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Turbine Tech

Many companies and organizations are searching for cleaner, more reliable, more efficient, and affordable energy.

Photo: Solar Turbines

By Lori Lovely

To meet the demand, the US Department of Energy's Office of Distributed Energy and Electric Reliability is working with energy technology suppliers to promote advances in and adoption of distributed energy. Increasingly restrictive emissions requirements, the rising cost of energy, and the drive of the green movement have set the bar higher for producers and users of distributed energy systems. Because of the new parameters, impressively effective new methods are being designed.

In 2003, the Distributed Gas Turbine of the Future Workshop gathered experts together to discuss then-pressing issues: emissions, alternative fuels, competitive costs, reliability, and combined heat and power (CHP) efficiency. Seven years later, the issues are unchanged—only magnified. However, some progress has been made on the development of technology to address the concerns discussed at the workshop.

Around the same time, the US Department of Energy, Office of Energy Efficiency and Renewable Energy anticipated that at least half of all new power generating capacity to be added by 2010 would use gas turbines, because they can be used in a variety of applications with a range from 1 MW to 20 MW. Primary end-users include petro-chemical companies, the pulp and paper industry, pharmaceutical companies, the cement and textile industries, and oil and gas exploration, as well as universities and colleges, hospitals, and airports.

Photo: Solar Turbines Outside Paris, France, a Mars 100 gas turbine transforms landfill gas into electricity.

Their predictions weren't far off. Gas turbines are compact and simple to operate, making them popular for use at colleges, hospitals, commercial buildings, and industrial settings as a means of producing supplemental or standby power. Often located near the building benefiting from the energy they produce, these units provide a reliable power source with reduced emissions.

According to the Department of Energy, mid-sized turbines have tremendous potential as a source for baseload, CHP, peaking, and standby/backup power in commercial and industrial settings. Large-frame turbines have advanced in efficient production of high-quality heat and low emissions, particularly when heat recovery equipment, combined cycle designs, and CHP applications are added. However, transferring those accomplishments to smaller distributed systems has remained a challenge.

Hybrid Integration

Hybrids were high on the list of priorities for the 2003 workshop. Other considerations for small gas turbines included ultra-low emissions and the capability of being fully integrated with the grid. With NOx regulations becoming stricter and CO_2 emissions more heavily regulated, the role of gas turbines in relation to increasingly stringent emissions regulations is critical. Both NOx and CO_2 emissions can be reduced by lean premixed, pre-vaporized combustion and by enriching the fuel stream with hydrogen fuel.

Everest Sciences Corp., in Tulsa, OK, is a young company working to address many of the issues surrounding turbines used for distributed energy. In particular, it focuses on turbine inlet cooling, a technique that improves a gas turbine's fuel efficiency and power output. “Cooling inlet air, increases the density of the air ingested by the gas turbine, allowing the engine to operate at higher mass flow rates,” explains Marcus Bastianen, director of sales and marketing. “Besides the additional power gain that results, the increase in mass flow allows the gas turbine to operate more efficiently, thus reducing emissions per kilowatt of energy produced.”

Everest Sciences builds inlet cooling systems that provide cooler air than traditional evaporative techniques and chilled air systems that use less power than conventional refrigeration methods. “By minimizing the energy required to cool inlet air, the total NET power output of the engine increases while decreasing the total NET heat rates,” he adds.

A lower net heat rate also means that CO_2 emissions decrease per incremental kilowatt produced. Traditionally, smaller gas turbines have higher heat rates relative to large industrial-sized gas turbines. However, using efficient inlet cooling can provide additional incremental net power with emissions that rival the national average emissions for natural gas-fueled power generation. That’s a hot button, because Congress is looking more closely at emissions and greenhouse gases. In fact, proposed EPA rules may require “best-available control technologies and energy efficiency measures to minimize greenhouse gas emissions” when certain industrial facilities are constructed or significantly modified.

Everest has developed technology to continue to improve on gas turbine performance, focusing on hybrid turbine inlet cooling. The heart of the hybrid design uses an indirect evaporative cooling mechanism. Although indirect evaporative methods have been used in comfort cooling for quite some time, Everest Sciences uses this technology efficiently for the high air-flows that gas turbines consume. They build hybrid systems that add supplementary mechanical chilling and/or a direct evaporative process after the indirect evaporative cooling process. The company integrates and ships complete units/systems for engines up to 25 MW and scaling larger to 50–60MW. Everest has had requests for 100-MW gas turbines.

