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cospp

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THE UTILITY GRID AS STAND-BY POWER

The worst possible problem faced by a manufacturing facility in the state of New York used to be power interruptions. Even a momentary power event would be as damaging as a long outage, as days of work in process would be lost and computer numerical controlled machinery and other production equipment would need to be reprogrammed and reset. Earlier this year a new, micro-turbine-based power, heat and chilling system was installed. STEVE GILLETTE reports on that new system and its performance.

Located outside of Rochester, New York State, US, Harbec Plastics produces highly engineered, custom plastic parts for customers in the medical, automotive, consumer goods, and other industries. The company makes every effort to minimize waste through re-use and recycling, even saving floor scraps which, combined with plastic granules and other waste products, are re-melted to produce long-lasting, decay-resistant plastic lumber.

Likewise, energy efficiency is another of the company's priorities. The 40,000 sq. ft (3700 m²) facility uses an array of microturbine systems to produce high-quality, uninterrupted power and heat for space heating and cooling. Some of the power is even used to charge the company's fleet of electric vehicles, further reducing air and noise pollution.

The company, which now has 100 employees, was originally a machine shop performing various welding and fabricating processes; by using computer numerical controlled (CNC) machinery this has now developed into the production of high-value, customized tools – instead of high volume, mass-produced parts. After developing expertise with computer-controlled metalworking equip-

ment, the company found the same techniques applied to the growing market for plastic parts. Today, it makes use of more than 200 polymer blends to produce high-tolerance, specialty parts using engineered resins and complex inserting processes.

ON-SITE POWER

Harbec supplies complex, one-of-a-kind parts with extremely short lead times. Being dependent on a large number of CNC spindles and numerous CAD stations, the worst possible problem the operation faces is a power failure. Even during a momentary grid outage or voltage problem, the sophisticated sequences that the CNC machines are performing are lost, requiring 6–8 hours to reprogram and restart. If the cutter on the CNC damages the part being made, days of work in process may be lost. Multiply this problem by the 30 CNC machines conducting these processes, then add the loss of at least one hour of production time to reset each of the many other production machines, and the cost of lost raw materials, and the implications of a power failure, start to become clear.



The Harbec Plastics plant

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Microturbines

Microturbines are scaled down turbine engines with integrated generators and power electronics. They are generally characterized by having often only one rapidly moving part (moving at 100,000 rpm) supported either by air- or liquid-lubricated bearings. The microturbine generates high-frequency AC power that is rectified by a power electronics package into utility grid-quality, three-phase 400–480 V AC. Microturbines can operate on a wide variety of gaseous and liquid fuels, and have extremely low emissions of nitrogen oxides (although factory rated at full load at 'less than 9 ppmV NO_x @ 15% O₂', Capstone microturbines operating on natural gas have been independently measured at less than 3 ppm by the California Energy Commission and by the Cambridge Energy Research Associates). Electrical efficiency of microturbines is in the 25–30% range. Although the latest combined cycle gas turbines can achieve maximum output efficiencies nearing 60%, the US Environmental Protection Agency and the Department of Energy notes that average power plant efficiency in the country is 34%. Since 5–10 points of that is lost in transmission and distribution, the national average may actually be about the same as that of on-site microturbines.

Large-scale combined cycle turbines use ancillary heat to increase efficiency to 50–60%. Ancillary heat from microturbines

can be used on-site for water and space heating, process drying, food processing and absorption chilling. Doing so delivers a total system efficiency of at least 70%, and use of the exhaust stream for process drying, greenhouse heating/CO₂ supplementation and similar tasks yields efficiencies exceeding 90%.

Capstone Turbine Corporation began shipping microturbines in December of 1998. As of September 2001, Capstone had sold more than 1800, 30 kW and 60 kW microturbines, primarily in North America, Japan and Europe. Capstone's nearest competitor was Honeywell Power Systems, which had produced a total of about 300 of their 75 kW Parallon microturbines. However, earlier this year Honeywell recalled, or disabled *in situ*, all their Parallon systems and have said that they were unable to capture microturbine market opportunities as well as hoped.

Two significant players planning to offer microturbine systems later this year are Ingersoll-Rand and Turbec (the latter is a co-operative venture of ABB and Volvo). The 70 kW Ingersoll-Rand PowerWorks microturbine will use a two-shaft design that may have some advantages in secondary mechanical drive applications. The 100 kW Turbec T100 will have a pre-integrated heat exchanger to deliver a claimed 30% electrical efficiency and an 80% total system efficiency.

In June 1999 Harbec experienced three such outages, and company President Bob Bechtold was concerned that something had to be done. The criteria he outlined for an alternative system included the following:

- *The system must be the facility's primary source of power.* Since even a momentary power event was as damaging as a lengthy one, stand-by generation was not adequate. Battery UPSs cannot respond properly to the inrush current of the firm's many high-horsepower motors. The on-site system must instead be a continuous source of power to the facility, with some level of redundancy. If the on-site system failed, as well as the redundant system, the grid would serve as the final back-up. Since the on-site system normally operates independently of the grid, the odds of both failing simultaneously are extremely low.
- *The system must have extremely low emissions.* The ISO 14000 certified company's commitment to an environmentally benign system ensured that investigation focused on wind power, fuel cells and microturbines.
- *The system must be efficient.* The company envisioned using a system that would recapture waste heat from power generation for use in space heating, process drying and even space cooling.
- *The system must be commercially available, and economically feasible.*

As far as Harbec was concerned, microturbines fulfilled all of these criteria.

