ten unit array of microturbines running on biogas powers a Los Angeles landfill site

Figure 2. Landfill gases are far more destructive than CO_2

Eliminating pollutants

During a demonstration test programme three years ago at one of the world's largest landfills – Puente Hills landfill in Los Angeles – and at a wastewater treatment plant also in Southern California, the performance of these units on biogas was verified.

According to Ed Wheless, solid waste management division engineer of the Los Angeles County Sanitation Districts: "Capstone thought that NO_x emissions below 9 ppm were possible while operating on landfill gas with as little as 35 per cent methane. These were lofty goals of immense importance to the industry." In fact, the Capstone microturbine at Puente Hills routinely operated on 35 per cent methane landfill gas, and its NO_x emissions were independently measured by the LACSD at 1.3 ppm (at 15 per cent O_2). Carbon Monoxide (CO) emissions were confirmed to be 36 ppm, methane 2.2 ppm and non-methane organic compounds destruction was verified as 98.6 per cent. Unlike flaring and genset applications, microturbine exhaust is odour-free.

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"No other small technology we have evaluated can work reliably on landfill gas with NO_x emissions equivalent to or below the 30 ppm of flares," Wheless said following completion of the demonstration programme in 2000. "To achieve 1.3 ppm is remarkable. That approaches the level of fuel cells, but at a fraction of the cost," he said.

In terms of greenhouse impact, methane flared or vented into the atmosphere is more than 20 times more destructive than CO_2. Biogas emerges from its sources (landfill or digester) as a wet, corrosive gas at low pressure. For good performance, it must be fed to microturbines as a dry, clean, pressurized gas. The following equipment items are commonly used to deliver biogas to microturbines:

- Gas-liquid separator (also known as a knockout pot)
- Compressor (preferably a rotary sliding vane compressor) rated to 80 psig
- Refrigerated dryer (reducing the dew point of the gas to about 2°C)
- Siloxane filter (graphite filter that

Figure 3. Microturbines at a sewage plant in California

removes silicon-containing chemicals, which damage any combustion device – reciprocating engine or turbine)

• Pressure regulator with coalescing filter.

All of the above equipment must be designed and proven to be effective with biogas. Stainless steel construction is the norm. Farm digesters and food processing waste digesters normally do not require siloxane filters.

H_2S removal from the biogas is required at some facilities to meet emissions permits or to assist in siloxane removal. However, Capstone microturbines can accept up to 700 000 ppm of corrosive H_2S emissions with no adverse effects (such levels would destroy a reciprocating engine genset). In digester applications, exhaust heat from the microturbine(s) is recovered to heat the water used to maintain proper digester temperature.

Figure 4. Anaerobic digester at a cattle farm in Japan

Why microturbines?

Many sites that have deployed reciprocating engine generators to use biogas have had less than desired results. Maintenance costs and unscheduled downtime/repair needs are problematic.

Since the methane content of biogas is very low – about half to a third that of natural gas – some installations require "sweetening" with purchased natural gas or propane to boost the Btu content to a level that the engine can accept. Conditioning of the biogas stream, particularly H_2S removal in digester gas streams, can be cumbersome.

Microturbines require more extensive gas compression and moisture removal than reciprocating engines, but offer a number of potential advantages:

• Ability to run exclusively on low-Btu gas (eliminating commercial fuel purchase)

• Enormously lower emissions (NO_x and CH_4) than gensets or flaring

• Designed to operate continuously at full load

• Few moving parts (some models have just one)

• Appropriately sized for smaller facilities (wastewater treatment plants that process as little as one million gallons per day; small or closed landfills, 100-head dairy farms, etc.)

• Relatively quiet and easily scalable (one array of 50 microturbines at a Los Angeles landfill generates up to 1.5 MW)

• No post-combustion cleanup devices

• Some models use no oil, antifreeze or other hazardous fluids (and thus have no pumps, radiators, hoses, gearboxes or other mechanical subsystems).

Although still a relatively new technology, microturbines have already paid some significant dues. Capstone has individual units that have surpassed 25 000 hours of operating with maintenance encompassing little more than a few minor filter and injector cleanings/replacements and servicing/replacement of an ignitor (spark plug). Of the installed fleet that it can access, Capstone has verified more than 2.6 million hours of documented operation – equivalent to 300 years of continuous operation.

What's on the market

For biogas applications, Ingersoll-Rand offers a 70 kW system with internal heat recovery; Capstone has a 30 kW offering with optional heat recovery modules that accept exhaust from one to four units. A biogas-fuelled version of their 60 kW model is expected in the first half of 2003.

Flex Energies and Capstone are working on a US Department of Energy funded microturbine development project with the goal of creating a system that can accept much lower energy fuel sources and not require gas pressurization. Capstone has not yet announced an expected availability date for such a product.

"A DOE project will create a system which accepts lower energy fuel sources"

"We hope to develop even more advantageous products in the years ahead," said Capstone's biogas product director George Wiltsee. "But we are very excited to have hundreds of systems worldwide destroying these environmentally damaging gases more effectively than any other technology … and creating renewable, sustainable onsite energy in the process." PEi

Figure 5. Microturbines running on palm oil in Malaysia