“We’ve spent a great deal of time and effort testing and fine-tuning our heat exchange technology and configuring our products such that the pressure loss through the system is minimized while our cooling efficiency is maximized,” says Bastianen. “Our product is different.”

The three new, engineered products are ECOCool, ECO CHILL, and Hydro-Flexcool. ECOCool is a hybrid package system featuring indirect evaporation with an air wash cycle. Air washing is direct evaporation with proven filtration benefits. This combination lowers the inlet air temperature below ambient wet bulb temperature while consuming a parasitic power similar to conventional evaporative techniques. Where traditional evaporative cooling methods are limited to the wet bulb temperature, the Everest hybrid design can bring ambient air as low as 14 degrees below ambient wet bulb in certain climate conditions. Cooling the inlet air below wet bulb and only using power to turn fans and pumps makes ECOCool the most efficient water-based turbine inlet system available, Bastianen claims. This has the added bonus of improving CO_2 emissions per unit of useable net power.

ECO CHILL is a hybrid, incorporating indirect evaporative cooling and chilling with an optional air washing stage. Although the engine makes more power, fuel consumption is reduced per unit of power; it is an integrated package system with lower parasitic loads than conventional refrigeration.

Mechanical chilling requires a compressor and condenser to refrigerate air. The capital cost is generally high and there is a high parasitic load: It takes a lot of power to chill air mechanically. By performing up to half the cooling with the indirect process and finishing with chilling, using similar albeit smaller compressors, less power is consumed and greater net fuel economy is achieved.

Depending on the climate conditions, an optional air wash stage can be added to ECO CHILL for use in combination. Their control processes work in conjunction with one another, so different parts of the cooling process can be turned on, minimizing the overall power consumption of the hybrid cooling process. ECO CHILL is a hybrid, incorporating indirect evaporative cooling and adding air washing and chilling. Air washing is direct evaporation with filtration benefits. Although the engine makes more power, fuel consumption is reduced; it is an integrated package system with lower parasitic loads.

The Hydro-Flexcool is Everest Sciences’ other new product and is the first integrated system safe for use with brackish or reclaimed water. Bastianen explains that the concept came from remote locations that needed cooling but didn’t want a large chilling system. The poor quality of water at these locations made water-based cooling complicated and more costly. Typical reverse osmosis systems or other water treatment techniques have an added cost. It’s not uncommon that some processes break down and need much attention in harsh remote climate locations. If the system fails, inlet cooling doesn’t work. “A lot of things can go wrong,” says Bastianen.

With the Hydroflex system, there’s no need for water treatment. The evaporated air/water stream passes in a separate channel so the air to the turbine never comes in contact with it. The system benefits plants with stringent requirements on effluent or locations that don’t have access to clean water. Plants that have effluent constraints often build retention ponds to allow the sun to evaporate the effluent. “We can run it through the Hydro-Flex system and evaporate much of it,” says Bastianen. An added benefit is that the clean, dry, and cooled air runs through the turbine for additional power and reduced heat rates.

The cooling concept is the same, he indicates, but design changes, materials, and components make the Hydro-Flex more efficient. For instance, fogging systems need demineralized water. To get that, Bastianen says, you have to “make” it. That adds cost. But the Hydro-Flex allows for use of non-treated water and eliminates the power and emissions associated with the water treatment process.

“Nobody we know of offers a product like this,” he says proudly. There hasn’t been a lot of recent innovation in this area; traditional evaporative techniques and chilling are the norm. “Our innovative hybrid is different. It provides equal chilling for less power and can perform inlet cooling with bad water.

“We are the integrator,” he continues. “We build technology around the indirect evaporative process.” The system is built to be compatible with filtration, with integrated framework and a filter house added on for easy installation. Maintenance is very minimal, with high industrial-grade components that are easily inspected and serviced, by design. “All moving parts can be worked on while the gas turbine is running, because it’s not in the air path line to the engine. All moving parts are in the secondary air stream in the heat exchange or out of the primary turbine inlet air path. It’s a well thought-through system design with redundancy so if a pump or fan goes down, all cooling is not lost.

In development for 11 years and in operation for two, the system is not widely known yet. Everest Sciences’ targets end users, gas turbine original equipment manufacturers, and engineering companies. End users include food processing facilities that use CHP; pulp and paper companies that want the flexibility of selling excess power to the grid; and other industrial plants and factories.

Photo: Everest Sciences twin ECOChill™ installation at a facility owned and operated by Enterprise Products Partners L.P in the greater Houston area.