THE HARBEC SYSTEM

Electrical and mechanical design firm IBC Engineering was enlisted to evaluate the electrical loads of the building, and selected the number of microturbines. Nearly all of the 25 Capstone Turbine systems were mated with a heat recovery boiler; each boilers using the exhaust heat from four microturbines to generate 100°C (210°F) water. Total system efficiency exceeds 70%. (A webcam view of the system is at www.harbec.com/lp/stitched_result_cogen.html)

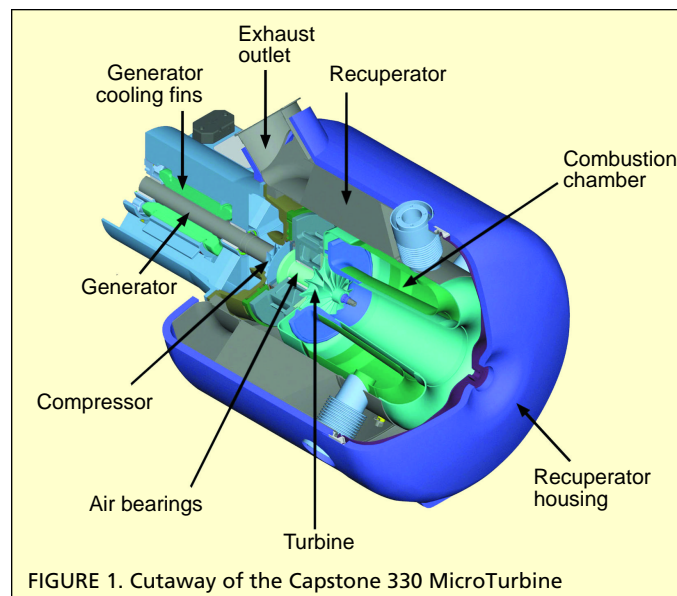


FIGURE 1. Cutaway of the Capstone 330 MicroTurbine

THE UTILITY GRID AS STAND-BY POWER

In the winter, the hot water is routed to a radiant floor heating system built into the concrete slab of Harbec's warehouse area. This warehouse was added as part of an overall remodel that included the on-site power system, and is the first industrial warehouse in the US to comply with the LEED standard for ultra-efficient construction. LEED – Leadership in Energy and Environmental Design – is a system managed by the US Green Buildings Council, and is designed for rating new and existing buildings. The energy efficiency-enhancing features include the use of recycled materials, daylighting, twice the insulation used in



The Harbec installation

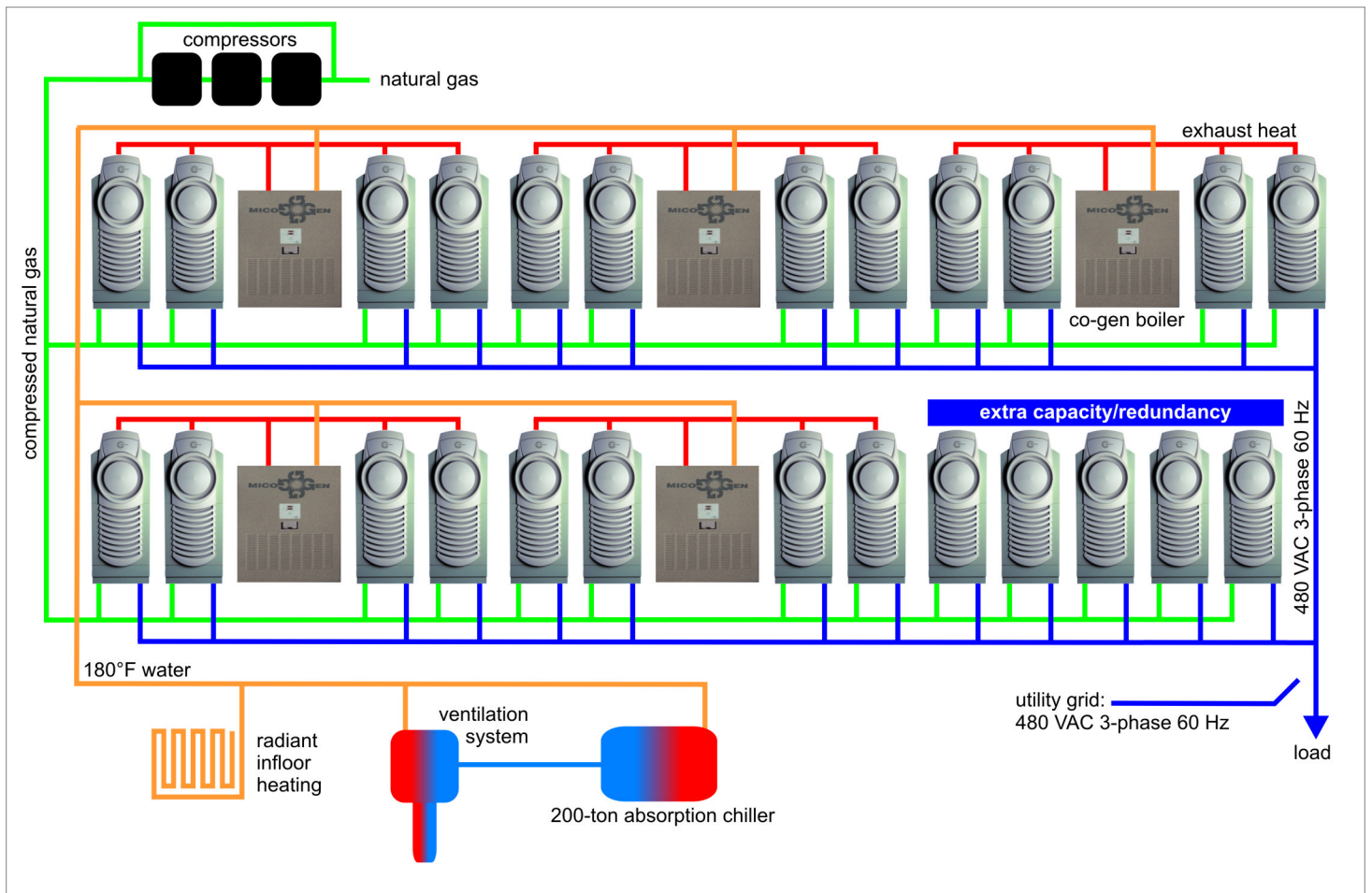
typical construction, and heat from the microturbines as the source of space heating.

It is also advantageous to use the microturbine heat during the non-heating season. The facility had no air conditioning, so a cooling system was designed using hot water to fire an absorption chiller that generates chilled water. The chilled water is piped to a fan-coil system that now air conditions Harbec's warehouse and production areas. Thus, air conditioning is made available with near zero electrical load. And added benefit is an integrated desiccant that reduces humidity and eliminates a materials drying process that had been a routine cost during the humid summer months.

System performance

The system ran and has continued to run well throughout the summer months. This is the period historically plagued by power outages, and during which the facility's power load is at its highest. Harbec uses a number of sophisticated production devices that have sensitivity to very brief voltage sags and other power quality events which would have no perceptible impact on lighting, PCs and so on.

The system has worked reliably, and one additional Model 330 has been added for a small capacity increase, bringing the total to 25 units. The workforce has been especially pleased to benefit from their 'electricity-free' air conditioning as there was no air conditioning at the company prior to this installation. The system is also used for drying of raw materials, thus streamlining a Harbec production process.



Harbec has secured a natural gas contract with TXU that delivers fuel to the facility at an average cost of US\$6.85/Mcf. At this rate, the value of the hot water recovered from the microturbines equates to \$0.03/kWh. Net of this recaptured heat, power is generated for approximately \$0.074/kWh, compared to the mean grid price of approximately \$0.105/kWh. At the time of writing, long-term natural gas contracts are available in many parts of the USA for about \$4/Mcf; at that rate, the per kWh cost would net at less than \$0.05/kWh. This differential will pay for the capital cost of the system even without outage cost avoidance. More importantly, Harbec will have achieved certainty in its source of power, and known costs for the foreseeable future. This is significant in an environment of growing uncertainty about the reliability and cost of grid-supplied power. With slightly higher electrical efficiency and hotter exhaust temperature, Capstone's newer microturbine models would provide even more favourable economics with just half the number of systems. Incentives for CHP installations available in several parts of Europe and the Americas make further improvements to the return-on-investment picture.

CONCLUSION

All businesses, but especially continuous process manufacturers, require a continuous supply of high-quality power. When even momentary disruptions result in lost work-in-process, down time and missed deadlines, on-site power systems provide an economically attractive

alternative to avoid such financial losses. Microturbines are among the proven technologies capable of providing a continuous source of high-quality power with near-zero emissions and extremely little maintenance. Coupling them with heat recovery and providing thermal energy for space and process conditioning makes these systems extremely energy efficient.

Even greater total system efficiencies – exceeding 90% – are possible when the exhaust is used directly in process drying. Since Capstone systems use no liquid or chemical lubricants or coolants, there is no exhaust stream contamination to foul sensitive materials. (One Capstone distributor, Advantica in the UK, has even engineered award-winning installations in which the exhaust stream is ported directly into horticultural greenhouses.)

The economics of on-site power with heat recovery enable businesses to achieve an extremely reliable power supply from a system whose energy economics can pay for itself. In these times of volatile electricity prices, on-site generation systems enable companies to budget for exactly what their electricity will cost. Such systems are creating a positive working environment at businesses like Harbec Plastics.

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